COURSES OF STUDY
2011-2012

GOLDEN JUBILEE

INDIAN INSTITUTE OF TECHNOLOGY DELHI

IIT DELHI

Vision

To contribute to India and the world through excellence in scientific and technical education and research; to serve as a valuable resource for industry and society; and to remain a source of pride for all Indians.

Mission

To generate new knowledge by engaging in cutting edge research and to promote academic growth by offering state-of-the-art undergraduate, postgraduate and doctoral programmes.

To identify, based on an Informed perception of Indian, regional and global needs, areas of specialization upon which the Institute can concentrate.

To undertake collaborative projects which offer opportunities for long-term interaction with academia and industry.

To develop human potential to its fullest extent so that intellectually capable and imaginatively gifted leaders can emerge in a range of professions.

Values

❑ Academic integrity and accountability.

❑ Respect and tolerance for the view of every individual.

❑ Attention to issues of national relevance as well as of global concern.

❑ Breadth of understanding, including knowledge of the human sciences.

❑ Appreciation of intellectual excellence and creativity.

❑ A unfettered spirit of exploration, rationality and enterprises.

COURSES OF STUDY

2011-2012

Undergraduate programmes

Bachelor of Technology

Dual Degree

Integrated Master of Technology

Postgraduate programmes

Diploma of I.I.T. Delhi

Master of Science

Master of Business Administration

Master of Design

Master of Technology

Master of Science (Research)

Doctor of Philosophy

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1. INTRODUCTION

1.1 Background

I.I.T. Delhi provides science-based engineering education with a view to produce quality engineer-scientists. The curriculum provides broad based knowledge and simultaneously builds a temper for the life long process of learning and exploring. At the undergraduate level, a student needs to do compulsory foundation courses in the areas of basic sciences, humanities and social sciences and engineering sciences apart from departmental requirements. Departmental courses (core and electives) constitute 50% of the total curriculum. Further, students do open category electives to develop broad inter-disciplinary knowledge base or to specialize significantly in an area outside his parent discipline. At the postgraduate level, students are encouraged to look beyond their area of specialization to broaden their horizons through open electives.

The medium of instruction in the Institute is English.

The Institute follows the semester system. An academic year runs from July through June next year and is comprised of three semesters. Typically, the 1st semester starts in the last week of July and ends in the 2nd week of December; the 2nd semester starts in the last week of December/first week of January and ends in the 2nd week of May. The summer semester starts in the 3rd week of May and ends in the 2nd week of July. Detailed schedule is given in the Semester Schedule that is available before the start of the semester.

1.2 Departments and Centres

Each course is offered by an academic unit which could be a department, centre or school. The various Departments, Centres and Schools and their two-letter code are given below. Some courses are offered jointly by multiple academic units and are classified as interdisciplinary courses; their codes are also given in table 1.

Table 1. Academic departments, centres and schools.

Name of Academic Unit (alphabetical order)	Code
Applied Mechanics, Department of	AM
Applied Research in Electronics, Centre for	CR
Atmospheric Sciences, Centre for	AS
Biochemical Engineering and Biotechnology, Department of (dual degree entry no. 'BB')	BE
Biological Sciences, School of	BL
Biomedical Engineering, Centre for	BM
Chemical Engineering, Department of	CH
Chemistry, Department of	CY
Civil Engineering, Department of	CE
Computer Science and Engineering, Department of	CS
Electrical Engineering, Department of	EE
Energy Studies, Centre for	ES
Humanities and Social Sciences, Department of	HU
Industrial Tribology, Machine Dynamics and Maintenance Engineering Centre	IT
Information Technology, Amar Nath and Shashi Khosla, School of	SI
Instrument Design and Development Centre	ID
Management Studies, Department of	SM
Mathematics, Department of	MA
Mechanical Engineering, Department of	ME
Physics, Department of (Engineering Physics courses start with 'EP')	PH
Polymer Science and Technology, Centre for	PS
Rural Development and Technology, Centre for	RD
Telecommunication Technology and Management, Bharti School of	BS
Textile Technology, Department of	TT
Value Education in Engineering, National Resource Center for	VE

Table 2. Interdisciplinary programmes

Name of Interdisciplinary programme (alphabetical order)	**Code**
Computer Applications	**JCA**
Energy Studies	**JES**
Energy and Environment Management	**JEN**
Industrial Tribology and Maintenance Engineering	**JIT**
Instrument Technology	**JID**
Optoelectronics and Optical Communication	**JOP**
Polymer Science and Technology	**JPT**
Power Generation Technology	**JPG**
Telecommunication Technology and Management	**JTM**
VLSI Design Tools and Technology	**JVL**

1.3   Programmes offered

IIT Delhi offers a variety of academic programmes for students with a wide range of backgrounds. Admission to many of these programmes are based on performance in national level tests / entrance examinations followed by interviews in some cases. Details are given in Prospectus booklet.

The programmes offered by IIT Delhi are presently classified as undergraduate and postgraduate programmes. This classification is based primarily on entry/admission qualification of students rather than the level of degree offered. For all undergraduate programmes, students are admitted after 10+2 schooling while for all postgraduate programmes, students are admitted after they have obtained at least a college level Bachelor's degree. As this course of study would indicate, there is considerable overlap in courses for senior undergraduate students and junior postgraduate students. The various programmes and their specialization are listed below.

1.3.1   Undergraduate programmes

A.   Bachelor of Technology: (B.Tech.)

Department	**Specialization**	**Code**	
Chemical Engg.	B.Tech. in Chemical Engineering	**CH1**	CH
Computer Sc. and Engg.	B.Tech. in Computer Science and Engineering	**CS1**	CS
Civil Engg.	B.Tech. in Civil Engineering	**CE1**	CE
Electrical Engg.	B.Tech. in Electrical Engineering	**EE1**	EE
	B.Tech. in Electrical Engineering (Power)	**EE2**	EP
Mechanical Engg.	B.Tech. in Mechanical Engineering	**ME1**	ME
	B.Tech. in Production and Industrial Engineering	**ME2**	PE
Physics	B.Tech. in Engineering Physics	**PH1**	PH
Textile Technology	B.Tech. in Textile Engineering	**TT1**	TT

B.   Dual-Degree: (B.Tech. and M.Tech.)

Department	**Specialization**	**Code**	
Biochemical Engg. and Biotechnology	B.Tech. in Biochemical Engineering and Biotechnology, and M. Tech. in Biochemical Engineering and Biotechnology	**BE5**	BB
Chemical Engg.	B.Tech. in Chemical Engineering, and M. Tech. in Chemical Engineering	**CH7**	CM
Computer Sc. and Engg.	B.Tech. in Computer Science and Engineering, and M. Tech. in Computer Science and Engineering	**CS5**	CO
Electrical Engg.	B.Tech. in Electrical Engineering, and M. Tech. in Information and Communication Technology	**EE5**	EI

C. *Integrated Master of Technology: (Integrated M.Tech.)*

Department	Specialization	Code	
Mathematics	M. Tech. in Mathematics and Computing	**MT5**	MT

1.3.2 Postgraduate programmes

A. *Postgraduate Diploma*

Department	Specialization Code	
Applied Mechanics	D.I.I.T (Naval Construction) (for candidates sponsored by the Indian Navy)	**AMX**
Civil Engineering	PG Diploma in Metro Rail Transport: Technology and Management (for candidates sponsored by DMRC)	**CEX**

The DIIT is also available in every corresponding Master of Technology programme listed in Item E below. It is awarded only to those students who have been able to complete only partially the corresponding M.Tech. degree requirements. For details see *Section 5.6 in Courses of Study.*

B. *Master of Science: (M.Sc.)*

Department	Specialization	Code
Chemistry	M.Sc. in Chemistry	**CYS**
Mathematics	M.Sc. in Mathematics	**MAS**
Physics	M.Sc. in Physics	**PHS**

C. *Master of Business Administration: (M.B.A.)*

Department	Specialization	Code
Management Studies	M.B.A. (with focus on Management Systems)	**SMF**
	M.B.A. (with focus on Telecommunication Systems management)	**SMT**
	M.B.A. (with focus on Technology Management) (part-time and evening programme)	**SMN**

D. *Master of Design: (M.Des.)*

	Specialization	Code
Interdisciplinary	Master of Design in Industrial Design	**JDS**

E. *Master of Technology: (M.Tech.)*

Department/Centre	Specialization	Code
Applied Mechanics	M.Tech. in Engineering Mechanics	**AME**
	M.Tech. in Design Engineering	**AMD**
Chemical Engg.	M.Tech. in Chemical Engineering	**CHE**
Chemistry	M.Tech. in Molecular Engineering: Chemical Synthesis & Analysis	**CYM**
Civil Engg.	M.Tech. in Geotechnical and Geoenvironmental Engineering	**CEG**
	M.Tech. in Rock Engineering and Underground Structure	**CEU**
	M.Tech. in Structure Engineering	**CES**
	M.Tech. in Water Resources Engineering	**CEW**
	M.Tech. in Construction Engineering and Management	**CET**
	M.Tech. in Construction Technology and Management (✷)	**CEC**
	M.Tech. in Environmental Engineering and Management	**CEV**
	M.Tech. in Transportation Engineering	**CEP**

3

Computer Science & Engg.	M.Tech. in Computer Science and Engineering	**MCS**
Electrical Engg.	M.Tech. in Communications Engineering	**EEE**
	M.Tech. in Computer Technology	**EET**
	M.Tech. in Control and Automation	**EEA**
	M.Tech. in Integrated Electronics and Circuits	**EEN**
	M.Tech. in Power Electronics, Electrical Machines and Drives	**EEP**
	M.Tech. in Power Systems	**EES**
Mechanical Engg.	M.Tech. in Design of Mechanical Equipment	**MED**
	M.Tech. in Industrial Engineering	**MEE**
	M.Tech. in Production Engineering	**MEP**
	M.Tech. in Thermal Engineering	**MET**
Physics	M.Tech. in Applied Optics	**PHA**
	M.Tech. in Solid State Materials	**PHM**
Textile Technology	M.Tech. in Fibre Science & Technology	**TTF**
	M.Tech. in Textile Engineering	**TTE**
Applied Research in Electronics	M.Tech. in Radio Frequency Design and Technology	**CRF**
Atmospheric Sciences	M.Tech. in Atmospheric-Oceanic Science and Technology	**AST**
Interdisciplinary Programme	M.Tech. in Computer Applications	**JCA**
	M.Tech. in Energy Studies	**JES**
	M.Tech. in Energy and Environmental Management	**JEN**
	M.Tech. in Industrial Tribology and Maintenance Engineering	**JIT**
	M.Tech. in Instrument Technology	**JID**
	M.Tech. in Optoelectronics and Optical Communication	**JOP**
	M.Tech. in Polymer Science and Technology	**JPT**
	M.Tech. in Telecommunication Technology Management	**JTM**
	M.Tech. in VLSI Design Tools and Technology (∗)	**JVL**

NOTE: (∗) These are sponsored programmes.

F. Master of Science (Research): M.S.(R)

The Master of Science (Research) programme is offered by the respective department, centre or school.

Department/School	Code
Applied Mechanics	**AMY**
Bharti School of Telecommunication Technology and Management	**BSY**
Biochemical Engineering and Biotechnology	**BEY**
Chemical Engineering	**CHY**
Civil Engineering	**CEY**
Computer Science and Engineering	**CSY**
Electrical Engineering	**EEY**
Mechanical Engineering	**MEY**
Amar Nath and Shashi Khosla School of Information Technology	**SIY**

G.   Doctor of Philosophy: (Ph.D.)
All departments, centres and schools listed in Section 1 offer the Ph.D. programme. The two letter code of the academic unit followed by Z corresponds to the Ph.D. code of the respective academic unit. (e.g. MAZ is the Ph.D. code of the mathematics Departement) For details see section 7.

1.4 Student's entry number
The entry number of a student consists of eleven alpha-numerals.
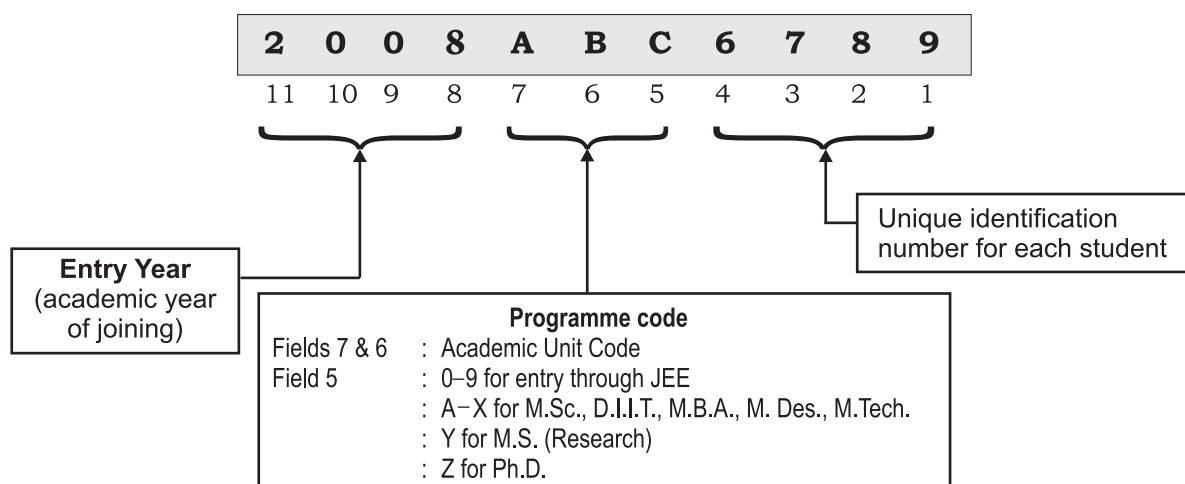
In case of a programme change, the three alphabets (fields 5, 6 and 7) will be changed. However, his/her unique numeric code will remain unchanged. Such students will have two entry numbers, one prior to programme change and one after the change. At any time, though, only one entry number, that corresponds to the students present status will be in use.

1.5 Honour Code

The *Honour Code* of IIT Delhi is given on the inside back cover of this booklet. Every student is expected to adhere to the *Honour Code.*

2.   COURSE STRUCTURE AND CREDIT SYSTEM

2.1 Course numbering scheme

Normally every course at IIT Delhi runs for the full length of the semester. Only exception is for V-type courses which may run for part of the semester. At the beginning of the semester, a student registers for courses that he/she wants to study and at the end of the semester a grade is awarded. On obtaining a pass grade, the student earns all the credits associated with the course while a fail grade does not get any credit; partial credits are not awarded.

Each course number is denoted by six alpha-numerals, three alphabets followed by three numerals:

$$E\,E\,L\,3\,2\,4$$

Code of the Academic Unit offering the course.
See Section 1 for all codes

Nature of the course.
See details below

Unique identification code for the course

Level of the course as determined by pre-requisite or number of earned credits. See details below.
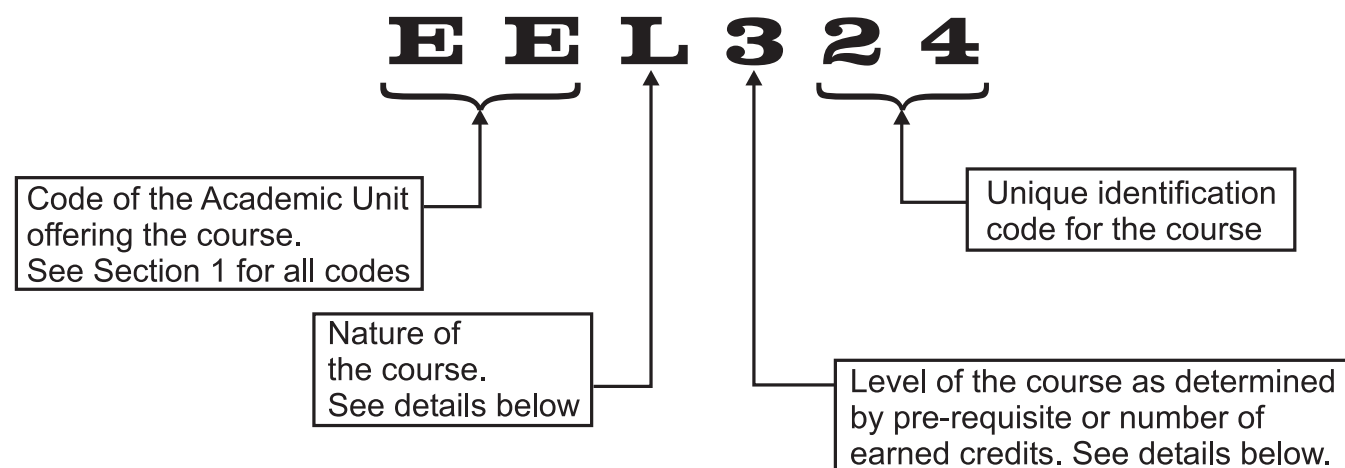
(a)   Codes for the nature of the course
The nature of the course corresponding to the third alphabet in the course code is given in table 3:

Table 3. Codes for the nature of courses.

| Code	Description
L	Lecture courses (other than lecture hours, these courses can have Tutorial and Practical hours, e.g. L-T-P structures 3-0-0, 3-1-2-, 3-0-2, 2-0-0, etc.)
P	Laboratory based courses (where performance is evaluated primarily on the basis of practical or laboratory work with LTP structures like 0-0-3, 0-0-4, 1-0-3, 0-1-3, etc.)
D	Project based courses leading to dissertation (e.g. Major, Minor, Mini Projects)
T	Training
C	Colloquium
R	Professional Practice
N	Introduction to the Programme or to Humanities and Social Sciences, etc.
S	Independent Study
V	Special Topics Lecture Courses (1 or 2 credits)

(b)   Level of the course
The first digit of the numeric part of the course code indicates level of the course as determined by pre-requisite course and/or by the maturity required for registering for the course. The latter requirement is enforced through a requirement of minimum number of earned credits. In general,

100 – 400 level courses   :   Core and elective courses for UG programmes.
                              These courses are not open to any PG student.
500 level courses   :   Courses for M.Sc. programmes.
                              These courses are not open to other PG students.

600 level courses	:	Preparatory/introductory courses for M.Tech. programmes. These courses are normally not open to UG students.
700 - 800 level courses	:	Core and elective courses for M.Tech., M.Des., M.B.A., M.S.(Research) and Ph.D. programmes. Usually 800 level courses are advanced courses for PG students.

(c)   Numbering scheme for courses of special nature
The numbering scheme for courses of special nature is given below. Here 'xx' is the Academic unit code, and 'y' is the digit from the programme code.

Table 4. Numbering scheme for courses of special nature

Course description	Course number
Introduction to the Programme	**xxN1y0**
Independent Study	**xxS3y0**
Professional Practices	**xxR3y0**
Practical Training	**xxT4y0**
Colloquium	**xxC4y0**
Mini Project	**xxD1y0**
B.Tech. Major Project Part 1	**xxD4y1**
B.Tech. Major Project Part 2	**xxD4y2**
Minor Project (Dual Degree)	**xxD7y0**
M.Tech. Major Project Part 1	**xxD8y1**
M.Tech. Major Project Part 1 (alternative)	**xxD8y3**
M.Tech. Major Project Part 2	**xxD8y2**
M.Tech. Major Project Part 2 (alternative)	**xxD8y4**

The alternative courses are only for dual degree and integrated M. Tech. programmes.

Each course is associated with a certain number of credits; see below.

2.2 Credit system

Education at the Institute is organized around the semester-based credit system of study. A student is allowed to attend classes in a course and earn credit for it, **only if** he/she has registered for that course. The prominent features of the credit system are a process of continuous evaluation of a student's performance/progress and flexibility to allow a student to progress at an optimum pace suited to his/her ability or convenience, subject to fulfilling minimum requirements for continuation.

A student's performance/progress is measured by the number of credits that he/she has earned, i.e. completed satisfactorily. Based on the course credits and grades obtained by the student, grade point average is calculated. A minimum grade point average is required to be maintained for satisfactory progress and continuation in the programme. Also a minimum number of earned credits and a minimum grade point average should be acquired in order to qualify for the degree. Details are given in the section on rules and regulations for UG students (Section 4) and PG students (Section 5).

All programmes are defined by the total credit requirement and a pattern of credit distribution over courses of different categories. Total credit requirement for different programmes are given in section 4 for UG students and section 5 for PG students. Category-wise break-up for each programme are given in sections 6 and 7 for UG and PG programmes, respectively.

2.3 Course credits assignment

Each course, except a few special courses, has a certain number of credits assigned to it depending upon its lecture, tutorial and laboratory contact hours in a week. This weightage is also indicative of the academic expectation that includes in-class contact and self-study outside of class hours.

Lectures and Tutorials: One lecture or tutorial hour per week per semester is assigned one credit.
Practical/Laboratory   : One laboratory hour per week per semester is assigned half credit.

A few courses are without credit and are referred to as non-credit (NC) courses.

Example: Course *EEL101 Fundamentals of Electrical Engineering*; 4 credits (3-0-2)
The credits indicated for this course are computed as follows:

3 hours/week lectures   = 3 credits
0 hours/week tutorial   = 0 credit   } Total = 3 + 0 + 1 = 4 credits
2 hours/week practical   = 2 x 0.5 = 1 credit

Also, (3-0-2) **4** credit course = (**3** h Lectures + **0** h Tutorial + **2** h Practical) per week
                        = **5** contact hours per week

For each lecture or tutorial credit, the self study component is 1 hour/week (for 100-600 level courses) and 2 hours/week (for 700-800 level courses). In the above example, the student is expected to devote 3 + 1 = 4 hours per week on self study for this course, in addition to class contact of 5 hours per week.

On completing all the degree requirements, the degree grade point average, DGPA, will be calculated and this value will be indicated on the degree/diploma. The DGPA will be calculated on the basis of category-wise best valid credits required for graduation.

A student who has earned the requisite credits but does not meet the graduation DGPA requirement, may do additional courses in any elective category to meet the DGPA requirement within the maximum permissible time limit. Further details are given in the Courses of Study.

2.4 Earning credits

At the end of every course, a letter grade is awarded in each course for which a student had registered. On obtaining a pass grade, the student accumulates the course credits as earned credits. A student's performance is measured by the number of credits that he/she has earned and by the weighted grade point average. A student has the option of auditing some courses. Grades obtained in these audit courses are not counted for computation of grade point average. However, a pass grade is essential for earning credits from an audit course; this does not apply to postgraduate programmes. A minimum number of earned credits are required in order to qualify for a degree and continuation of registration at any stage. Currently students in the postgraduate programmes can audit courses but they do not count towards earned credits.

The credit system enables continuous evaluation of a student's performance, and allows the students to progress at an optimum pace suited to individual ability and convenience, subject to fulfilling minimum requirement for continuation.

2.5 Course content description

Course content description consists of following components: (i) Course Number, (ii) Title of the Course; (iii) Credit and L-T-P; (iv) Pre-requisites; (v) Overlapping/Equivalent courses; and (vi) Description of the content. Content descriptions for all courses are given in Section 8. An example is given below:

> **CHL204 Transport Processes - II**
> *4 credits (3-1-0)*
> *Pre-requisites: CHL110*
> *Overlaps with: CHL251*
> Empirical correlations based on analogy between momentum, heat and mass transfer; mass balance in co-current and counter-current continuous contact equipment; operating line concept; ideal stage and stage efficiency; design on continuous contact equipment; HTU and NTU concept; batch and continuous distillation; absorption; adsorption: applications to chromatography; extraction and leaching operations; equipments and equilibrium diagrams; design procedures and calculations; humidification operations; design of cooling towers; drying of solids; design of batch and continuous dryers.

2.6 Pre-requisites

Each course, other than 100 level courses, has specified pre-requisites which may be another course or a fixed number of earned credits or both. A student who has not obtained a pass grade, viz., A, A(-), B, B(-), C, C(-), D, NP or S, in the pre-requisite or has not earned requisite number of credits will not be eligible to do that course. Examples:

AML310 Computational Mechanics
Pre-requisite: AML140/AML150/AML160/AML170/AML180/CHL231/CHL204 and E.C. 60

A student who has obtained a pass grade in any one of the courses AML140, AML150, AML160, AML170, AML180, CHL231, or CHL204, *and* has earned 60 credits will be eligible to register for this course.

BEL702 Bioprocess Plant Design
Pre-requisite: AML110 & MEL110 & CHL205 & CHL204 & BEL401 and E.C. 90.

A student who has obtained a pass grade in all these courses AML110, MEL110, CHL205, CHL204, and BEL401, and has earned 90 credits will be eligible to register for this course.

Pre-requisite earned credits for some courses of special nature are given below; the complete requirements are given in section 4.9:

Independent Study	80
Mini Project	80
Minor Project (Dual Degree)	120
B.Tech. Major Project Part 1	120
M.Tech. Major Project Part 1 (Dual Degree /Integrated M.Tech.)	165
Practical Training	90

Postgraduate students are deemed to have satisfied those pre-requisites that are of 100-400 level.They should use the pre-requisites information to evaluate their preparedness for registering in a course.

If no pre-requisite is specified for 700 and 800 level courses, a UG student needs to earn 90 and 120 credits to register for 700 and 800 level courses, respectively.

2.7 Overlapping/Equivalent courses

Wherever applicable, for a given course overlapping and equivalent courses have been identified. A student is not permitted to earn credits by registering for more than one course in a set of overlapping/equivalent courses. Departments may use these overlapping/equivalent courses for meeting degree/pre-requisite requirements in special circumstances. Example:

EEL301 Control Engineering - I
Overlapped course: MEL312, CHL261

A student who has earned a pass grade in EEL301 will not be eligible to register for and earn credits, under any category, for either MEL312 or CHL261. Further, registration in an overlaping course as an alternative to a core course of his/her programme is not allowed.

2.8 Course coordinator

Every course is usually coordinated by a member of the teaching staff of the Department/Centre/School which is offering the course in a given semester. For some courses, faculty from other departments/centres or even guest faculty participates in the teaching and/or coordination of a course. This faculty member is designated as the *Course Coordinator*. He/she has the full responsibility for conducting the course, coordinating the work of the other members of the faculty as well as teaching assistants involved in that course, holding the tests and assignments, and awarding the grades. For any difficulty related to a course, the student is expected to approach the respective course coordinator for advice and clarification. The distribution of the weightage for tests, quizzes, assignments, laboratory work, workshop and drawing assignment, term paper, etc. that will be the basis for award of grade in a course will be decided by the course coordinator of that course and generally announced at the start of the semester. For all non-100 level 'L' category courses, not more then 80% of the course aggregate can be associated with minor and major examination components. Course coordinator will have additional evaluation components over and above two minors and majors.

2.9 Grading system

The grading reflects a student's own proficiency in the course. While relative standing of the student is clearly indicated by his/her grades, the process of awarding grades is not based upon fitting performance of the class to some statistical distribution. The course coordinator and associated faculty for a course formulate appropriate procedure to award grades that are reflective of the student's performance *vis-à-vis* instructor's expectation.

2.9.1 Grade points

The grades and their equivalent numerical points are listed in table 5:

Table 5.   Grades and their description.

Grade	Grade points	Description
A	10	Outstanding
A (-)	9	Excellent
B	8	Very good
B (-)	7	Good
C	6	Average
C (-)	5	Below average
D	4	Marginal
E	2	Poor
F	0	Very poor
I	-	Incomplete
NP	-	Audit pass
NF	-	Audit fail
W	-	Withdrawal
X	-	Continued
S	-	Satisfactory completion
Z	-	Course continuation

2.9.2   Description of grades

A grade

An 'A' grade stands for outstanding achievement. The minimum marks for award of an 'A' grade is 80 %. However, individual course coordinators may set a higher performance requirement.

C grade

The 'C' grade stands for average performance. This average performance refers to "average" as per instructor's expectations in a holistic sense. This is the minimum grade required to pass in the Major Project Part 1 and Part 2 of Dual degree, Integrated M.Tech. and 2 year M.Tech. & M.S. Programmes.

D grade

The 'D' grade stands for marginal performance; i.e. it is the minimum passing grade in any course. The minimum marks for award of 'D' grade is 30 %, however, individual course coordinators may set a higher marks requirement.

E and **F** grades

A student who has scored at least 20% aggregate marks in a subject can be awarded an 'E' Grade. The Course Coordinators are, however, free to enhance this limit but should keep the percentage about 10% less than the cut-off marks for 'D' Grade. The Course Coordinators can also specify any additional requirements (to be specified at the beginning of the Semester) for awarding 'E' Grade. Students who obtain an 'E' Grade will be eligible to take a re-major test (an examination with weightage same as that of Major) for only 'L' Category Courses. If they perform satisfactorily, they become eligible for getting the grade converted to a 'D' Grade, otherwise they will continue to have 'E' Grade. However, the student will have only one chance to appear for re-major for an 'E' Grade. The re-major test will be conducted within the first week of the next semester. The date of re-major test of first year courses will be centrally notified by the Chairman, Time-Table Committee. A student can take a maximum of three such re-major tests in a given semester. If a student can not appear for the re-major test due to any reasons, he/she will not get any additional chance.

A student has to repeat all core courses in which he/ she obtains 'F' Grades until a passing grade is obtained. For 'E' Grade in a core course, a student has to repeat the same core courses or take a re-major test to obtain a passing grade. For the other (elective) courses in which 'E' or 'F' grade have been obtained, the student may take the same

course or any other course from the same category or take re-major in case of 'E' Grade. 'E' & 'F' Grades are not counted in the calculation of the CGPA; however, these are counted in the calculation of the SGPA.

I grade

An 'I' grade denotes incomplete performance in any L (lecture), P (practical), V (special module) category courses. It may be awarded in case of absence on medical grounds or other special circumstances, before or during the major examination period. The student should complete all requirements within

(i)   10 days of the last date of Major Tests; the request is to be made to the head of the department of the student's programme who will notify the same to concerned course coordinators, or
(ii)   with permission of the Dean (UGS)/Dean (PGS&R), the period can be extended to the first week of the next semester. A student will be eligible for an 'I' grade provided he/she has met the attendance criterion.

Upon completion of all course requirements, the 'I' grade is converted to a regular grade (A to F, NP or NF). 'I' grade does not appear permanently in the grade card.

Requests for I-grade should be made at the earliest but not later than the last day of major tests.

Attendance in the course for which I-grade is being sought will be certified by the course coordinator of the course. The course coordinators can instruct all students awarded I or extended I grade to appear for the re-major of the `E' grade. On the basis of their performance a student having I grade or extended I grade can earn any permissible grade unlike students taking re-major after obtaining 'E' grade. Please see other requirements in *Regulations and Procedures.*

NP and **NF** grades

These grades are awarded in a course that the student opts to audit. Only elective courses can be audited. Auditing a course is allowed until one week after the first Minor Tests. The audit pass (NP) grade is awarded if the student's attendance is above 75% in the class and he/she has obtained at least 'D' grade. Course coordinator can specify a higher criterion for audit pass at the beginning of the semester. If either of these requirements is not fulfilled, the audit fail (NF) grade is awarded. The grades obtained in an audit course are not considered in the calculation of SGPA or CGPA.

For UG programmes: the credits will be counted in total earned credits in the respective category.

For PG programmes: the credits will not be counted towards degree completion credit requirements.

W grade

A 'W' grade is awarded in a course where the student has opted to withdraw from the course. Withdrawal from a course is permitted until one week after the first Minor Tests. Withdrawal from PG major project part 2 is allowed only if he/she is given semester withdrawal. The W grade stays on grade card.

X grade

The 'X' grade is awarded for incomplete work typically in a project-type course based on a request by the student. The separate regulations for UG and PG students are given below.

> *The 'X' grade is awarded for incomplete work in Independent Study, Mini Project, Minor Project, or Major Project Part 1 and Part 2, based on the request of the student. On completion of the work, X grade can be converted to a regular grade within the first week of the next semester. Otherwise, the student will be awarded 'X' grade on a permanent basis and it will appear in his/her grade card. Further, the student will be required to register for the course in the next semester. The credits of the course will be counted towards his total load for the semester. In case of Major Project Part 1, the student will not be permitted to register for Major Project Part 2 simultaneously as Major Part 1 is a pre-requisite for Major Project Part 2. A regular full-time student can be awarded 'X' grade only once in a course, other than the summer semester. A part-time M.Tech. student is permitted a maximum of two X-grades in the major project part-2.*

S and **Z** grades

The 'S' grade denotes satisfactory performance and completion of a course. The 'Z' grade is awarded for non-completion of the course requirements, and if it is a core course, the student will have to register for the course until he/she obtains the 'S' grade. The specific courses in which S/Z grades are awarded for 2003 and post-2003 entry undergraduate students are:

(i)   Introduction to the Programme

(ii)   Practical Training

(iii)   NCC/NSO/NSS

(iv)   Introduction to Humanities and Social Sciences

(v)   Professional Practices

2.10 Evaluation of performance

The performance of a student will be evaluated in terms of three indices, viz. the Semester Grade Point Average (SGPA) which is the Grade Point Average for a semester, Cumulative Grade Point Average (CGPA) which is the Grade Point Average for all the completed semesters at any point in time and Degree Grade Point Average (DGPA).

A student who completes the course and credit requirements but has CGPA below the minimum required for award of degree will be evaluated in terms of Degree Grade Point Average (DGPA) which is calculated on the basis of the best valid credits; for all the completed semesters at any point of time until the maximum permissible period.

The Earned Credits (E.C.) are defined as the sum of course credits for courses in which students have been awarded grades between A to D or NP or S; for UG students, credits from courses in which NP or S grade has been obtained are also added.

Points earned in a semester = Σ (Course credits x Grade point) for courses in which A - D or NP or S grade has been obtained)

The SGPA is calculated on the basis of grades obtained in all courses, except audit courses and courses in which S/Z grade is awarded, registered for in the particular semester.

$$SGPA = \frac{\text{Points secured in the semester}}{\text{Credits registered in the semester, excluding audit and S/Z grade courses}}$$

The CGPA is calculated on the basis of all pass grades, except audit courses and courses in which S/Z grade is awarded, obtained in all completed semesters.

$$CGPA = \frac{\text{Cumulative points secured in all passed courses (A-D grade)}}{\text{Cumulative earned credits, excluding audit and S/Z grade courses}}$$

An example of these calculations is given in table 6 (a).

Table 6(a). Typical academic performance calculations - I semester

Course no.	Course credits	Grade awarded	Earned credits	Grade points	Points secured
(column 1)	(column 2)	(column 3)	(column 4)	(column 5)	(column 6)
MALXXX	5	C	5	6	30
CSLXXX	4	C(-)	4	5	20
PHLXXX	4	A	4	10	40
PHPXXX	2	B	2	8	16
MELXXX	4	E	0	2	08
TTNXXX	2	S	2	—	—

Credits registered in the semester *(total of column 2)*   =   21
Credits registered in the semester excluding audit and S/Z grade courses   =   19
Earned credits in the semester *(total of column 4)*   =   17
Earned credits in the semester excluding audit & S/Z grade courses   =   15
Points secured in this semester *(total of column 6)*   = 114
Points secured in this semester in all passed courses *(total of column 6 & A-D grade)* = 106

$$\text{SGPA} = \frac{\text{Points secured in the semester}}{\text{Credits registered in the semester, excluding audit and S/Z grade courses}} = \frac{114}{19} = 6.000$$

$$\text{CGPA} = \frac{\text{Cumulative points secured in all passed courses (A-D grade)}}{\text{Cumulative earned credits, excluding audit and S/Z grade courses}} = \frac{106}{15} = 7.067$$

Semester performance: Earned credits (E.C.) = 17   SGPA = 6.000
Cumulative performance: Earned credits (E.C.) = 17   CGPA = 7.067

Table 6(b). Typical academic performance calculations - II semester

Course no.	Course credits	Grade awarded	Earned credits	Grade points	Points secured
(column 1)	(column 2)	(column 3)	(column 4)	(column 5)	(column 6)
MALXXX	5	B	5	8	40
EELXXX	4	A(–)	4	9	36
CYLXXX	4	W	—	—	—
CYPXXX	2	B(–)	2	7	14
MELXXX	4	C	4	6	24
AMLXXX	4	A	4	10	40
HUNXXX	1	S	1	—	—

Credits registered in the semester *(total of column 2)*   =   24
Credits registered in the semester excluding audit and S/Z grade courses   =   23
Earned credits in the semester *(total of column 4)*   =   20
Earned credits in the semester excluding audit & S/Z grade courses   =   19
Points secured in this semester *(total of column 6)*   =   154
Points secured in this semester in all passed courses *(total of column 6 & A-D grade)*   =   154
Cumulative points earned in all passed courses = 106 (past semesters) + 154 (this sem.) =   260
Cumulative earned credits = 17 (past semesters) + 20 (this sem.)   =   37

$$\text{SGPA} = \frac{\text{Points secured in the semester}}{\text{Credits registered in the semester, excluding audit and S/Z grade courses}} = \frac{154}{19} = 8.105$$

$$\text{CGPA} = \frac{\text{Cumulative points secured in all passed courses (A-D grade)}}{\text{Cumulative earned credits, excluding audit and S/Z grade courses}} = \frac{106+154}{15+19} = 7.647$$

Semester performance   :   Earned credits (E.C.) = 20   SGPA = 8.105
Cumulative performance :   Earned credits (E.C.) = 37   CGPA = 7.647

On completing all the degree requirements, the degree grade point average, DGPA, will be calculated and this value will be indicated on the degree/diploma. The DGPA will be calculated on the basis of category-wise best valid credits required for graduation.

A student who has earned the requisite credits but does not meet the graduation DGPA requirement, may do additional courses in any elective category to meet the DGPA requirement within the maximum permissible time limit. Further details are given in the Courses of Study.

3.   REGISTRATION AND ATTENDANCE

3.1 Registration

Registration is a very important procedural part of the academic system. The registration procedure ensures that the student's name is on the roll list of each course that he/she wants to study. No credit is given if the student attends a course for which he/she has not registered. Registration for courses to be taken in a particular semester will be done according to a specified schedule before the end of the previous semester. Each student is required to complete the registration form on the computer by indicating the slot-wise choice of courses. Web based registration facility is available only on the intranet of I.I.T. Delhi. The choice of courses must be approved by his/her adviser.

The student must also take steps to pay his/her dues before the beginning of the semester by making use of internet banking facility of SBI through the intranet of I.I.T. Delhi. Students who do not make payments by a stipulated date will be de-registered for the particular semester.

In absentia registration *or registration after the specified date* will be allowed only in rare cases at the discretion of Dean (UGS)/Dean (PGS&R). In case of illness or absence during registration, the student should intimate the same to his/her course adviser and Dean (UGS)/Dean (PGS&R). A student must meet his/her advisor within the first week of the new semester for confirmation of his/her registration. A student's registration record will be available on-line for reference.

Various activities related to registration are listed below. The relevant dates are included in the *Semester Schedule* that is available before the start of the semester.

3.2   Registration and student status

Registration by a student confirms his/her status as student at the Institute. Failure to register before the last date for late registration will imply that the student has discontinued studies and his/her name will be struck-off the rolls.

Every registered student, except part-time postgraduate students, is considered as a full-time student at the institute. They are expected to be present at the Institute and devote full time to academics. Students registered only for a self-study course (only for undergraduates) or only for project or thesis are also considered as full-time students.

3.3 Advice on courses

At the time of registration, each student must consult his/her student adviser/programme coordinator to finalize the academic programme, keeping in view factors, such as, minimum/maximum numbers of total and lecture credits, past performance, backlog of courses, SGPA/CGPA, pre-requisite, work load and student's interests, amongst others. Special provisions exist for academically weak students.

3.4 Registration validation

Before the first day of classes, every student is required to be present on campus and validate his/her registration by logging in at the website. The updated registration record will be available on the website and the hard copy will be available with the student's advisor/programme coordinator. Students who do not do registration validation will not be permitted to add/drop courses.

3.5 Minimum student registration in a course

An undergraduate course (100, 200, 300, 400 level course) will run if minimum of 12 students register for the course. Under special circumstances, a departmental elective course may be allowed to run with minimum registration of 8 students, with prior permission of Chairman, Senate. A 700 or 800 level course can run with minimum of 4 students; and in the case of a pre-Ph.D. course, a minimum of three students excluding those auditing the course are required. This checking will be done on the last date for Add/Drop. Courses without the minimum enrolment will be dropped by the UG/PG section. The students who had registered for these courses will be de-registered, and they will be given one more day for adding a course in lieu of the dropped course.

3.6 Late registration

Late registration is permitted under the following conditions:

(a)   A student, who was not in the campus during the period of registration in the previous semester, needs to complete the registration process on or before the first day of the semester before commencement of classes; or

(b)   For reasons beyond his/her control, if a student is not able to register or send an authorized representative with a medical certificate, he/she may apply to the Dean (UGS)/Dean (PGS&R) for late registration. Dean (UGS)/Dean (PGS&R) will consider and may approve late registration in genuine cases on payment of an extra fee called late registration fee. Late registration is permitted until one week after the start of the semester.

3.7 Addition, Deletion, Audit and Withdrawal from Courses

(a)   Add/Drop: A student has the option to add a course(s) that he/she has not registered for, or drop a course(s) for which he/she has already registered for. This facility is restricted to the first week of the semester.

(b)   Audit: A student may apply for changing a credit course to an audit one within one week of the end of the first minor test.

(c) Withdrawal: A student who wants to withdraw from a course should apply within one week of the end of first minor test. A withdrawal grade (W) will be awarded in such cases.

Appropriate web-based applications are to be used at the academic web site from I.I.T. Delhi intranet for availing the above options.

3.8 Semester Withdrawal

(a) Semester withdrawal and absence for a semester under different conditions viz. (i) medical and personal grounds (ii) industrial internship (iii) exchange / deputation to another academic institution in India or abroad, & (iv) disciplinary condition (for both UG and PG students) should be clearly identified.

(b) Semester Withdrawal (SW) is proposed to reflect the condition in which a student is forced to withdraw from all courses in the semester for medical conditions or for a part-time student when he/she is sent for an outstation assignment by his/her employer. A student can apply for semester withdrawal if he /she has missed at least 20 teaching days on these grounds. Under no circumstances an application for semester withdrawal be acceptable after the commencement of major. A student is not permitted to request for withdrawal with retrospective effect.

(c) Semester Leave (SL) is proposed to indicate the situation in which a student is permitted to take one or more semester off for industrial internship or any other assignment with prior approval and planning. The application is to be routed through his/her advisor / programme coordinator and HOD or HOC and the final approving authority will be Dean UGS or Dean PGS as the case may be. All such applications must be processed before the beginning of the semester in which the leave will be taken. At present, JEE-entry B.Tech., dual degree and integrated M.Tech. students are allowed one extra semester for completion of the programme for every semester leave for industrial internship. Such students are permitted maximum of two semesters of leave. The full-time 2 year M.Tech./M.S. students be permitted a maximum of one semester leave for industrial internship or other assignment as approved by the Dean. These semesters will not be counted towards the maximum permitted time period for completion of the degree similar to the provision of JEE entry students.

(d) When a student (UG or PG) registers at another academic institution in India or abroad with the expectation of credit transfer or research work through a pre-approved arrangement including MoU, the student should be considered as being on a Semester Exchange (SE). The SE period will be counted towards the total period permitted for the degree.

(e) When a student is suspended for one or more semesters on disciplinary grounds, the student status should be called Disciplinay Withdrawal period (DW). Time spent in DW status will be counted towards the total period permitted for completion of the degree.

3.9 Registration in special module courses

Special module courses, i.e. 'V'-category courses, can be offered at the beginning of the semester in which case the regular registration procedure will be followed. A 'V'-category course may also be offered during the semester. In such a case, students will be allowed to add this course before classes for the course begin.

3.10 Registration for practical training

Before proceeding for practical training or training as part of the curricular requirement, the students should register for the respective course after obtaining approval from the training coordinator and head of the department. On returning after training, a continuation grade will be awarded and the students must register for the course in the regular semester immediately following the training period. During this semester, evaluation of the training will be carried out and a regular grade will be awarded.

3.11 Pre-requisite requirement for registration

A student should register for a course only if he/she fulfills the pre-requisite requirement(s). If the pre-requisite course is being done at the time of registration, the pre-requisite check will be performed after grading is done for the semester and those not fulfilling the pre-requisite will be deregistered from the course.

3.12 Overlapping/Equivalent Courses

A student is not allowed to earn credits from two overlapping /equivalent courses. Overlapping/equivalent courses are specified along with each course.

3.13 Limits on registration

A student is permitted to register for a specified minimum and maximum number of credits and/or lecture credits. Details are given in sections 4.3 and 5.4 for undergraduate and postgraduate students, respectively.

3.14 Registration and fees payment

Every registered student must pay the stipulated fees in full before the specified deadlines. In the event that a student does not make these payments, he/she will be de-registered from all courses and his/her name will be struck-off the rolls.

3.15 Registration record

In addition to web-based entries related to registration, the student should ensure that the same are entered on the *Registration Record*. Queries related to registration will be considered only when accompanied by the original Registration Record. This record must be preserved until the semester grade card is received by the student.

3.16 Continuous absence and registration status

If a student, whether full time, sponsored or part time, is absent from the Institute for more than four weeks without notifying the Head of Department/Centre or Dean (UGS)/Dean (PGS&R), his/her registration will be terminated and name will be removed from the Institute rolls.

3.17 Attendance rule

(i) It is mandatory for the students to attend all classes. Attendance Records of all students for each course will be maintained.

(ii) For all Ist year courses (100-level courses) the attendance will be taken and maintained by U.G. Section. If any student's attendance falls below 75% attendance in any of these courses, he/she will be put under academic probation. Henceforth, he/she will be governed by the rules for student under academic probation.

(iii) For all other courses, the Course Coordinator will announce the class policy on attendance with respect to grading etc., at the beginning of the semester. This shall be done keeping in mind the importance of classroom learning in the teaching-learning process. Once the class attendance policy has been made clear to all the students registered for the course, the Course Coordinator will implement the same in totality.

For the purpose of attendance calculation, every scheduled practical class will count as one unit irrespective of the number of contact hours.

Attendance record will be maintained based upon roll calls (or any equivalent operation) in every scheduled lecture, tutorial and practical class. The course coordinator will maintain and consolidate attendance record for the course (lectures, tutorials and practicals together, as applicable).

A faculty may choose any one or more of the following as attendance policy (approved by the Senate):

1. Faculty can assign 10% of the total marks to surprise quiz. If attendance of the student is greater than 90%, result of the best three quizzes will be considered else average of all quizzes will be considered.

2. Faculty can allocate specific marks for participation in discussions in the class on a regular basis.

3. If a student's attendance is less than 75%, the student will be awarded one grade less than the actual grade that he (she) has earned. For example, a student who has got A grade but has attendance less than 75% will be awarded A-grade.

4. A student can not get NP for an audit course if his attendance is less than 75%.

A faculty can implement any other attendance policy provided the policy is approved by the Dean.

Attendance statistics will also be used in the following way:

(i) If a student's attendance is less than 75% in more than two courses with out any valid reason in a semester will be issued warning and put under probation. If this is repeated, he/she will not be allotted a hostel seat in the next semester.

(ii) If a student's attendance is less than 75% in any course and CGPA is less than 7.0, then he (she) will not be eligible to hold any position of responsibility in the hostel/institute in the next semester.

4.   UNDERGRADUATE DEGREE REQUIREMENTS, REGULATIONS AND PROCEDURES

4.1 Overall requirements

4.1.1 B.Tech.

The total credit requirement for the B.Tech. (4-year programme) is 180 credits. For B.Tech. programmes and undergraduate part of the dual degree programmes, the total credits are distributed over two categories: undergraduate core (UC) and undergraduate elective (UE).

The Undergraduate core (UC) has following categories:

(i)   *Basic Sciences* (BS) which include Mathematics, Physics and Chemistry courses.

(ii)   *Engineering Arts and Sciences* (EAS) which include fundamental engineering courses.

(iii)   *Departmental Core* (DC) which include courses of relevant discipline.

Undergraduate electives (UE) courses belong to basically three categories:

(i)   *Departmental Electives (DE)*: Electives related to the parent discipline.

(ii)   *Humanities and Social Sciences, and Management (HM)*: Electives to provide a wide exposure to different areas of Humanities, Social Sciences and Management.

(iii)   *Open Category (OC)*: Electives to provide an opportunity to the student to develop broad inter-disciplinary knowledge base or to specialize significantly in an area outside the parent discipline.

4.1.2 Dual degree programmes

The total credit requirement for the Dual Degree and Integrated M.Tech. programmes is 216-218 credits. In case of Dual degree programmes, credits of the M.Tech. part are divided into two categories:

(i)   *Programme Core* (PC): Core courses related to the M.Tech. specialization.

(ii)   *Programme Electives* (PE): Elective courses related to the M.Tech. specialization.

The B.Tech. credit requirements are same as those in 4.1.1 for the B.Tech. (4-year programme) but with major project parts 1 and 2 excluded.

4.1.3 Integrated M.Tech.

Total credit for the integrated M.Tech. programme is divided into two categories:

(i)   *Integrated Core* (IC)
(ii)   *Integrated Electives* (IE)

Integrated Core and Integrated Electives have components similar to those of the undergraduate core and undergraduate electives, respectively.

4.2 Degree requirements breakup

The degree requirements for the various programmes listed earlier are detailed below.

4.2.1 Earned credits

(a)   Completion of 180 earned credits for 4-year B. Tech. Programmes.

(b)   Completion of 216 earned credits for Integrated M.Tech. programme in Mathematics and Computing.

(c)   For the Dual-Degree programmes, completion of 168-170 earned credits for the B. Tech. degree and 48-50 earned credits for the M. Tech. degree.

These credits are needed to be earned under different categories as specified in Section 4 for individual programmes.

4.2.2 Degree Grade Point Average (DGPA) requirement

A student must obtain a minimum DGPA of 5 to be eligible for award of the B.Tech. degree and 5.5 for the Integrated M.Tech. degree. The minimum DGPA requirement for M.Tech. part of dual degree programme is 6.0.

All exceptions to the above conditions will be dealt with as per following regulations:

(a)   If a student completes required credits for B.Tech./Integrated M.Tech. with DGPA less than 5/5.5, respectively then the student will be permitted to do additional elective courses under appropriate category to improve the DGPA within the

maximum time limit for completion of B.Tech./ M.Tech. degree respectively, as the case may be. In case a DGPA of 5/5.5 or more is achieved within the stipulated period, a B.Tech./Integrated M.Tech. degree will be awarded and in case the same is not achieved no degree will be awarded.

(b)   If a student completes requisite credits for Dual Degree Programme:

(i)   with B. Tech. DGPA less than 5 but M.Tech. DGPA more than 6.0

The student will be permitted to do additional elective courses (under any appropriate category) to improve the DGPA for completion of B. Tech. part within the maximum time limit. In case a DGPA of 5 or more is achieved for B.Tech., the student will be eligible for award of the Dual Degrees (B.Tech. & M. Tech.) and in case the same is not achieved no degree will be awarded.

(ii)   with B. Tech. DGPA more than 5 but M. Tech. DGPA less than 6.0

The student will be eligible for grant of only B.Tech. degree provided a written request is made to the Dean (UGS). Alternatively, the student may opt to do additional elective courses (PE category only) to improve the DGPA within the maximum time limit. If no programme elective (PE) courses are available, other relevant 700 and 800 level courses as certified by the department can be done for the purpose of improving the DGPA. In case DGPA of 6.0 or more is achieved for the M. Tech. part, the student will be eligible for award of the dual degrees (B. Tech. & M. Tech.). However, in case the same is not achieved at the end of stipulated period, the student will be eligible for the award of only B. Tech. degree, provided a written request for the same is made to the Dean (UGS).

(iii)   with B. Tech. DGPA less than 5 and M. Tech. DGPA less than 6.0

The student will be permitted to do additional elective courses (under any category) to improve the DGPA for completion of B. Tech./M. Tech. degrees (PE category only) within the maximum time limit. (If no programme elective courses are available, relevant 700 and 800 level courses as certified by the department can be done for the purpose of improving the DGPA of the M.Tech. part). In case a DGPA of 5 or more for B.Tech. and 6.0 or more for M.Tech. is achieved, the student will be eligible for award of the Dual Degrees (B.Tech. & M.Tech.). However, in case a DGPA 5 or more for B.Tech. is achieved but the DGPA 6.0 or more for M.Tech. is not achieved at the end of stipulated period, the student will be eligible for award of only B.Tech. degree provided a written request for the same is made to the Dean (UGS).

(c)   A student is eligible to apply for a Diploma provided he/ she has earned 120 credits and has exhausted the maximum number of permitted registered semesters for completion of his/ her degree. If the student has completed 60 credits (out of 120 credits) from his/ her DR+DC+PE+PC categories then the student will be awarded 'Undergraduate Diploma in respective discipline' on completion. If the student has not completed 50% credits from these categories but has completed 120 credits then he/ she will be awarded 'Undergraduate Diploma in Engineering'

(d)   No self-study course will be permitted for the purpose of improvement of DGPA for M. Tech. or B.Tech. part.

4.2.3 Practical Training

A student of the B.Tech., Dual-degree and Integrated M.Tech. programmes must complete the prescribed number of days of practical training to the satisfaction of the concerned department. This training will be normally arranged in the summer vacation following the 6th semester. Practical training duration is a minimum of 50 working days. Practical training should be carried out preferably in industry or R&D institutions in India. Practical training in academic institutions is not permitted. Details are given in section 4.9(f).

4.2.4 NCC/NSS/NSO

All students are required to enroll for either one of NCC, NSS or NSO in their first year. This requirement should be completed in one year. If, however, a student is not able to complete this requirement in the first year, he/she must complete it by the end of the 2nd year (4th semester). See also 4.9(a). All students will need to attend 10 hours of Counselling sessions as part of these activites on compulsory basis.

4.2.5 Break-up of earned credits

The minimum earned credit requirements for the B.Tech., Dual Degree and Integrated M.Tech. programmes along with detailed break-up of the credits in various categories are given in Table-7.

Maximum of 6 credits under open category can be taken from the departmental U.G. or P.G. courses, and other programme-relevant courses as identified by the department.

Exact requirements for each programme are detailed in Section 6. For completing graduation requirements, a student must complete a minimum of 8 credits of Mathematics category courses, and 6 credits each of Physics and Chemistry category courses with a valid pass grade. A student must also earn valid credits (audit not permitted) for a course of Environment Studies category under OC for graduation.

Table 7: Degree requirements of undergraduate programmes (see section 4.2.5 for additional information).

	Category	Symbol	Programme		
			B.Tech. (4-year)	Dual degree	Integrated M.Tech.
1	UG Core	UC	106	99-112	133 (IC)
1.1	Departmental core	DC	54 (min.)	48-50 (min.)	90
1.2	Basic Sciences*	BS	20 (min.)	20 (min.)	20 (min.)
1.3	Engineering Arts and Sciences	EAS	20 (min.)	20 (min.)	20 (min.)
1.4	Humanities and Social Sciences	HU	2	2	2
2	UG Elective	UE	74	68	83 (IE)
2.1	Departmental electives	DE	26 (min.)	20 (min.)	40
2.2	Humanities and Social Sciences	HM	14	14	14
2.3	Open category*	OC	25 (min.)	25 (min.)	30
3	Departmental requirement	DR (=DC+DE)	90	78-80	130
4	TOTAL REQUIREMENT (B.Tech./Integrated)	UR (=UC+UE)/ IR (=IC+IE)	180	168-170	216
5	M.Tech REQUIREMENT	PR	—	48-50	—
5.1	Programme core	PC	—	32	—
5.2	Programme elective	PE	—	16-18	—
6	TOTAL M.Tech. REQUIREMENT	PR (=PC+PE)	—	48-50	—
7	TOTAL REQUIREMENT (Dual degree)	UR+PR	—	216-218	—

* Minimum of 8 Credits can be earned through departmental courses.

<u>4.2.6 Audit courses</u>

Audit facility is open to all students who have completed 100 earned credits. A student will be permitted to do any number of audit courses over and above the graduation requirements. The audit rules are:

(a)   <u>B.Tech. (4-year) programme</u>: A maximum of 8 credits from the elective courses in any category *out of 180 credits* required for B.Tech. degree may be completed on audit basis.

(b)   <u>Dual-degree programme</u>: A maximum of 8 credits from the elective courses in any category may be completed on audit basis from the UG part of the programme.

(c)   <u>Integrated M.Tech. programme</u>: A maximum of 8 credits from the elective courses in any category may be completed on audit basis.

For completion of graduation requirements, a student must complete a minimum of 8 credits of Mathematics category courses and 6 credits each of physics and chemistry category courses with valid pass grade. A student must also earn valid credits (audit not permitted) for a course of "Environmental Studies" Category.

4.3 Lower and upper limits for credits registered

A student must register for a minimum of 15 credits and a maximum of 26 credits in a semester. The minimum and maximum lecture credits that a student can register for in a semester are 9 and 18, respectively. For the dual-degree and Integrated M.Tech. programmes, the above limits apply up to the 8th semester. In the 9th and 10th semesters, these students will normally register for a minimum of 12 credits and a maximum of 22 credits per semester.

Under exceptional circumstances a student can register for a maximum of 28 credits including not more than 6 (six) 'L' (Lecture) courses. However, this will be permitted at most twice during the programme in semesters other than 1st and 2nd, and those in which the student is registered for Major Project Part 1 or 2.

These conditions will not be applicable for those students who are on probation according to the criteria defined in section 4.5.

4.4 Absence during the semester

(a) A student must inform the Dean (UGS) immediately of any instance of continuous absence from classes.

(b) A student who is absent due to illness or any other emergency, up to a maximum of two weeks, should approach the course coordinator for make-up quizzes, assignments and laboratory work.

(c) A student who has been absent from a minor test due to illness should approach the course coordinator for a make-up test immediately on return to class. The request should be supported with a medical certificate from institute's medical officer. A certificate from a registered medical practitioner will also be acceptable for a student normally residing off-campus provided registration number of the medical practitioner appears explicitly on the certificate.

(d) In case a student cannot appear in a minor test on the same day in which he/she has appeared in a test, a medical certificate only from the institute's medical officer will be acceptable.

(e) In case of absence on medical grounds or other special circumstances, before or during the major examination period, the student can apply for I-grade. 75 % attendance in a course is necessary for being eligible for request of I-grade in that course. An application requesting I-grade should be made at the earliest but not later than the last day of major tests. The application should be made to the Head of the Department of the student's programme who will grant approval depending on the merit of the case and inform course coordinators and U.G section. The student should complete all course requirements within ten days of the last date of Major Tests. The I-grade will then be converted to a proper grade (A to F, NP or NF).

(f) In special situations arising due to the student's inability to be present at the institute during the stipulated period, in (e) above, the period for conversion of I grade can be extended to the first week of the next semester. Approval for this extension can be granted by Dean (UGS) on recommendations of the concerned Head of the department, course coordinators and concerned warden. A request to this effect must be included in the application for I-grade.

(g) In case the period of absence on medical grounds is more than 20 working days during the semester, a student may apply for withdrawal from the semester, i.e. withdrawal from all courses registered that semester. Such application must be made as early as possible and latest before the start of the major tests. No applications for semester withdrawal will be considered after the major tests have commenced. Dean (UGS), depending on the merit of the case, will approve such applications. Partial withdrawal from courses registered in a semester is not allowed.

(h) If a student is continuously absent from the institute for more than four weeks without notifying the Dean (UGS), his/her name will be removed from institute rolls.

4.5 Conditions for termination of registration, probation and warning

1.   Students admitted through JEE

If the performance at the end of first two registered semesters (not including summer semester) is poor, then the student can opt to start a fresh, or else his/her registration will be terminated. The criteria "poor" performance is defined in Table 8.

Table 8. Rules for termination of registration at the end of the 2nd registered semester.

Quality of performance	Earned credits		Decision
	GE/OBC	SC/ST/PD	
Poor performance	≤ 26	≤ 22	Re-start (once only) or Termination of registration

(a)   If a student chooses to restart after the first two registered semesters, then his/her credits earned and semesters registered will not be carried over. The re-start will be indicated on the transcript. The re-start will be permitted only once. If at the end of two registered semesters after re-start, the earned credits are less than or equal to 26 for GE/OBC or less than or equal to 22 for SC/ST/PD students, then the registration will be terminated.

(b)   Each student is expected to earn at least 12 credits in the first registered semester and 15 credits in each subsequent registered semester with a SGPA greater than or equal to 5.0. If the performance of a student at the end of any registered semester is below this minimum acceptable level, then he/she will be placed on probation and a warning shall be given to him/her and intimation sent to the parents.

(c)   The student placed on probation shall be monitored, including mandatory attendance in classes, special tutorials and mentoring. Mentoring will comprise structured guidance under a senior/postgraduate student.

(d)   If the performance of a student on probation does not meet the above criterion (b) in the following registered semester, then the student will be permitted to register by the Dean, UGS only if the department makes a favourable recommendation. The Head of the Department's recommendation shall be prepared after consultation with the student, and should include (i) feasibility of completing the programme requirements, and (ii) identification of remedial measures for the problems leading to poor performance.

(e)   The registration of any student will be limited to 1.25 times the average earned credits of the previous two registered semesters, subject to a minimum of 15 credits and a maximum of 26 credits.

1.1   Slow-paced programme

(i)   A student who has earned between 27 and 36 credits at the end of the first two registered semesters will be eligible to opt for the slow-paced programme. A student opting for such a programme shall be permitted two additional registered semesters for completing degree requirements as indicated in section 4.6.

(ii)   In the slow paced programme, the upper limit for credits registered in a semester will be 18. A student in this programme is expected to earn at least 12 credits with minimum SGPA 5.0 in any semester, falling which he/she will be issued a warning and placed on probation.

The student placed on probation shall be monitored, including mandatory attendance in special tutorials and mentoring.

If the performance of a student on probation does not meet the above criterion in the following registered semester, then the student will be permitted to register by the Dean, UGS only if the department makes a favourable recommendation. The Head of the Department's recommendation shall be prepared after consultation with the student, and should include (i) feasibility of completing the programme, and (ii) identification of remedical measures for the problems leading to poor performance.

(iii)   Slow-paced programme shall be defined by the respective department for each student.

4.6 Maximum duration for completing degree requirements

1.   The maximum permitted duration of each programme will be determined in terms of number of registered regular semesters, hereinafter called registered semesters. Any semester in which a student has registered for a course will be called a registered semester subject to the following:

(a)   Only the 1st and 2nd semesters of an academic year can be registered semesters. The summer semester will not be considered as a registered semester.

(b)   A semester when a student has been granted semester withdrawal or granted leave will not be considered as a registered semester.

(c)   The semester when a student is suspended from the Institute on disciplinary grounds will not be counted towards the number of registered semesters.

The summer semesters falling in between the permitted registered semesters shall be available for earning credits. After the student has registered for the maximum permissible number of registered semesters, the subsequent summer semesters will not be available for earning credits.

2.   The maximum permissible number of registered semesters for completing all degree requirements would be:

Table 9. Maximum permissible duration for completing degree requirements.

Programme Name	Maximum number of registered semesters permitted for completing degree requirements
B.Tech.	12 (*)
Dual Degree	14 (*)
Integrated M.Tech.	14 (*)

Note: (*) If a student opt for the slow-paced programme (as defined in clause B1),then the maximum permissible number of registered semesters shall be increased by two semesters.

4.7 Courses of special nature

Courses of special nature are: National Cadet Corps (N.C.C.), National Sports Organization (N.S.O.) and National Service Scheme (N.S.S); Introduction to the Programme, Introduction to Humanities and Social Sciences; Independent Study, Mini Project, Practical Training, Colloquium, and Major Project. Salient features of these courses are given below. (See section 2.1 for numbering scheme).

(a)   N.C.C., N.S.O. and N.S.S.
The B.Tech., Dual Degree and M.Tech. Integrated student have to complete 100 hours in any one of the activities, namely NCC, NSS, NSO to complete non-credit requirement. On completion of 100 hours, student is awarded "S" grade; 100 hours requirement over a period of one year is broken into 50 hours requirement per semester.

The student is registered in NCN100/NSN100/NPN100 level course in the Ist Semester and on obtaining "S" grade he/she is registered in NCN101/NSN101/NPN101 in the IInd Semester. Unless a student obtains "S" grade in both 100 and 101 level courses he/she does not complete the non-credit requirement of NCC, NSS, NSO. In case a student can not complete this requirement in the first year, he must do so by the end of second year; otherwise he/she will not be allowed to register for any course until he/she completes this requirement.

(b)   Introduction to the Programme
A student is introduced to his/her engineering discipline through this course in the first semester itself. This is a 2 credit compulsory course. A student is required to complete this course in the first year by getting 'S' grade. In case, a student is not able to complete it in the first year, he/she must do so by the end of the second year, otherwise he/she will not be allowed to register in the 3rd year, as is the case for NCC/NSS/NSO courses.

(c)   Introduction to Humanities and Social Sciences
A student is exposed to various facets of humanities and social sciences along with instructions for improving English language proficiency through this course. This is a compulsory 2 credit course that is normally done in first year. In case, a student is not able to complete it in the first year, he/she must do so by the end of the second year, otherwise he/she will not be allowed to register in the 3rd year, as is the case for NCC/NSS/NSO courses.

(d)   Independent Study
'Independent Study' is an elective course that some departments may offer from fourth semester onwards. It is a 3-credit course covering one or more of the following:

    (i)   In-depth study and critical review of a specified topic;
    (ii)   Specialized laboratory work/experimental project/feasibility study;
    (iii)   Work on a research project;
    (iv)   Software development on a specified topic.

An individual student and teacher should decide upon the topic and submit an initial write-up to get the approval of the Course Coordinator before the end of the semester when the course is registered for (i.e. in the semester prior to doing the course). The duration of the course will be the entire semester. A written report should be submitted by the student on completion of the course. The student's performance will be evaluated by a departmental committee via a mid-term and final evaluation. A student has to earn 80 credits and obtain at least 7.5 CGPA to become eligible to do Independent Study.

(e)   Mini Project
An elective course under this title may be floated by departments from fifth semester onwards. Mini project will be a regular course to conduct a design and fabrication type project. The student and teacher would decide upon the topic, prepare a plan of work and get the approval of the Course Coordinator before the end of the semester when

the course is registered for. The duration of the course will be the entire semester. A project report would be submitted by the student on completion of the course. The student's performance will be evaluated by a departmental committee via a mid-term and a final evaluation. Mini-project can be done jointly by 2 students, each having earned 80 credits with a CGPA of at least 6.5. A dual degree student can do either Mini Project or Minor Project.

(f)   Practical Training

Practical Training is a non-credit departmental core course (NC) to be done typically in the summer semester following sixth semester. A student who has earned at least 90 credits at the end of 5 semesters is eligible to undergo practical training in the summer following sixth semester. The duration for practical training is 50 working days (minimum), preferably in an industry or R&D institution in India. Practical training in academic institutions is not permitted.

It is the joint responsibility of the departments and the Training and Placement (T&P) unit to arrange for training for all their students. In the beginning of each academic session, T&P unit will prepare programme-wise lists of potential training organizations in consultation with the respective departments. These organizations will be approached by the T&P unit with a request to provide training seats. Consolidated lists of training offers will be made available to the students through departments in the beginning of the second semester of the session. If a student is interested in making his/her own arrangement for the training seat, he/she will need to have the training organization approved and route the application through the departmental training incharge and T&P unit. All such applications must be completed before the end of first semester. No self-arranged practical training, not approved through the above process, will be allowed and faculty members will not sign any forms for the purpose.

The department will appoint a training supervisor for each student. The supervisor is expected to keep contact with the assigned students through e-mail and /or telephone. The students will be required to get their training plan reviewed by their supervisor within the first week and report their progress on weekly basis. The supervisor, if desires, may visit the organization. Visits within the country will be supported by the institute.

A student will be registered for practical training course in the summer semester in which the training is being done. At the end of the summer semester, a 'Z' grade will be awarded and he/she should register for practical training course in the following semester. The Department will scrutinize the training report and the training certificate and will award 'S' grade within the next semester, if the training is satisfactory. In case the training is considered to be unsatisfactory, a 'Z' grade will be awarded and the student may have to undergo fresh practical training for a part or full duration. Practical Training and submission of summer training report is a mandatory requirement for graduation.

(g)   Colloquium

Colloquium is a 3-credit course and includes assessment of practical training. A student will be eligible to do Colloquium if he/she had registered for Practical Training earlier. Typically, a student will register for Colloquium in the regular semester following the summer semester in which he/she has done the practical training.

(h)   B. Tech Project

The B.Tech Major Project is structured into two parts - Core and Elective. The Core B.Tech Project will have 4 credits. It will be scheduled in the seventh semester. The Elective B.Tech project will be of 8 credits. The students will be eligible to do Elective B.Tech project, if he/she secures a grade not below 'B' in Core B.Tech Project. Elective B.Tech project will be scheduled in the eight semester. Normally, Elective B.Tech project will be continuation of Core B.Tech project.

All awards based on B.Tech project will consider performance in Elective B.Tech project. Those students who do not qualify or does not opt for Elective B.Tech Project will do DE category courses in its place to make up total credits.

(i)   Major Project (Dual- Degree, Integrated M.Tech, 2yr M.Tech)

The Major Project is a core course spread over at least two regular semesters and comprises of Part 1 and Part 2. The allocation of major projects, faculty guides and tentative plan of work are to be done typically before the end of the previous semester. Part 2 is normally expected to be a continuation of Part 1, except under those exceptional circumstances in which the supervisor (guide) is changed at the end of Part 1. A mid-term assessment and an end semester assessment will be carried out for each part. Part 1 and Part 2 will be graded separately. C grade is considered as the minimum pass grade in each part of the M.Tech. Major Project in Dual Degree, Integrated M.Tech. Programmes & 2 year M.Tech. Programmes.

A student must have obtained a pass grade in Project Part 1 in order to be eligible for registering for Project Part 2.

Major project will be spanned over one summer semester and two regular semesters. Typically a student will register for the Part 1 of major project in the summer semester. He/she will be automatically awarded an X-grade in the summer semester unless he/she is awarded an F grade. If a student is awarded X grade, he/she will be automatically registered for M.Tech. Project Part 1 (xxD8y1) in the following regular semester. Mid-term evaluation of the M.Tech. Project Part 1 will be held within first two weeks of the corresponding semester. At the end of the regular semester, the student will be awarded a proper grade in M.Tech. Project Part 1 (xxD8y1). If he/she obtains a valid pass grade in this

course, he/she can register for M.Tech. Project Part 2 (xxD8y2-14 credits) in the following regular semester. His/her M.Tech. Project Part 2 will be evaluated at the end of the corresponding semester as per the stipulated deadline.

In case a student does not obtain an X-grade in M.Tech. Project Part 1 in the summer semester, he/she will require permission from the Head of the Department to register for M.Tech. Project Part 1 in a regular semester. In this situation, he/she will register for M.Tech. Project Part 1 with reduced credits, viz. 4 credits (xxD8y3). After completing this course with a valid pass grade he/she will be required to register for M.Tech. Project Part 2 with 16 credits (xxD8y4). In this case the project will either start in the regular semester and extend into the following summer semester or start in the summer semester and extend into the following regular semester. M.Tech. Project Part 2 will be evaluated taking into account the work done in both the semesters. Extension from one semester to the other will be permitted automatically by awarding X-grade to the student. An F grade instead of X will bar a student from continuing the M.Tech. Project Part 2 in the following semester. The student will need to do fresh registration for M.Tech. Project Part 2.

(xxD8ym – is the course number for M.Tech. Major Project as explained in section 2.1(c))

Norms for conducting M.Tech. project of Dual degree and Integrated M.Tech. programmes at location outside IIT Delhi.

(a)   The student is permitted to work at location outside IIT, Delhi in summer or in the 2nd Semester of MTP when the student is not registered for other courses.

(b)   Projects can be carried out at an University or Institue if it is linked through consultancy/sponsored project or covered under MoU. Else with approval of Dean on recommendation of HoD. However, the description of the proposed work must be approved by Departmental UG Committee.

(c)   At the commencement of the project, a description of the proposed work will be made available and be approved by the Departmental Undergraduate Committee.

(d)   An External Supervisor will be appointed by the Department with approval of the Head of the Department and conveyed to Dean, UGS and notified by the UG Section.

(e)   The student is required to come back for mid-term evaluation / presentation.

(i)   Special Module (V-category) Courses
Special module courses are 1 or 2 credit courses that can be offered at the beginning of the semester or during the semester. These courses will usually cover specialized topics that are not generally available in the regular courses. Eligible students can register for these courses for credit. The course coordinator will evaluate the students' performance and award a letter grade. The credits so earned will count towards the appropriate category for degree completion purposes.

4.8   Open category credits

Open category credits should provide an opportunity to a student to exercise his/her options in an unrestricted fashion.

A.   A student can complete open category credits by choosing courses from different departments. The student will be permitted to register for maximum of 8 credits of departmental courses under open category.

B.   A student, if he (she) so desires, can complete 20 credits out of the 'Open Category' basket by exercising one of the following options.
   (i)   The 20 credits belong to one of the Minor Area programmes.
   (ii)   The 20 credits could be utilised be for a specialization within the Department only by those students who opt for joining an M.Tech program in the third year as continuation of his/her current B.Tech programme as per existing provision. This will enable the student to earn credits towards his/her M.Tech degree.
   (iii)   The 20 credits could be utilised for inter-disciplinary specialisations in which a student can earn credits by doing courses from multiple departments (including the parent department). Such specialisations can be defined jointly by more than one participating department.

   Implementation rules

   (i)   it will be possible for a student to register for a minor area / inter-disciplinary specialization. Registration for a Minor Area / specialization will be based on the performance of the student in a qualifier course which will be one of the core courses for the Minor Area / specialisation. Departments/Centres need

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to identify qualifier courses for the offered minor area programmes/specialisations. In order to discourage non-serious students, if someone registers for a minor area / specialization but does not complete it, that information will be recorded on the academic transcripts.

(ii) Interdisciplinary specialization: This requires two or more Departments/Centres to identify courses totalling 20 credits which will lead to an inter-disciplinary specialization. This will have courses from all the participating Departments/Centres and will also have a core component totalling 6-8 credits. The specialization will be mentioned on the degree.

(iii) A student opting for Departmental Specialisation/Inter-disciplinary specialisation will not have the option for registering for departmental courses for remaining open category credits.

4.9   Minor Area

4.9.1   A set of pre-defined courses of total 20 credits in a focus area comprises a Minor Area. A student can use Open Category (OC) credits to complete the specific requirements.

4.9.2   Any student is eligible to take the Minor Area at the end of the 3rd semester and may register for Minor Area courses from 4th semester onwards.

4.9.3   A student registered in any programme of a specific department will not be eligible to take the minor area(s) offered by the same department; additional conditions and details of individual minor areas are given in Section 6.

4.9.4   If any course of a minor area overlaps with any core course (DC or PC category courses) or elective course (DE or PE category courses) of the student's programme, then credits from this course will not count towards the minor area credit requirements, though this course may contribute towards satisfying the core requirement of the minor area. In such a case, the requirement of 20 credits must be completed by taking other courses of the minor area.

For example, a student of BB5 programme intending to complete the minor area *Computational Mechanics* (that has CHL204, or any of its alternates, and AML310 as core courses) will take CHL204 as a DC category course and complete the minor area requirements by completing AML310 (core course of the minor area) and 16 credits (4 courses in this case) from the listed minor area elective courses, viz. AML410 AML430, AML440, AML705, and AML710.

4.9.5   For purposes of completing minor area requirements, the listed minor area course may be substituted by an equivalent course so identified in the course descriptions.

4.10   Self-study course

A self-study course will be from the regular UG courses listed in the *Courses of Study* bulletin. The main features of a self-study course are as follows:

(a) A student may be given a self-study course of weightage not exceeding 5 credits in the final semester if he/she is short by a maximum of 5 earned credits required for graduation provided that the course is not running in that semester as a regular course. Students in the Dual-degree and Integrated M.Tech. programmes are allowed to avail of this provision during their last semester. However, they would be permitted to take only a UG course as a possible self-study course. A student can make use of this provision only once during the programme.

(b) A student may also be permitted to do a U.G. (UC/IC) core course not exceeding 5 credits in self-study mode at most once during the program, provided he/she has failed in it earlier and the course is not being offered as a regular course during that semester.

(c) Students should apply for a self-study course with appropriate recommendation of the Course Coordinator and the Head of the Department of the student's programme. The final sanction of a self-study course to a student is made by the Dean (UGS).

(d) Grant of a course to be taken as a self-study course cannot be claimed by any student as a matter of right.

(e) Normally, no formal lectures will be held for a self-study course but laboratory, design and computation exercises will be conducted if they form an integral part of the course.

(f) The Course Coordinator will hold minor and major tests besides other tests/quizzes for giving his/her assessment at the end of the semester. In summer semester, there will be at least one mid semester test and a major test.

(g) The self-study course will run during the total duration of the semester (including summer semester).

(h) The grades after due moderation by the Moderation Committee will be sent by the Department to Officer In-charge (UGS) at the end of the semester along with grades of all other courses.

(i) Colloquium will not be offered as a self-study course.

4.11 Summer semester

In the summer semester, registration for 'L' (lecture) and 'P' (practical) category courses will be strictly limited to the students who have obtained an E grade in the subject earlier or whose load has been restricted by SRC. In a summer semester, a student cannot earn more than 12 credits (in all the categories) except when he/she is registered for M.Tech. Project Part 2 with maximum of 16 credits.

A summer course will run only if there is a minimum registration of 5 students.

4.12 Assistantship for Dual-degree and Integrated M.Tech. programmes

The students of dual-degree programmes and 5 year integrated M.Tech programmes will be considered for award of institute research/teaching assistantship if they have earned 165 credits. Only those students who have qualified GATE / have CGPA more than 8.0 will be eligible for this assistantship. The assistantship will be provided for a maximum period of 14 months beginning from the summer semester following 8th semester, provided the student is registered for M.Tech major project part-I in that semester. The student will be required to provide 8 hours of assistance per week besides his normal academic work. For continuation of assistantship a student will need to secure SGPA of 7.0. A student will be eligible to receive assistantship from sources other than institute fund or MHRD if he/she has a CGPA of 7.0 and has earned 165 credits.

A student receiving assistantship will be eligible for total of 30 days leave during the 14-month period. He/she will not be entitled to mid-semester breaks, winter and summer vacations.

4.13 Change of programme

4.13.1 Programme change at the end of first year

The following regulations apply for change of programme at the end of first year, i.e. end of the 2nd semester.

(a)   A student is eligible to apply for change of discipline at the end of first year only, provided he/she satisfies the following criteria:-
         (i)   CGPA for general category student   :   7.50
         (ii)   CGPA for SC/ST/PH category student   :   6.50
         (iii)   Earned credits at the end of first academic session   :   40

(b)   Change of the discipline will be permitted strictly in the order of merit as determined by their CGPA at the end of first year subject to the limitation that the actual number of students in the third semester in the discipline to which the transfer is to be made, should not exceed the sanctioned strength and the strength of the discipline from which transfer is being sought does not fall below 90% of existing strength.

(c)   For a student with CGPA 9.0 or more, even if a vacancy does not exist, he/she will be permitted to change provided the strength in the discipline to which the change is being sought does not exceed by 5 % of the approved strength.

(d)   A student with CGPA 9.0 or more will be permitted to change discipline even if strength of discipline from which change is being sought falls below 90 % of the existing strength.

(e)   Stipulation of minimum credits and CGPA requirements will not be insisted upon for change of discipline to a branch in which a vacancy exists and the concerned student was eligible for admission to that discipline at the time of entry to IIT Delhi. However, requirements of credits and CGPA will continue to apply in case of both general and SC/ST category students seeking change to a discipline to which the concerned student was not eligible for admission at the time of entry to IIT Delhi.

4.13.2   Change from 4-year B.Tech. to dual degree programme

A student registered for a 4-year degree programme in a Department can be permitted to change his/her registration from the 4-year to a 5-year programme of the same department provided the B.Tech. part of the dual degree programme into which the student is desirous of registering is the same as the programme for which the student was admitted through JEE subject to fulfilling the following criteria:

(a)   The student must have completed at least 120 credits by the end of 6th semester and secured a minimum CGPA of 7.5.

(b)   The maximum number of students that can be permitted such a change of registration will be limited to 10 % of sanctioned strength of the intake into the relevant 4-year programme of the department.

4.14 Measures for helping SC/ST Students

A number of measures exist for helping students belonging to SC and ST categories. A senior faculty member is appointed as adviser to SC/ST students for advising them on academic and non-academic matters. Financial measures for helping SC and ST student are described in the *Prospectus*.

4.15 Admission of UG Students to PG Programmes with Advance Standing

UG students of IIT Delhi are eligible for admission to PG programmes with advance standing at IIT Delhi. For admission to PG programme minimum CGPA required at the end of sixth semester shall be 7.5. The student will be awarded both the degrees- B.Tech and a PG degree on successful completion of both the programmes. The student will be required to complete the major project in both the UG and PG programmes. A student can have maximum of 24 credits of the PG programme waived. A student can earn these credits through DE & OC courses.

5.   POSTGRADUATE DEGREE REQUIREMENTS, REGULATIONS AND PROCEDURES

5.1 Degree requirements

The detailed degree requirements for M.Sc., D.I.I.T., M.B.A., M.Des. M.Tech., M.S. (Research) and Ph.D. degrees are listed in Table 9.

5.2 Continuation requirements

The detailed requirements for continuation as a student in the respective programme for M.Sc., D.I.I.T., M.B.A., M.Des. M.Tech., M.S. (Research) and Ph.D. degrees are listed in Table 9. Failure to maintain the specified academic standing will result in termination of registration and the student's name will be struck-off the rolls.

The maximum permitted duration of each programme will be determined in terms of number of registered regular semesters, hereinafter called registered semesters. Any semester in which a student has registered for a course will be called a registered semester subject to the following:

(a) Only the 1st and 2nd semesters of an academic year can be registered semesters. The summer semester will not be considered as a registered semester.

(b) A semester when a student has been granted semester withdrawal or granted leave will not be considered as a registered semester.

(c) The semester when a student is suspended from the Institute on disciplinary grounds will not be counted towards the number of registered semesters.

The summer semesters falling in between the permitted registered semesters shall be available for earning credits. After the student has registered for the maximum permissible number of registered semesters, the subsequent summer semesters will not be available for earning credits.

5.3 Minimum student registration for a programme

A M.Sc., M.B.A., M.Des. or M.Tech. programme will not be run unless the number of students registered for that programme is six or more. If the number of students left in a programme at the end of the 2nd semester is less than four, the same programme may be looked into for temporary suspension by the Board of Educational Research and Planning.

5.4 Lower and upper limits for credits registered

For full-time students pursuing M.Sc., M.B.A., M.Tech. and M.S.(Research), the minimum registration requirement in a semester is 12 credits, and for part-time students, the minimum registration requirement is 3 credits. These minimum credit requirements are not applicable for graduating students who require lower than the proposed minimum to graduate.

5.5 Audit requirement

a.   A student can request for an audit grade in any course provided he/she is eligible to earn audit credits, he/she is already registered for that course and it is not a core requirement of the student's programme. The request for auditing a course should be made on or before the last date for audit requests as defined in the semester schedule.

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b. A JEE entry student is eligible to audit a course provided he /she has earned 100 credits.

c. M.Tech./M.S./ Ph.D. students are eligible for auditing a course at any time before completion of the programme.

d. A student earn either a NP (audit pass) or a NF (audit fail) grade for an audit course. The audit pass (NP) grade may be awarded if the student satisfies the attendance criteria specified for the course and he/she has obtained at least a 'D' grade. The course coordinator can specify a higher criterion for audit pass at the beginning of the semester. If either of these requirements is not fulfilled, the audit fail (NF) grade is awarded.

e. Grades obtained in an audit course are not considered in the calculation of SGPA or CGPA.

f. All JEE entry students (B.Tech., Dual-Degree, Integrated M.Tech.) can earn a maximum of 8 credits from elective course as audit, in any category out of total credits required for graduation.

g. M.Tech., M.Sc., M.S and Ph.D students can audit a course over and above their core requirements, as specified by the supervisor and SRC.

h. A student (UG/PG) is permitted to audit courses over and above their graduation requirement.

i. Non-credit core courses or core courses not considered for calculation of SGPA or CGPA for PG programmes like Ph.D., MBA, M.Tech., M.S. should not be referred to as audit courses.

j. These courses should be treated like similar core requirements for UG programmes such as Introduction to Programme/ Introduction to Humanities & Social Sciences. These courses should be numbered with N as the third letter, indicating the fact that these courses will not be considered for CGPA or SGPA calculation but are core requirements for the programmes. For example, HUL810, which is a core requirement for all Ph.D. students, should be numbered HUN810/. A student can earn either a S or Z grade in such courses. The grade S indicates successful completion. A student has to earn a S grade in such a course to meet the core requirements of a programme.

5.6 Award of D.I.I.T. to M.Tech. students

In case a student after completing the maximum period available for the M.Tech. programme is not able to get the required minimum CGPA of 6.0 with at least 60 valid credits, then he/she can apply for a D.I.I.T. irrespective of whether the department/centre runs a Diploma programme or not. For the award of D.I.I.T., the student must have earned a minimum of 45 valid credits with a minimum CGPA of 5.5. The request for the award of DIIT must be made within 5 years of the date of joining the programme.

5.7 Part-time students regulations

Normally, part-time M.Tech. and M.S.(Research) students are expected to complete the degree requirements in six semesters. In case of special circumstances, including extension of project work, the student can be allowed to continue beyond six semesters but in any case he/she cannot extend registration beyond ten semesters excluding summer semesters.

In case of full-time students converting to part-time registration, the limit of six semesters will continue to apply.

5.8 Leave rules for D.I.I.T., M.Des., M.Tech. and M.S. (Research)

A full-time D.I.I.T., M.Des., M.Tech. or M.S.(Research) student during his/her stay at the Institute will be entitled to leave for 30 days (including leave on medical grounds), per academic year. Even during mid-semester breaks, and summer and winter vacations, he/she will have to explicitly apply for leave. He/she, however, may be permitted to avail of leave only up to 15 days during winter vacation at the end of the first semester.

The leave will be subject to approval of the Head of Department/Centre/Programme Coordinator concerned and a proper leave account of each student shall be maintained by the Department/Centre/Programme Coordinator concerned.

5.9 Assistantship requirements

A D.I.I.T., M.Des., M.Tech. or M.S.(Research) student irrespective of the source of assistantship, must attend at least 75 % of classes in each course in which he/she is registered. In case his/her attendance falls below 75 % in any course during a month, he/she will not be paid assistantship for that month. Further, if his/her attendance again falls short of 75 % in any course in any subsequent month in that semester, his/her studentship and assistantship will be terminated. For the above purpose, if 75 % works out to be a number which is not a whole number, the immediate lower whole number will be treated as the required 75 % attendance.

All students who are offered assistantship are required to register for a special course with Satisfactory/Unsatisfactory grade. The students are expected to put in 8 hours per week towards the work assigned by the Institute. Continuation of assistantship in a subsequent semester would be conditional to obtaining a satisfactory grade in this course and a SGPA of 7.0 or more (relaxed to 6.75 for SC/ST and PH students registered in M.Des., M.Tech. and M.S. (Research) programmes) in other courses registered in the same semester.

5.10 Summer registration

Summer semester registration for PG students is admissible. M.Tech./ M.S.(R)/ M. Des. students will be allowed to register for maximum of one course (upto 4 credits) and M.B.A./M.Sc. students upto 2 courses in the summer if and only if that is the only requirement for completion of the degree and is recommended by DRC/CRC. For projects, in case X or I grade is awarded in the second semester, the student would be expected to register during summer for completion of the project. Normally regular courses would not be offered during summer semester. Courses can be offered by departments/centres for taking care of special situations subject to the availability of faculty.

5.11 Master of Science (Research) regulations

The M.S. (Research) programme comprises of 20 credits of course work (minor project is not allowed) and 40 credits of research work. The larger project component gives the student an opportunity to conduct in-depth investigation on a topic of his/her interest. The project will be monitored by the Student Research Committee (SRC) and the student will have to register for thesis (project course no. xxD895, 'xx' is department/school code) for 40 credits. An 'X' grade is awarded at the end of each semester until the project work gets completed and the thesis is written. Nominally the M.S.(R) programme is expected to take 4 semesters (excluding summer). Upon completion of project work, a thesis is written that is evaluated by one internal and one external examiner. Upon satisfactory recommendations from the examiners, the thesis defence can be conducted before a committee. Conversion to Ph.D. is also possible. For further details, see "*Rules and Regulations for Master of Science (Research) Programme*".

5.12 Doctor of Philosophy (Ph.D.) regulations

The award of Ph.D. degree is in recognition of high achievements, independent research and application of scientific knowledge to the solution of technical and scientific problems. Creative and productive enquiry is the basic concept underlying the research work. In order to overcome any deficiency in the breadth of fundamental training or proper foundation for advanced work, special preliminary or pre-doctoral courses are given by each department/centre. These courses are given either by faculty members or by guest-speakers and specialists in the profession.

5.12.1 Course requirements

Candidates admitted to non-engineering departments and having a B.Tech./M.Sc./M.A. or equivalent degree are required to complete a minimum of 12 credits. Relaxation up to 6 credits in the course work can be considered for those with M.Phil. degree. The requirement of pre-Ph.D. Course Credits/work for Ph.D. student having B.Tech. and M.Sc. Degree (entering Engineering Departments only) will be 20 credits.

Further, in case the Ph.D. student having completed 20 credits is unable to complete the research at the Ph.D. level for any reason whatsoever, he/she be allowed to complete M.S. (Research) degree requirement.

M.Tech. or equivalent degree holders are required to complete a minimum of 6 credits. The departments/centres may require a larger number of credits in general or in specific cases. The course requirement will be determined by the Department/Centre's Research Committee (DRC/CRC) on the recommendations of the supervisor after due consideration of the background of the student in relation to the proposed topic of research. These courses can be prescribed from existing M.Tech. courses, special pre-Ph.D. courses including laboratory, seminar, foreign language, etc. Normally, no independent study course will be allowed for Ph.D. students.

Full-time M.Tech. and M.S.(R) students of IIT Delhi interested in joining the Ph.D. programme within two years of completion of their M.Tech./M.S.(R) will be granted waiver of residency period. The course work requirements be made up by either additional credits (6 credits as per present norms) taken during their M.Tech./M.S.(R) period (over and above their minimum Degree requirements) or in the summer semester (first or second) by identifying courses. In all cases, such credit transfer be recommended by the concerned DRC/CRC as relevant to their Ph.D. programme.

The minimum CGPA requirement for the course work is 7.50. If the CGPA at the end of any semester is above 7.00 but less than 7.50, he/she will be asked to take more courses in order to make up the required CGPA. If the SGPA at the end of the first semester and CGPA at the end of any subsequent semester is below 7.00, he/she will have to

Table 9 : Continuation of Registration and Graduation Requirements for Postgraduate Programmes

Degree	Registration limits (per semester)	Criteria for continuation of registration	Graduation requirements		
			Valid credits ($)	Minimum DGPA	Max. period of stay
D.I.I.T.£ (Naval Construction)	Minimum 12 credits Maximum 20 credits	CGPA $\geq$ 5.0 at the end of each semester.	49	6.0	6 sem. #
M.Sc., Chemistry	Minimum 20 credits Maximum 28 credits	(i) At the end of the 1st registered semester, a student with SGPA of 4.0 or more will be permitted to continue. If the SGPA is less than 4.0 then registration will be terminated. (ii) After the first registered semester, the minimum acceptable performance level in any registered semester is SGPA of 5.0 or more. (iii) If at the end of any registered semester, the SGPA is less than 5.0 then the student will be issued a warning letter and placed on probation; a copy of the warning letter will be sent to the parents. The Chairperson DRC/CRC shall assess the feasibility of completing degree requirements and identify remedial measures for problems leading to poor performance. (iv) The registration of any student will be limited to 1.25 times the average earned credits of the previous two registered semesters, subject to a minimum of 15 credits and a maximum of 26 credits. (v) If a student is on probation and his/her academic performance is below the minimum acceptable level in the following registered semester then his/her registration will be terminated.	90	5.0	6 sem.
M.Sc., Mathematics					
M.Sc., Physics					
M.Tech., full time	Minimum 12 credits Maximum 22 credits with the condition that no. of lecture courses to be not more than 6.	(i) At the end of the 1st registered semester, a student with SGPA of 5.0 or more will be permitted to continue. If the SGPA is less than 5.0 then registration will be terminated. (ii) After the first registered semester, the minimum acceptable performance level in any registered semester is SGPA of 6.0 or more. (iii) If at the end of any registered semester the SGPA is less than 6.0, then the student will be issued a warning letter and placed on probation; a copy of the warning letter will be sent to Chairperson DRC/CRC. The Chairperson DRC/CRC shall assess the feasibility of completing degree requirements and identify remedial measures for problems leading to poor performance. (iv) The registration of any student shall be limited to 1.25 times the average earned credits of the previous two registered semesters, subject to a minimum of 12 credits and a maximum of 22 credits for full time students. (v) If a student is on probation and his/her academic performance is below the minimum acceptable level in the following registered semester then his/her registration will be terminated.	60 (For some M.Tech. programmes the requirement may be more than 60).	6.0	6 sem.
M.Tech., part time	Minimum one course and/or Minor/ Major Project. Maximum 12 credits with the condition that no. of lecture courses to be not more than 3.				10 sem. @
M. Des.	Minimum 18 credits Maximum 30 credits		91.5	6.0	6 sem.
M.B.A., full time	Same as M.Tech. full time		72 + 6 compulsory audit courses.	6.0	6 sem.
M.B.A., part time	Same as M.Tech. part time				10 sem.

M.S. (Res.) full time	See note +	(i) At the end of the 1st registered semester, a student with SGPA of 6.0 or more will be permitted to continue. If the SGPA is less than 6.0 then registration will be terminated. (ii) After the first registered semester, the minimum acceptable performance level in any registered semester is SGPA of 7.0 or more. (iii) If at the end of any registered semester, the SGPA is less than 7.0, then the student should be issued a warning letter and placed on probation; a copy of the warning letter should be sent to the Chairperson DRC/CRC. The Chairperson DRC/CRC shall assess the feasibility of completing degree requirements and identify remedial measures for problems leading to poor performance. (iv) If a student is on probation and his/her academic performance is below the minimum acceptable level in the following registered semester then his/her registration will be terminated. (v) During the research work period, each unsatisfactory performance grade would entail a warning and two consecutive warnings would result in termination of registration.	7.0	60 including Thesis.	6 sem.
M.S. (Res.) part time	See note ++				10 sem.+++
Ph.D.	For details please refer to Ph.D. Ordinances and Regulations	$CGPA \geq 7.5$. If, at the end of 1st semester, the SGPA is 7.0 or more but less than 7.5, he/she will be required to take more courses to attain a CGPA of 7.5.	7.5 in the course work + Thesis	12 for B.Tech./M.Sc., 6 for M.Tech. or equivalent; A Deptt./Centre may prescribe additional credits.	14 sem.

NOTE:

$ Detailed break-up of core, elective and open category courses are given in the *Courses of Study* bulletin.

£ If a student at the end of the M.Tech. programme fails to complete 60 valid credits to complete a regular Diploma programme does not have a regular Diploma programme provided: (i) he/she has a minimum of 45 valid credits; and (ii) he/she has secured a minimum CGPA of 5.50. The request for the award of D.I.I.T. must be made within 5 years of the date of joining the programme. *(with a CGPA of 6.00 or above, he/she still can get a DIIT even though the Department/Interdisciplinary Programme)*

+ In the first semester the student has to register for a minimum of 15 and a maximum of 20 credits of course work only. In the subsequent 3-semesters the student shall complete the research work and the course work remaining, if any.

++ In the first two semesters the part-time student shall register only for the course work with the minimum and maximum limits of 6-12 credits. The research work and the remaining course work, if any, shall be completed in the remaining 4 semesters. However, the course work must be completed within the first 4-semesters of registration.

+++ The 10 Semester rule for part-time M.S.(Research) students will be applicable only to those who have joined initially as part-time students. For students converting from full-time to part-time the maximum stay limit of 6 semesters will be applicable, subject to recommendations of DRC/CRC and approval by Dean, PGS&R.

@ The 10 Semester rule for part-time M.Tech. students will be applicable only to those who have joined initially as part-time students. For students converting from part-time, the maximum stay limit of 6 semester will be applicable.

The summer semester will not be considered as a registered semester.

Table 10 : Ph.D. Time limits.

		Candidate's qualification	
		M.Tech. or equivalent	B.Tech./M.Sc. or equivalent
1	**Time limits for registration**		
1.1	Minimum period of registration	2 years	3 years (can be reduced to 2 years with the approval of Senate)
1.2	Normal maximum period of registration	5 years	5 years
1.3	Extended maximum period of registration	7 years	7 years
2	**Conversion from Full-time to Part-time registration**		
2.1	Employment outside the Institute – minimum period	3 years, with Dean (PGS&R) approval	3 years, with Dean (PGS&R) approval
2.2	Employment in a sponsored project in IIT Delhi	One year or Completion of course work and comprehensive, whichever is later	Two years or Completion of course work and comprehensive, whichever is later

discontinue the doctoral programme. In some departments, the required performance level may be higher than that stated above. The admitted students must acquire a copy of departmental norms. The course work must be completed within the first two semesters of joining the programme.

A student shall be formally registered/admitted to the candidacy of Ph. D. degree only after he/she has cleared the comprehensive examination. Students would be permitted to take the comprehensive examination only after they have submitted a research plan and have completed the course work (including compulsory audit course - *HUL 810 Communication Skills*). Full-time and part-time students must clear the comprehensive examination within a period of 18 months and 24 months, respectively, from the date of joining. A maximum of two chances will be given to any student to clear the comprehensive examination. Every student, after having completed the comprehensive examination must formally register for the candidacy on a form obtainable from the PG Section.

5.12.2 Time limit

In addition to the information in Table 9, the time limits shown in Table 10 apply for Ph.D. work.

5.12.3   Leave regulations

(a)   Leave during course work

A full-time Ph.D. student, during his/her stay at the Institute will be entitled to leave for 30 days, including leave on medical grounds, per academic year. Even during mid-semester breaks, and summer and winter vacations, he/she will have to explicitly apply for leave. He/she, however, may be permitted to avail of leave only up to 15 days during winter vacation at the end of the first semester.

Leave beyond 30 days in an academic year may be granted to a research scholar in exceptional cases subject to the following conditions:

(i)   the leave beyond 30 days will be without Assistantship/Scholarship, and

(ii)   such an extension of up to additional 30 days will be granted only once during the programme of the scholar.

In addition, a Ph.D. scholar who has completed his/her course work may be granted leave on medical grounds up to 10 days per academic year.

Women research scholars will be eligible for Maternity Leave with assistantship for a period not exceeding 135 days once during the tenure of their award.

The leave may be subject to the approval of the Head of Department/Centre/Programme Coordinator concerned on the recommendation of the Supervisor; and a proper leave account of each scholar shall be maintained by the Department/Centre/Programme Coordinator concerned.

5.12.4 Attendance requirements for assistantship

A Ph.D. student irrespective of the source of research assistantship while pursuing course work, must attend at least 75 % of classes in each course in which he/she is registered. In case his/her attendance falls below 75 % in any course during a month, he/she will not be paid Assistantship for that month. Further, if his/her attendance again falls short of 75 % in any course in any subsequent month in that semester, his/her studentship and Assistantship will be terminated. A research scholar after having completed the course work must attend to his/her research work on all the working days and mark attendance except when he/she is on duly sanctioned leave. The requirement of 75 % attendance will apply as above, on daily attendance except in the cases where longer leave has been duly sanctioned within the leave entitlement of the student. For the above purpose, if 75 % works out to be a number which is not a whole number, the immediate lower whole number will be treated as the required 75 % attendance.

All scholars who are offered assistantship are required to register for a special course with Satisfactory/Unsatisfactory grade. They are expected to put in 8 hours per week towards the work assigned by the Institute. Continuation of assistantship in a subsequent semester would be conditional to obtaining a satisfactory grade in this course.

5.12.5 Further regulations governing Ph.D. students

The Ph.D. degree of the Institute may be conferred on a candidate who fulfills all the requirements detailed in the *Ordinances* and other rules, approved by the Senate. Some of the important regulations are given below:

1. Applications for Ph.D. registration, i.e., for entry to a course of study and research leading to Ph.D. degree must be made to BPGS on the approved form. The date of registration is normally the date of joining the programme. However, in exceptional cases the date of registration may be preponed by a maximum of 6 months by BPGS if it is convinced that the candidate has spent adequate amount of time on research earlier.

2. The academic programme of all the Ph.D. candidates in a department/centre will be coordinated by the DRC/CRC appointed by BPGS&R.

3. The supervisor shall be a full-time member of the academic staff of the Institute. The supervisor(s) shall be appointed within three months of joining the programme. If necessary, the Board of Postgraduate Studies & Research on the recommendations of the Supervisor through the DRC/CRC, may appoint Joint Supervisor(s) not exceeding two from inside or outside the Institute. Normally, there should not be more than two supervisors for a candidate from within the Institute. Appointment of any Joint Supervisor would not be permitted after a lapse of eighteen months from the date of registration of the candidate, except in case when none of the supervisors is in the Institute for a year or more at a stretch.

4. The DRC/CRC shall meet from time to time and review the progress of each candidate in course work, as well as research, by any means, including oral examination of the candidate, if necessary, and recommend, after due consultation with the supervisor(s), such steps to the candidate as are necessary to improve his performance.

5. The progress of each candidate will be monitored by DRC/CRC. For this purpose the following procedures will be followed:

   (a) Ph.D. research work will be compulsorily given a course number, DTD 899 (Doctoral Thesis) for all candidates across the Institute.

   (b) The DRC/CRC Secretary/Ph.D. Coordinator will be Coordinating collection of progress reports written and signed by the scholars and forwarded by the supervisors every semester.

   (c) The supervisor(s)/SRC/DRC/CRC will evaluate the progress of the student every semester.

   (d) 'X' grade will be awarded if the progress is 'satisfactory' in that semester.

   (e) If the progress is 'unsatisfactory', 'U' grade will be awarded. For the first appearance of 'U' grade, a warning would be issued to the candidate by Dean (PGS&R). If his/her performance does not improve after warning, the fellowship may be withheld.

   (f) If there are two consecutive 'U's, the registration will stand terminated.

(g)   Submission of progress report should continue till submission of thesis.

(h)   Like all other courses, the grades for DTD 899 will be discussed in the Department/Centre as per semester schedule.

The above process will continue till the thesis is submitted.

6.   The candidate may submit his thesis at any time provided that :

(a)   He/she has completed the minimum period of registration including any extension prescribed by the Board of Postgraduate Studies & Research.

(b)   He/she has completed the course work requirement as prescribed by the DRC/CRC with CGPA not below 7.50 and has also cleared the comprehensive examination.

(c)   He/she has submitted at least two months in advance, the title and a synopsis of the thesis. The Synopsis along with the list of examiners suggested by the supervisor needs to be approved by the DRC/CRC and then forwarded to Dean (PGS&R).

7.   The thesis shall normally be written in English in the specific format and shall contain a critical account of the candidate's research. It should be characterized by discovery of facts, of fresh approach towards interpretation of facts and theories or significant contribution to knowledge of design or development, or a combination of them. It should bear evidence of the candidate's capacity for analysis and judgement and also his/her ability to carry out independent investigation, design or development. A thesis should normally be supplemented by published work. No part of the thesis or supplementary published work, shall have been submitted for the award of any other degree/Diploma. Normally, three copies of thesis in soft cover have to be submitted in the format prescribed by the Institute. In case of joint supervision, four copies of the thesis are required to be submitted.

8.   On receipt of the title and synopsis of a thesis, the Dean (PGS&R) will appoint a Board of Examiners for each candidate. The Board will consist of one (or two) internal examiner(s), normally the supervisor(s), and two external examiners, one from within India and one from abroad who shall be expert in the subject of thesis. These external examiners shall be chosen from a list of eight, to be recommended by the supervisor(s) through the DRC/CRC while forwarding the title and synopsis of the thesis. The candidate will be required to submit a fresh synopsis if more than 9 months elapse from the synopsis submission date to the thesis submission date.

9.   Each Examiner will submit a detailed assessment report recommending to the BPGS, one of the following courses of action:

(a)   that the thesis be deemed satisfactory and that the candidate may defend his/her thesis orally before a committee constituted for the purpose and any members of the faculty and research students who wish to be present.

(b)   that the candidate may submit a revised thesis after the expiry of a specific period. In the normal circumstances, he/she may submit the revised thesis within a period of one year from the date of communication in this regard from the Dean (PGS&R). However, in exceptional circumstances, this period may be extended by the BPGS&R by another one year : the total revision time irrespective of the number of revisions allowed will not exceed a period of two years.

(c)   that the thesis be rejected outright.

In the event of disagreement between the external examiners, the BPGS may, as a special case, appoint another external examiner, if the merit of the case so demands. The examiner will report independently to the BPGS.

10. The oral defence of the thesis shall be conducted by a committee consisting of the internal examiner(s) and one external examiner. If none of the external examiners, is available for the conduct of the oral defence, an alternative external examiner shall be appointed by the BPGS for this purpose only.

11. On the completion of all stages of the examination, the Oral Defence Committee shall recommend to the BPGS one of the following courses of action:

(a)   that the degree be awarded.

(b)   that the candidate should be examined on a further occasion in a manner they shall prescribe.

(c)   that the degree shall not be awarded.

In case (a), the Oral Defence Committee shall also provide to the candidate a list of all corrections and modifications, if any, suggested by the examiners.

12. The degree shall be awarded by the Senate, provided that:

(a)   the Oral Defence Committee, through the BPGS so recommends.

(b)   the candidate produces a 'no dues certificate' from all concerned in the prescribed form and gets it forwarded along with the report of the Oral Defence Committee;and

(c)   the candidate has submitted two hard cover copies of the thesis, from amongst the same ones submitted by him earlier, after incorporating all necessary corrections and modifications including appropriate IPR notice. The hard bound copies of the Ph. D. thesis, submitted after the viva-voce examination, must contain the appropriate copyright certificate in the beginning of the thesis, on a separate page on the left side. One of these copies is for the Department/Centre's Library and the other is for the Central Library.

13. The relevant IPR notice to be incorporated in the soft/hard bound thesis, reports etc. shall be chosen from the following:

a)   the thesis/report etc. for which formal copyright application has NOT been filed should carry the copyright notice as:

© Indian Institute of Technology Delhi (IITD), New Delhi , 200 ...[the year of submission of the thesis/report].

b)   and for which formal copyright application has been filed with the copyright office. Should carry the copyright notice as:

© Indian Institute of Technology Delhi (IITD), New Delhi , 200 ...[the year of submission of the thesis/report]. All right reserved. Copyright Registration Pending.

c)   and for which in-addition to a formal copyright application with the Copyright Office, patent/design application has also been filed with the patent office, should carry the "IPR Notice" as:

Intellectual Property Right
(IPRs) notice

Part of this thesis may be protected by one or more of Indian Copyright Registrations (Pending) and/or Indian Patent/ Design (Pending) by Dean, Industrial Research & Development (IRD) Unit Indian Institute of Technology Delhi (IITD) New Delhi-110016, India. IITD restricts the use, in any form, of the information, in part or full, contained in this thesis ONLY on written permission of the Competent Authority: Dean, IRD, IIT Delhi OR MD, FITT, IIT Delhi.

The notices at 'b' and 'c' should ONLY be, repeat ONLY be inserted after the formal application(s) has (have) been filed with the appropriate office(s) as the case may be and the same has been confirmed by FITT office.

14. If a member of the academic staff, who is registered for the degree, leaves the Institute before the minimum period of registration is completed, he/she will be permitted to submit his thesis in due course, provided that:

(a)   a substantial part of the research has been completed at the Institute; and

(b)   any additional work required can be adequately supervised.

15. A member of the academic staff who has commenced his research before joining the Institute may, at the discretion of the BPGS and on the recommendation of the Supervisor through the DRC concerned, be permitted to include in his period of registration, part or all of the time spent on research before joining the Institute, up to a maximum of one year.

16. A member of the non-academic staff of the Institute who satisfies eligibility qualifications may be considered for admission to the degree as a part-time candidate provided his/her application is duly approved by the Director of the Institute.

6. UNDERGRADUATE PROGRAMME STRUCTURES

The following pages give details of the programme definitions that includes courses in each category, for every B.Tech., dual degree and integrated M.Tech. programme.

The left page gives the category-wise credits requirement followed by the list of courses in each category. Students are also required to complete the NCC/NSS/NSO requirements. A student must also earn valid credits (audit not permitted) for a course of Environmental Studies category under OC for graduation.

The table on the right page is a typical plan for scheduling the courses. This plan is only suggestive and will vary from student-to-student. Each student is encouraged to make his/her individual plan in consultation with his/her course advisor.

Programme Code: CH1 / (CH)
Bachelor of Technology in Chemical Engineering
Department of Chemical Engineering

The overall credits structure

Undergraduate Core (UC)		Undergraduate Elective (UE)	
Category	Credits	Category	Credits
DC	64	DE	26
BS	20	HM	14
EAS	20	OC	34
HU	2		
TOTAL	106	TOTAL	74

Total credits = 180

Basic Sciences (BS) Core

CYL110	Physical Chemistry: Concepts and Applications	3-1-0	**4**
CYL120	Inorganic and Organic Chemistry: Concepts and Applications	3-1-0	**4**
CYP100	Chemistry Laboratory	0-0-4	**2**
MAL110	Mathematics - I	3-1-0	**4**
MAL120	Mathematics - II	3-1-0	**4**
PHP100	Physics Laboratory	0-0-4	**2**
	TOTAL BS Core	**12-4-8**	**20**

* In addition to the above BS core courses, either PHL110 or PHL120 has to be taken as an open category course for graduation.

Engineering Arts and Sciences (EAS) Core

AML120	Materials Science	3-0-2	**4**
CSL101	Introduction to Computers and Programming OR	3-0-2	**4**
CSL102	Introduction to Computer Science	3-0-2	**4**
EEL102	Principles of Electrical Engineering	3-0-2	**4**
MEL110	Graphic Science	2-0-4	**4**
MEL120	Manufacturing Practices	2-0-4	**4**
	TOTAL EAS Core	**13-0-14**	**20**

Humanities and Social Sciences (HC) Core

HUN100	Introduction to Humanities and Social Sciences	0-0-4	**2**

Departmental Core (DC)

CHC410	Colloquium (CH)	0-3-0	**3**
CHD411	Major Project Part 1 (CH)	0-0-8	**4**
CHL110	Transport Phenomena	3-1-0	**4**
CHL111	Material and Energy Balance	2-2-0	**4**
CHL112	Chemical Process Technology	3-1-0	**4**
CHL121	Chemical Engineering Thermodynamics	3-1-0	**4**
CHL122	Chemical Reaction Engineering – I	3-1-0	**4**
CHL221	Chemical Reaction Engineering – II	3-1-0	**4**
CHL231	Fluid Mechanics for Chemical Engineers	3-1-0	**4**
CHL251	Heat and Mass Transfer	3-1-0	**4**
CHL261	Instrumentation and Process Control	3-1-0	**4**
CHL331	Fluid-particle Mechanics	3-1-0	**4**
CHL351	Mass Transfer Operations	3-1-0	**4**
CHL471	Process Equipment Design and Economics	3-0-3	**4.5**
CHN110	Introduction to Chemical Engineering	0-0-4	**2**
CHP301	Fluid Mechanics and Heat Transfer Laboratory	0-0-3	**1.5**
CHP302	Mass Transfer and Fluid Particle Mechanics Laboratory	0-0-3	**1.5**
CHP303	Chemical Reaction Engineering and Process Control Laboratory	0-0-3	**1.5**
CHP311	Design and Laboratory Practices	0-0-4	**2**
CHT410	Practical Training (CH)	—	**NC**
	TOTAL DC	**35-15-28**	**64**

Departmental Electives (DE)

CHD310	Mini Project (CH)	0-0-6	**3**
CHL133	Powder Processing and Technology	3-1-0	**4**
CHL260	Applications of Programming in Chemical Engineering	3-0-2	**4**
CHL275	Safety and Hazards in the Process Industries	3-1-0	**4**
CHL277	Materials of Construction	3-0-0	**3**
CHL291	Introduction to Biochemical Engineering	3-1-0	**4**
CHL296	Nano Engineering of Soft Materials	3-0-0	**3**
CHL332	Fluidization Engineering	3-1-0	**4**
CHL353	Modern Separation Processes	3-1-0	**4**
CHL390	Process Utilities and Pipeline Design	3-0-2	**4**
CHL392	Polymer Science and Engineering	3-1-0	**4**
CHL705	Electrokinetic Transport Phenomena	3-0-2	**4**
CHL707	Adsorption Separation Processes	3-0-0	**3**
CHL710	Process Dynamics and Control	3-1-2	**5**
CHL722	Fundamentals of Fuel Cell Technology	3-0-2	**4**
CHL724	Environmental Engineering and Waste Management	3-1-0	**4**
CHL727	Heterogeneous Catalysis and Catalytic Reactors	3-0-2	**4**
CHL743	Petrochemical Technology	3-0-0	**3**
CHL751	Multi-component Mass Transfer	3-0-0	**3**
CHL766	Interfacial Engineering	3-0-0	**3**
CHL768	Fundamentals of Computational Fluid Dynamics	2-0-2	**3**
CHL771	Process Operation Scheduling	3-0-2	**4**
CHL773	Planning of Experiments and Analysis of Engineering Data	3-0-2	**4**
CHL774	Process Optimization	3-0-2	**4**
CHL793	Membrane Science and Engineering	3-0-0	**3**
CHL794	Petroleum Refinery Engineering	3-0-2	**4**
CHR310	Professional Practices (CH)	0-1-2	**2**
CHS310	Independent Study (CH)	0-3-0	**3**
CHD412	Major Project Part 2 (CH)	0-0-16	**8**

B.Tech. in Chemical Engineering

(CH) CH1

Sem.								Lect Courses	L	T	P	Weekly contact	Credits
I	CHN110 Intr to Chem Engg (0-0-4) 2	CSL101/102 Int Comp Prg/Sc (3-0-2) 4	MEL110 Graphic Science (2-0-4) 4	MAL110 Mathematics-I (3-1-0) 4	CYL120 Inorg & Org Chem (3-1-0) 4	CYP100 Chemistry Lab (0-0-4) 2	HUN100 * Intro Hu & So Sc (0-0-4) 2	4	11	2	18	31	22
II	CHL110 Transp Phen (3-1-0) 4	EEL102 Prin Elec Engg (3-0-2) 4	MEL120 Mfg Practices (2-0-4) 4	MAL120 Mathematics-II (3-1-0) 4	CYL110 Physical Chem. (3-1-0) 4	PHP100 Physics Lab (0-0-4) 2		5	14	3	10	27	22
III	CHL111 Matl Energy Bal. (2-2-0) 4	CHL121 Ch Engg Thermo (3-1-0) 4	CHL231 Fl Mech Ch Engr (3-1-0) 4	CHL251 Heat Mass Transf (3-1-0) 4	AML120 Materials Science (3-0-2) 4		HUL2xx Hu. & So. Sc. #1 (3-1-0) 4	6	17	6	2	25	24
IV	CHL112 Chem Proc Techn (3-1-0) 4	CHL122 Ch React Engg-I (3-1-0) 4	CHP311 Des Lab Practices (0-0-4) 2	CHL351 Mass Transf Oprns (3-1-0) 4	CHP301 F M & H T Lab (0-0-3) 1.5	OC-1 (3-1-0) 4	HUL2xx Hu. & So. Sc. #2 (3-1-0) 4	5	15	5	7	27	23.5
V	CHL221 Ch React Engg-II (3-1-0) 4	CHL261 Instr Proc Control (3-1-0) 4	CHL331 Fluid-particle Mech (3-1-0) 4	CHP302 M T & F P M Lab (0-0-3) 1.5	OC-2 (3-1-0) 4	OC-3 (3-1-0) 4	HUL2xx Hu. & So. Sc. #3 (2-1-0) 3	6	17	6	3	26	24.5
VI	CHL471 Proc Eq Des Eco (3-0-3) 4.5	CHP303 Ch RE & PC Lab (0-0-3) 1.5	DE-1 (3-1-0) 4	DE-2 (3-1-0) 4	OC-4 (3-1-0) 4	OC-5 (3-1-0) 4		5	15	4	6	25	22
summer			CHT410 Practical Training (CH)					NC					
VII	CHC410 Colloquium (CH) (0-3-0) 3	CHD411 Maj Proj P-1 (CH) (0-0-8) 4	DE-3 (3-1-0) 4	DE-4 (3-1-0) 4	OC-6 (3-0-0) 3	OC-7 (3-0-0) 3	HUL2xx Hu. & So. Sc. #4 (2-1-0) 3	5	14	6	8	28	24
VIII			DE-5 (3-1-0) 4	DE-6 (3-0-0) 3	DE-7 (3-0-0) 3	OC-8 (3-1-0) 4	OC-9 (3-1-0) 4	5	15	3	0	18	18

TOTAL = 180.0

DC = 64, EAS = 20, BS = 20, HC = 2 (* either in 1st or 2nd sem.)

Reqd. DE=26, plan DE = 7 courses, or 5 courses, or 5 courses & Major Project Part 2.

HU = 2@4 + 2@3 = 14 cr. from 4 courses.

Reqd. OC=34, plan OC = 7@4 + 2@3 = 34 cr. from 9 courses.

Programme Code: CE1 / (CE)
Bachelor of Technology in *Civil Engineering*
Department of Civil Engineering

The overall credits structure

Undergraduate Core (UC)		Undergraduate Elective (UE)	
Category	Credits	Category	Credits
DC	63	DE	27
BS	20	HM	14
EAS	21	OC	33
HU	2		
TOTAL	*106*	*TOTAL*	*74*

Total credits = 180

Basic Sciences (BS) Core

CYL110	Physical Chemistry: Concepts and Applications	3-1-0	**4**
CYP100	Chemistry Laboratory	0-0-8	**4**
MAL110	Mathematics - I	3-1-0	**4**
MAL120	Mathematics - II	3-1-0	**4**
PHL110	Fields and Waves	3-1-0	**4**
PHP100	Physics Laboratory	0-0-4	**2**
	TOTAL BS Core	**12-4-8**	**20**

Engineering Arts and Sciences (EAS) Core

AML110	Engineering Mechanics	3-0-2	**4**
AML120	Materials Science	3-0-2	**4**
AML150	Mechanics of Solids and Fluids	3-1-2	**5**
CSL101	Introduction to Computers and Programming OR	3-0-2	**4**
CSL102	Introduction to Computer Science	3-0-2	**4**
MEL110	Graphic Science	2-0-4	**4**
	TOTAL EAS Core	**14-1-12**	**21**

Humanities and Social Sciences (HC) Core

HUN100	Introduction to Humanities and Social Sciences	0-0-4	**2**

Departmental Core (DC)

CEC410	Colloquium (CE)	0-3-0	**3**
CED411	Major Project Part 1 (CE)	0-0-8	**4**
CEL212	Environmental Engineering	3-0-2	**4**
CEL222	Engineering Geology and Soil Mechanics	3-1-3	**5.5**
CEL231	Structural Analysis – I	3-1-2	**5**
CEL232	Concrete Material and Design	3-1-4	**6**
CEL241	Transportation Engineering – I	3-0-2	**4**
CEL251	Hydrology and Hydraulics	3-1-4	**6**
CEL271	Elements of Surveying	2-0-2	**3**
CEL321	Geotechnical Engineering	3-1-3	**5.5**
CEL331	Structural Analysis – II	3-1-2	**5**
CEL332	Design of Steel Structures	3-1-2	**5**
CEL351	Design of Hydraulic Structures	2-0-2	**3**
CEN110	Introduction to Civil Engineering	0-0-4	**2**
CEP200	Design Concepts in Civil Engineering	0-0-4	**2**
CET410	Practical Training (CE)	—	**NC**
	TOTAL DC	**31-10-42**	**62**

Departmental Electives (DE)

CED310	Mini Project (CE)	0-0-6	**3**
CEL311	Advanced Water and Wastewater Engineering	3-0-2	**4**
CEL341	Transportation Engineering – II	3-1-0	**4**
CEL362	Construction Management	3-1-0	**4**
CEL411	Industrial Waste Management	3-0-0	**3**
CEL412	Environmental Assessment Methodologies	3-0-0	**3**
CEL421	Ground Improvement	3-0-2	**4**
CEL422	Rock Engineering	3-0-0	**3**
CEL423	Designs of Foundation, Earth and Earth Retaining Structures	3-1-0	**4**
CEL431	Advanced Structural Analysis	2-0-2	**3**
CEL432	Design of Prestressed Concrete and Industrial Structures	3-0-2	**4**
CEL433	Advanced Structural Design	3-0-2	**4**
CEL442	Traffic and Transportation Planning	2-1-0	**3**
CEL443	Transportation Safety and Environment	3-0-0	**3**
CEL451	Water Power Engineering	3-0-2	**4**
CEL453	Water Resources Management	3-1-0	**4**
CEL455	Introduction to Geographic Information Systems	2-0-2	**3**
CEL459	River Mechanics	2-0-2	**3**
CEL464	Construction Contract and Economics	2-1-0	**3**
CEL466	Construction Equipment and Methods	2-1-0	**3**
CEP452	Computational Aspects in Water Resources	1-0-4	**3**
CED412	Major Project Part 2 (CE)	0-0-16	**8**

B.Tech. in Civil Engineering (CE) CE1

Sem.								Lect Courses	L	T	P	Weekly contact	Credits
I	CEN110 Intro to Civil Engg (0-0-4) 2	AML110 Engg Mechanics (3-0-2) 4	AML120 Materials Science (3-0-2) 4	MAL110 Mathematics - I (3-1-0) 4	PHL110 Fields & Waves (3-1-0) 4	PHP100 Physics Lab (0-0-4) 2	HUN100 * Intro Hu & So Sc (0-0-4) 2	4	12	2	16	30	22
II	AML150 Mech Fluid Solid (3-1-2) 5	CSL101/102 Int Comp Prg/Sc (3-0-2) 4	MEL110 Graphic Science (2-0-4) 4	MAL120 Mathematics - II (3-1-0) 4	CYL110 Physical Chem. (3-1-0) 4	CYP100 Chemistry Lab (0-0-4) 2		5	14	3	12	29	23
III	CEL231 Struc. Analysis - I (3-1-2) 5	CEL241 Transp. Engg. - I (3-0-2) 4	CEL251 Hydrol. Hydraul. (3-1-4) 6	CEL271 Ele. Surveying (2-0-2) 3	OC-1 (3-0-0) 3			6	17	3	10	30	25
IV	CEL212 Environ. Engg. (3-0-2) 4	CEL222 Eng Geo So Mech (3-1-3) 5.5	CEL232 Conc Matl & Des. (3-1-4) 6	CEL351 Des Hydraulic Str. (2-0-2) 3	CEP200 Des Concept CE (0-0-4) 2	HUL2xx Hu. & So. Sc. #2 (2-1-0) 3		5	13	3	15	31	23.5
V	CEL321 Geotech. Engg. (3-1-3) 5.5	CEL331 Struc. Analysis - II (3-1-2) 5	OC-2 (3-1-0) 4	OC-3 (3-1-0) 4	HUL2xx Hu. & So. Sc. #3 (3-1-0) 4			5	15	5	5	25	22.5
VI	CEL332 Design Steel Str. (3-1-2) 5	DE-1 (3-1-0) 4	OC-4 (3-1-0) 4	OC-5 (3-0-0) 3	OC-6 (3-0-2) 4	HUL2xx Hu. & So. Sc. #4 (2-1-0) 3		6	17	4	4	25	23
summer		CET410 Practical Training (CE)						NC					
VII	CEC410 Colloquium (CE) (0-3-0) 3	CED411 Maj Proj Pt 1 (CE) (0-0-6) 3	DE-2 (3-0-0) 3	DE-3 (3-1-0) 4	DE-4 (3-0-0) 3	OC-7 (3-1-0) 4	OC-8 (3-0-0) 3	5	15	5	6	26	23
VIII			DE-5 (3-0-0) 3	DE-6 (3-1-0) 4	DE-7 (3-0-0) 3	DE-8 (3-0-2) 4	OC-9 (3-0-2) 4	5	15	1	4	20	18
												TOTAL =	180.0

DC = 62, EAS = 21, BS = 20, HC = 2   (* either in 1st or 2nd sem.)

Reqd. DE=28, plan DE = 8 courses, or 6 courses+Major Project Part 2.

HU = 2@4 + 2@3 = 14 cr. from 4 courses.

Reqd. OC=33, plan OC = 6@4 + 3@3 = 33 cr. from 9 courses.

Programme Code: CS1 / (CS)
Bachelor of Technology in Computer Science and Engineering
Department of Computer Science and Engineering

The overall credits structure

Undergraduate Core (UC)		Undergraduate Elective (UE)	
Category	Credits	Category	Credits
DC	58	DE	32
BS	24	HM	14
EAS	20	OC	30
HU	2		
TOTAL	104	TOTAL	76

Total credits = 180

Basic Sciences (BS) Core

CYL110	Physical Chemistry: Concepts and Applications	3-1-0	**4**
CYP100	Chemistry Laboratory	0-0-4	**2**
MAL111	Introduction to Analysis and Differential Equations	3-1-0	**4**
MAL124	Introduction to Algebra and Matrix Analysis	3-1-0	**4**
PHL110	Fields and Waves	3-1-0	**4**
PHL120	Physics of Materials	3-1-0	**4**
PHP100	Physics Laboratory	0-0-4	**2**
	TOTAL BS Core	**15-5-8**	**24**

Engineering Arts and Sciences (EAS) Core

AML110	Engineering Mechanics	3-0-2	**4**
CSL101	Introduction to Computers and Programming	3-0-2	**4**
	OR		
CSL102	Introduction to Computer Science	3-0-2	**4**
EEL101	Fundamentals of Electrical Engineering	3-0-2	**4**
MEL110	Graphic Science	2-0-4	**4**
MEL120	Manufacturing Practices	2-0-4	**4**
	TOTAL EAS Core	**13-0-14**	**20**

Humanities and Social Sciences (HU) Core

HUN100	Introduction to Humanities and Social Sciences	0-0-4	**2**

Departmental Core (DC)

CSC410	Colloquium (CS)	0-3-0	**3**
CSD411	Major Project Part 1 (CS)	0-0-8	**4**
CSL105	Discrete Mathematical Structures	3-1-0	**4**
CSL201	Data Structures	3-0-4	**5**
CSL211	Computer Architecture	3-1-2	**5**
CSL302	Programming Languages	3-0-4	**5**
CSL356	Analysis and Design of Algorithms	3-1-0	**4**
CSL373	Operating Systems	3-0-4	**5**
CSL374	Computer Networks	3-0-3	**4.5**
CSN110	Introduction to Computer Science and Engineering	0-0-4	**2**
CSP301	Design Practices in Computer Science	0-1-4	**3**
CST410	Practical Training (CS)	—	**NC**
EEL201	Digital Electronic Circuits	3-1-0	**4**
EEL205	Signals and Systems	3-1-0	**4**
EEP201	Electronics Laboratory - I	0-0-3	**1.5**
MAL250	Introduction to Probability Theory and Stochastic Processes	3-1-0	**4**
	TOTAL DC	**30-10-36**	**58**

Departmental Electives (DE)

CSD310	Mini Project (CS)	0-0-6	**3**
CSL303	Logic for Computer Science	3-0-2	**4**
CSL316	Digital Hardware Design	3-0-4	**5**
CSL332	Introduction to Database Systems	3-0-3	**4.5**
CSL333	Artificial Intelligence	3-0-2	**4**
CSL361	Numerical and Scientific Computing	3-1-2	**5**
CSL705	Theory of Computation	3-1-0	**4**
CSL719	Synthesis of Digital Systems	3-0-2	**4**
CSL724	Advanced Computer Networks	3-0-2	**4**
CSL728	Compiler Design	3-0-3	**4.5**
CSL730	Modern Parallel Programming	3-0-2	**4**
CSL740	Software Engineering	3-0-2	**4**
CSL750	Foundations of Automatic Verification	3-0-2	**4**
CSL759	Cryptography and Computer Security	3-0-0	**3**
CSL771	Database Implementations	3-0-2	**4**
CSL781	Computer Graphics	3-0-3	**4.5**
CSL783	Digital Image Analysis	3-0-3	**4.5**
CSP315	Embedded System Design Laboratory	0-1-6	**4**
CSR310	Professional Practices (CS)	0-1-2	**2**
CSS310	Independent Study (CS)	0-3-0	**3**
CSD412	Major Project Part 2 (CS)	0-0-16	**8**
SIL765	Network and System Security	3-0-2	**4**
SIL769	Internet Traffic Measurement, Modelling and Analysis	3-0-2	**4**

B.Tech. in Computer Science and Engineering
(CS) CS1

Sem.								Lect Courses	L	T	P	Weekly contact	Credits
I	CSN110 Intr Comp Sc Engg (0-0-4) 2	CSL101/102 Int Comp Prg/Sc (3-0-2) 4	MEL110 Graphic Science (2-0-4) 4	MAL111 Analysis Diff Eqns (3-1-0) 4	PHL110 Fields & Waves (3-1-0) 4	PHP100 Physics Lab (0-0-4) 2	HUN100 * Intro Hu & So Sc (0-0-4) 2	4	11	2	18	31	22
II	CSL201 Data Structures (3-0-4) 5	EEL101 Fund Elec Engg (3-0-2) 4	MEL120 Mfg Practices (2-0-4) 4	MAL124 Alg Matrix Analys (3-1-0) 4	CYL110 Physical Chem. (3-1-0) 4	CYP100 Chemistry Lab (0-0-4) 2		5	14	2	14	30	23
III	CSL105 Discrete Math Stru (3-1-0) 4	CSL211 Computer Arch (3-1-2) 5	CSP301 Des Pract in CS (0-1-4) 3	EEL201 Digital Electronics (3-1-0) 4	EEP201 Electronics Lab-I (0-0-3) 1.5	AML110 Engg Mechanics (3-0-2) 4	HUL2xx Hu. & So. Sc. #1 (3-1-0) 4	5	15	5	11	31	25.5
IV	CSL302 Programing Lang. (3-0-4) 5	MAL250 Prob Stoch Proc. (3-1-0) 4	PHL120 Phy Materials (3-1-0) 4	DE-1 (3-0-4) 5			HUL2xx Hu. & So. Sc. #2 (3-1-0) 4	5	15	3	8	26	22
V	CSL356 Analy Des Algor (3-1-0) 4	EEL205 Signals Systems (3-1-0) 4	DE-2 OR Mini Project (3-0-0) 3		OC-1 (3-0-0) 3	OC-2 (3-0-2) 4	HUL2xx Hu. & So. Sc. #3 (2-1-0) 3	6	17	3	2	22	21
VI	CSL373 Operating Systems (3-0-4) 5		DE-3 (3-0-4) 5	DE-4 OR Indep. Study (3-0-0) 3	OC-3 (3-0-2) 4	OC-4 (3-0-0) 3	HUL2xx Hu. & So. Sc. #4 (2-1-0) 3	6	17	1	10	28	23
summer			CST410 Practical Training (CS)					NC					
VII	CSC410 Colloquium (CS) (0-3-0) 3	CSD411 Maj Proj Pt 1 (CS) (0-0-8) 4	CSL374 Compu Networks (3-0-3) 4.5	DE-5 (3-0-2) 4	OC-5 (3-0-2) 4	OC-6 (3-0-2) 4		4	12	3	17	32	23.5
VIII			DE-6 (3-0-2) 4	DE-7 (3-0-2) 4	DE-8 (3-0-2) 4	OC-7 (3-0-2) 4	OC-8 (3-0-2) 4	5	15	0	10	25	20

TOTAL = 180.0

DC = 62, EAS = 20, BS = 20, HC = 2 (* either in 1st or 2nd sem.)

Reqd. DE=32, plan DE = 8 courses, or 6 courses+Major Project Part 2.

HU = 2@4 + 2@3 = 14 cr. from 4 courses.

Reqd. OC=30, plan OC = 6@4 + 2@3 = 30 cr. from 8 courses.

Programme Code: EE1 / (EE)
Bachelor of Technology in Electrical Engineering
Department of Electrical Engineering

The overall credits structure

Undergraduate Core (UC)		Undergraduate Elective (UE)	
Category	**Credits**	**Category**	**Credits**
DC	63	DE	27
BS	20	HM	14
EAS	21	OC	33
HU	2		
TOTAL	*106*	*TOTAL*	*74*

Total credits = 180

Basic Sciences (BS) Core

CYP100	Chemistry Laboratory	0-0-4	**2**
MAL111	Introduction to Analysis & Differential Eqns.	3-1-0	**4**
MAL124	Introduction to Algebra and Matrix Analysis	3-1-0	**4**
MAL250	Introduction to Probability Theory and Stochastic Processes	3-1-0	**4**
PHL110	Fields and Waves	3-1-0	**4**
PHP100	Physics Laboratory	0-0-4	**2**
	TOTAL BS Core	**12-4-8**	**20**

* In addition to the above BS core courses, either CYL110 or CYL120 has to be taken as an open category course for graduation.

Engineering Arts and Sciences (EAS) Core

AML110	Engineering Mechanics	3-0-2	**4**
CSL101	Introduction to Computers and Programming OR	3-0-2	**4**
CSL102	Introduction to Computer Science	3-0-2	**4**
CSL201	Data Structures	3-0-4	**5**
EEL101	Fundamentals of Electrical Engineering	3-0-2	**4**
MEL120	Manufacturing Practices	2-0-4	**4**
	TOTAL EAS Core	**14-0-14**	**21**

Humanities and Social Sciences (HC) Core

HUN100	Introduction to Humanities and Social Sciences	0-0-4	**2**

Departmental Core (DC)

EEC410	Colloquium (EE)	0-3-0	**3**
EED411	Major Project Part 1 (EE)	0-0-8	**4**
EEL201	Digital Electronic Circuits	3-1-0	**4**
EEL202	Circuit Theory	3-1-0	**4**
EEL203	Electromechanics	3-1-0	**4**
EEL204	Analog Electronics Circuits	3-1-0	**4**
EEL205	Signals and Systems	3-1-0	**4**
EEL207	Engineering Electromagnetics	3-1-0	**4**
EEL301	Control Engineering - I	3-1-0	**4**
EEL303	Power Engineering - I	3-1-0	**4**
EEL306	Communication Engineering	3-1-0	**4**
EEL308	Computer Architecture	3-1-0	**4**
EEN110	Introduction to Electrical Engineering	0-0-4	**2**
EEP201	Electronics Laboratory - I	0-0-3	**1.5**
EEP203	Electromechanics Laboratory	0-0-3	**1.5**
EEP204	Electronics Laboratory - II	0-0-3	**1.5**
EEP211	Design (EE)	0-0-4	**2**
EEP301	Control Engineering Laboratory	0-0-3	**1.5**
EEP303	Power Engineering Laboratory	0-0-3	**1.5**
EEP306	Communication Engineering Laboratory	0-0-3	**1.5**
EEP307	Electromagnetics Laboratory	0-0-3	**1.5**
EEP308	Computer Technology Laboratory	0-0-3	**1.5**
EET410	Practical Training (EE)	—	**NC**
	TOTAL DC	**30-13-38**	**62**

Departmental Electives (DE)

EED310	Mini Project (EE)	0-0-6	**3**
EEL212	Measurements and Instrumentation	3-0-0	**3**
EEL218	Physical Electronics	3-0-0	**3**
EEL311	Graph Theory and its Appl. to Elect. Engg.	3-0-0	**3**
EEL315	Analog Integrated Circuits	3-0-0	**3**
EEL316	Digital Communications	3-0-2	**4**
EEL319	Digital Signal Processing	3-0-2	**4**
EEL322	Integrated Circuits Technology	3-0-0	**3**
EEL324	Digital Hardware Design	3-0-0	**3**
EEL325	Control Engineering - II	3-0-0	**3**
EEL326	Micromotors and their Applications	3-0-0	**3**
EEL327	Fault Diagnosis of Digital Circuits	3-0-0	**3**
EEL329	VLSI Technology and Design	3-0-2	**4**
EEL330	Selected Topics in Communication Engineering - I	3-0-0	**3**

EEL331	Electromagnetics and Advanced Electromechanics	3-0-0	**3**
EEL338	Antennas and Propagation	3-0-0	**3**
EEL340	Selected Topics in Power and Machines	3-0-0	**3**
EEL342	DSP based Control of Electric Drive	3-0-0	**3**
EEL346	Electrical Machines and Industrial Drives	3-0-0	**3**
EEL358	Operating Systems	3-0-0	**3**
EEL360	Selected Topics in Control Engineering - I	3-0-0	**3**
EEL365	Intelligent Control	3-0-0	**3**
EEL370	Selected Topics in Computers - I	3-0-0	**3**
EEL375	Embedded Systems	3-0-4	**5**
EEL380	Selected Topics in Electronics - I	3-0-0	**3**
EEL390	Selected Topics in Information and Communication Technology – I	3-0-0	**3**
EEL404	Flexible AC Transmission System	3-0-0	**3**
EEL420	Selected Topics in Electronics - II	3-0-0	**3**
EEL422	Computers in Biomedicine	3-0-0	**3**
EEL430	Selected Topics in Communication Engineering - II	3-0-0	**3**
EEL432	Satellite Communication	3-0-0	**3**
EEL433	Communication Engineering - II	3-0-0	**3**
EEL435	Optical Communication	3-0-0	**3**
EEL441	Industrial Electronics	3-0-2	**4**
EEL451	Power Systems Protection	3-0-0	**3**
EEL452	HVDC Transmission	3-0-0	**3**
EEL453	Power System Dynamics and Control	3-0-0	**3**
EEL455	Power System Planning	3-0-0	**3**
EEL456	Power Engineering - II	3-0-2	**4**
EEL460	Selected Topics in Control Engineering - II	3-0-0	**3**
EEL462	Identification and Adaptive Control	3-0-0	**3**
EEL470	Selected Topics in Computers - II	3-0-0	**3**
EEL472	Parallel and Distributed Processing	3-0-0	**3**
EEL473	Computer Communication	3-0-0	**3**
EEL482	Mechatronics	3-0-0	**3**
EEL704	Robotics and Automation	3-0-0	**3**
EEL706	Soft Computing	3-0-0	**3**
EEL710	Coding Theory	3-0-0	**3**
EEL713	Microwave Theory and Circuits	3-0-0	**3**
EEL715	Image Processing	3-0-2	**4**
EEL716	Telecommunication Switching and Transmission	3-0-0	**3**
EEL736	Medical Electronics	3-0-0	**3**
EEL749	Special Electromechanical Systems	3-0-0	**3**
EEL754	Computer Graphics	3-0-2	**4**
EEL758	Intelligent and Knowledge Based Systems	3-0-0	**3**
EEL772	Optimal Control Theory	3-0-0	**3**
EEL781	Neural Networks	3-0-0	**3**
EEL790	Selected Topics in Information and Communication Technology - II	3-0-0	**3**
EEP321	Measurements and Instrumentation Laboratory	0-0-3	**1.5**
EEP443	FEM Analysis of Machines Laboratory	0-0-3	**1.5**
EEP446	Electrical Machines and Industrial Drives Laboratory	0-0-3	**1.5**
EEP467	Computer Control Laboratory	0-0-3	**1.5**
EEP719	Communication Engineering Laboratory - II	0-0-3	**1.5**
EES310	Independent Study (EE)	0-3-0	**3**
EEV401	Special Module in Communication Engineering	1-0-0	**1**
EEV402	Special Module in Power Systems, Machines and Power Electronics	1-0-0	**1**
EEV404	Special Module in Control Engineering	1-0-0	**1**
EEV405	Special Module in Electronics	1-0-0	**1**
EEV704	Special Module in Computers	1-0-0	**1**
MAL341	File Structures and Information Systems Design	3-0-2	**4**
MAL342	Analysis and Design of Algorithms	3-1-0	**4**
MAL373	Wavelets and Applications	3-1-0	**4**
MAL382	Theory of Automata	3-1-0	**4**
MAL710	Database Management Systems	3-0-2	**4**
MAL717	Fuzzy Sets and Applications	3-1-0	**4**
MAL745	Software Engineering	3-0-2	**4**
MAL786	Cryptology	3-1-0	**4**
EED412	Major Project Part 2 (EE)	0-0-16	**8**

Elective Streams (DE-A,-B,-C)   Course Advise

Information & Commnication Technology	EEL358	EEL316	EEL319
Integrated Electronics and Circuits	EEL219	EEL329	EEL319
Control and Automation Engineering	EEL325	EEL704	EEL375
Power, Machines and Power Electronics	EEL331	EEL441	EEL456

The student has to opt for one elective stream and must take all courses of that stream.

B.Tech. in Electrical Engineering (EE) EE1

Sem.										Lect Courses	L	T	P	Weekly contact	Credits
I	EEN110 Intro to Elec Engg (0-0-4) 2	EEL101 Fund Elec Engg (3-0-2) 4	MEL120 Mfg Practices (2-0-4) 4	MAL111 Analysis Diff Eqns (3-1-0) 4	PHL110 Fields & Waves (3-1-0) 4	PHP100 Physics Lab (0-0-4) 2	HUN100 * Intro Hu & So Sc (0-0-4) 2			4	11	2	18	31	22
II	EEL205 Signals Systems (3-1-0) 4	EEL203 Electromechanics (3-1-0) 4	AML110 Engg Mechanics (3-0-2) 4	MAL124 Alg Matrix Analy (3-1-0) 4	CSL101/102 Int Comp Prg/Sc (3-0-2) 4	CYP100 Chemistry Lab (0-0-4) 2				5	15	3	8	26	22
III	EEL201 Digital Electronics (3-1-0) 4	EEP201 Electronics Lab - I (0-0-3) 1.5	EEL202 Circuit Theory (3-1-0) 4	EEP203 Electromech Lab (0-0-3) 1.5	CSL201 Data Structures (3-0-4) 5	MAL250 Prob Stoch Proc. (3-1-0) 4	HUL2xx Hu. & So. Sc. #1 (3-1-0) 4			5	15	4	10	29	24
IV	EEL301 Control Engg - I (3-1-0) 4	EEL204 Analog Elec Cir (3-1-0) 4	EEP204 Electronics Lab - II (0-0-3) 1.5	EEL306 Communic Engg (3-1-0) 4	EEL308 Computer Arch (3-1-0) 4	EEP308 Comp Tech Lab (0-0-3) 1.5	EEP211 Des Practice (EE) (0-0-4) 2	HUL2xx Hu. & So. Sc. #2 (3-0-0) 3		5	15	4	10	29	24
V	EEL207 Engg Electromag (3-1-0) 4	EEL303 Power Engg - I (3-1-0) 4	EEP301 Control Engg Lab (0-0-3) 1.5	EEP306 Comm Engg Lab (0-0-3) 1.5	DE-A (3-0-0) 3	DE-1 (3-0-0) 3	QC-1 (3-1-0) 4	HUL2xx Hu. & So. Sc. #3 (2-1-0) 3		6	17	4	6	27	24
VI	EEP303 Power Engg Lab (0-0-3) 1.5	EEP307 Electromag Lab (0-0-3) 1.5	DE-2 (3-0-0) 3	DE-B (3-0-2) 4	OC-2 (3-0-0) 3	OC-3 (3-0-2) 4	HUL2xx Hu. & So. Sc. #4 (3-1-0) 4			6	18	1	10	29	24
summer	EET410 Practical Training (EE)									NC					
VII	EEC410 Colloquium (EE) (0-3-0) 3	EED411 Maj Proj Pt1 (EE) (0-0-6) 3	DE-C (3-0-2) 4	OC-4 (3-1-0) 4	OC-5 (3-1-0) 4	OC-6 (3-0-0) 3	OC-7 (3-0-0) 3			5	15	5	8	28	24
VIII	DE-4 (3-0-0) 3	DE-5 EEV (1-0-0) 1	DE-6 (3-0-2) 4	OC-8 (3-1-0) 4	OC-9 (3-1-0) 4					4	13	2	2	17	16
	(- -) 0													TOTAL =	180.0

DC = 62, EAS = 21, BS = 20, HC = 2   (* either in 1st or 2nd sem.)

Reqd. DE=28, plan DE = 8/9 courses (or 6/7 courses+Major Project Part 2) + 1V course.

HU = 2@4 + 2@3 = 14 cr. from 4 courses.

Reqd. OC=33, plan OC = 6@4 + 3@3 = 33 cr. from 9 courses.

Programme Code: EE2 / (EP)
Bachelor of Technology in Electrical Engineering (Power)
Department of Electrical Engineering

The overall credits structure

Undergraduate Core (UC)		Undergraduate Elective (UE)	
Category	Credits	Category	Credits
DC	63	DE	27
BS	20	HM	14
EAS	21	OC	33
HU	2		
TOTAL	106	TOTAL	74

Total credits = 180

Basic Sciences (BS) Core

CYP100	Chemistry Laboratory	0-0-4	**2**
MAL111	Introduction to Analysis & Differential Eqns.	3-1-0	**4**
MAL124	Introduction to Algebra and Matrix Analysis	3-1-0	**4**
MAL230	Numerical Methods and Computation	3-1-0	**4**
PHL110	Fields and Waves	3-1-0	**4**
PHP100	Physics Laboratory	0-0-4	**2**
	TOTAL BS Core	**12-4-8**	**20**

* In addition to the above BS core courses, either CYL110 or CYL120 has to be taken as an open category course for graduation.

Engineering Arts and Sciences (EAS) Core

AML110	Engineering Mechanics	3-0-2	**4**
CSL101	Introduction to Computers and Programming	3-0-2	**4**
	OR		
CSL102	Introduction to Computer Science	3-0-2	**4**
CSL201	Data Structures	3-0-4	**5**
EEL101	Fundamentals of Electrical Engineering	3-0-2	**4**
MEL120	Manufacturing Practices	2-0-4	**4**
	TOTAL EAS Core	**14-0-14**	**21**

Humanities and Social Sciences (HC) Core

HUN100	Introduction to Humanities and Social Sciences	0-0-4	**2**

Departmental Core (DC)

EEC420	Colloquium (EP)	0-3-0	**3**
EED421	Major Project Part 1 (EP)	0-0-8	**4**
EEL201	Digital Electronic Circuits	3-1-0	**4**
EEL202	Circuit Theory	3-1-0	**4**
EEL203	Electromechanics	3-1-0	**4**
EEL204	Analog Electronics Circuits	3-1-0	**4**
EEL205	Signals and Systems	3-1-0	**4**
EEL209	Power Electronics Devices and Circuits	3-1-0	**4**
EEL301	Control Engineering - I	3-1-0	**4**
EEL303	Power Engineering - I	3-1-0	**4**
EEL305	Electric Drives	3-1-0	**4**
EEL308	Computer Architecture	3-1-0	**4**
EEN120	Introduction to Electrical Engineering (Power)	0-0-4	**2**
EEP201	Electronics Laboratory - I	0-0-3	**1.5**
EEP203	Electromechanics Laboratory	0-0-3	**1.5**
EEP204	Electronics Laboratory - II	0-0-3	**1.5**
EEP209	Power Electronics Laboratory	0-0-3	**1.5**
EEP221	Design (EP)	0-0-4	**2**
EEP301	Control Engineering Laboratory	0-0-3	**1.5**
EEP303	Power Engineering Laboratory	0-0-3	**1.5**
EEP305	Drives Laboratory	0-0-3	**1.5**
EEP308	Computer Technology Laboratory	0-0-3	**1.5**
EET420	Practical Training (EP)	—	**NC**
	TOTAL DC	**30-13-38**	**62**

Departmental Electives (DE)

EED320	Mini Project (EP)	0-0-6	**3**
EEL306	Communication Engineering	3-1-0	**4**
EEL319	Digital Signal Processing	3-0-2	**4**
EEL322	Integrated Circuits Technology	3-0-0	**3**
EEL325	Control Engineering - II	3-0-0	**3**
EEL326	Micromotors and their Applications	3-0-0	**3**

EEL331	Electromagnetics and Advanced Electromechanics	3-0-0	**3**
EEL339	Power Conditioning	3-0-0	**3**
EEL340	Selected Topics in Power and Machines	3-0-0	**3**
EEL341	Selected Topics in Power Electronics and Drives - I	3-0-0	**3**
EEL342	DSP based Control of Electric Drive	3-0-0	**3**
EEL344	Electric Transportation	3-0-0	**3**
EEL346	Electrical Machines and Industrial Drives	3-0-0	**3**
EEL349	Advanced Electrical Machines	3-0-0	**3**
EEL359	Electric Machine Design and CAD of Electric Machines	3-0-0	**3**
EEL360	Selected Topics in Control Engineering - I	3-0-0	**3**
EEL361	Selected Topics in Power Systems - I	3-0-0	**3**
EEL365	Intelligent Control	3-0-0	**3**
EEL375	Embedded Systems	3-0-4	**5**
EEL380	Selected Topics in Electronics - I	3-0-0	**3**
EEL388	Stepper Motors	3-0-0	**3**
EEL389	Computer Aided Testing of Electric Machines	2-0-2	**3**
EEL394	Permanent Magnet Motors	3-0-0	**3**
EEL398	Machines and Drives Dynamics	3-0-0	**3**
EEL404	Flexible AC Transmission System	3-0-0	**3**
EEL405	Power Engineering Instrumentation	3-0-0	**3**
EEL407	Distribution System Planning and Automation	3-0-0	**3**
EEL421	Selected Topics in Power Electronics and Drives - II	3-0-0	**3**
EEL423	Demand Side Management	3-0-0	**3**
EEL424	Nuclear Power Generation	3-0-0	**3**
EEL428	Substation Design	3-0-0	**3**
EEL437	Selected Topics in Power Systems - II	3-0-0	**3**
EEL440	Selected Topics in Power, Machines and Power Electronics	3-0-0	**3**
EEL450	Switchgear and Transients	3-0-0	**3**
EEL451	Power Systems Protection	3-0-0	**3**
EEL452	HVDC Transmission	3-0-0	**3**
EEL453	Power System Dynamics and Control	3-0-0	**3**
EEL455	Power System Planning	3-0-0	**3**
EEL456	Power Engineering - II	3-0-2	**4**
EEL458	Power Systems Optimization	3-0-0	**3**
EEL460	Selected Topics in Control Engineering - II	3-0-0	**3**
EEL462	Identification and Adaptive Control	3-0-0	**3**
EEL481	Testing and Commissioning of Electrical Equipment	3-0-0	**3**
EEL482	Mechatronics	3-0-0	**3**
EEL483	Hydro Power Generation	3-0-0	**3**
EEL486	Illumination and Heating	3-0-0	**3**
EEL487	Intelligent Algorithms for Power Systems	3-0-0	**3**
EEL499	Selected Topics in Electrical Machines	3-0-0	**3**
EEL741	Modelling and Analysis of Electrical Machines	3-0-0	**3**
EEL748	Power Quality	3-0-0	**3**
EEL749	Special Electromechanical Systems	3-0-0	**3**
EEL772	Optimal Control Theory	3-0-0	**3**
EEP443	FEM Analysis of Machines Laboratory	0-0-3	**1.5**
EEP446	Electrical Machines and Industrial Drives Laboratory	0-0-3	**1.5**
EEP452	Machine Modelling and Simulation Laboratory	0-0-3	**1.5**
EEP483	Neural Computing Applications to Power Systems Laboratory	0-0-3	**1.5**
EEP487	Power Quality Laboratory	0-0-3	**1.5**
EEP488	Power Electronics and Simulation Laboratory	0-0-3	**1.5**
EEP493	CAD of Electric Machines Laboratory	0-0-3	**1.5**
EEP495	Distribution System Design Laboratory	0-0-3	**1.5**
EEP496	Power System Dynamics and Control Laboratory	0-0-3	**1.5**
EES320	Independent Study (EP)	0-3-0	**3**
EEV403	Special Module in Electrical Machines	1-0-0	**1**
EEV404	Special Module in Control Engineering	1-0-0	**1**
EEV405	Special Module in Electronics	1-0-0	**1**
EEV406	Special Module in Power Electronics and Drives	1-0-0	**1**
EEV407	Special Module in Power Systems	1-0-0	**1**
EEV704	Special Module in Computers	1-0-0	**1**
EED422	Major Project Part 2 (EP)	0-0-16	**8**

B.Tech. in Electrical Engineering (Power) (EP) EE2

Sem.									Lect Courses	L	T	P	Weekly contact	Credits
I	EEN120 Intro Elec Engg (P) (0-0-4) 2	EEL101 Fund Elec Engg (3-0-2) 4	MEL120 Mfg Practices (2-0-4) 4	MAL111 Analysis Diff Eqns (3-1-0) 4	PHL110 Fields & Waves (3-1-0) 4	PHP100 Physics Lab (0-0-4) 2	HUN100 * Intro Hu & So Sc (0-0-4) 2		4	11	2	18	31	22
II	EEL205 Signals Systems (3-1-0) 4	EEL203 Electromechanics (3-1-0) 4	AML110 Engg Mechanics (3-0-2) 4	MAL124 Alg & Matrix Ana (3-1-0) 4	CSL101/102 Int Comp Prg/Sc (3-0-2) 4	CYP100 Chemistry Lab (0-0-4) 2			5	15	3	8	26	22
III	EEL201 Digital Electronics (3-1-0) 4	EEP201 Electronics Lab-I (0-0-3) 1.5	EEL202 Circuit Theory (3-1-0) 4	EEP203 Electromech Lab (0-0-3) 1.5	CSL201 Data Structures (3-0-4) 5	MAL230 Num Meth Compu (3-1-0) 4	HUL2xx Hu. & So. Sc. #1 (3-1-0) 4		5	15	4	10	29	24
IV	EEL301 Control Engg - I (3-1-0) 4	EEL204 Analog Elec Cir (3-1-0) 4	EEP204 Electronics Lab - II (0-0-3) 1.5	EEL209 P Elec Dev Circ (3-1-0) 4	EEL308 Computer Arch (3-1-0) 4	EEP308 Comp Tech Lab (0-0-3) 1.5	EEP221 Des Practice (EP) (0-0-4) 2		5	15	4	10	29	24
V	EEL305 Electric Drives (3-1-0) 4	EEL303 Power Engg - I (3-1-0) 4	EEP301 Control Engg Lab (0-0-3) 1.5	EEP209 Power Electr Lab (0-0-3) 1.5	DE-A (3-0-0) 3	DE-1 (3-0-0) 3	OC-1 (3-1-0) 4	HUL2xx Hu. & So. Sc. #3 (2-1-0) 3	6	17	4	6	27	24
VI	EEP303 Power Engg Lab (0-0-3) 1.5	EEP305 Drives Lab (0-0-3) 1.5		DE-2 (3-0-0) 3	DE-B (3-0-2) 4	DE-3 (3-0-0) 3	OC-2 (3-0-0) 3 / OC-3 (3-0-2) 4	HUL2xx Hu. & So. Sc. #4 (3-1-0) 4	6	18	1	10	29	24
summer			EET420 Practical Training (EP)						NC					
VII	EEC420 Colloquium (EP) (0-3-0) 3	EED421 Maj Proj Pt1 (EP) (0-0-6) 3			DE-C (3-0-2) 4	OC-4 (3-1-0) 4	OC-5 (3-1-0) 4 / OC-6 (3-0-0) 3	OC-7 (3-0-0) 3	5	15	5	8	28	24
VIII				DE-4 EEV (1-0-0) 1	DE-5 (3-0-2) 4	DE-6 (3-0-0) 3	OC-8 (3-1-0) 4	OC-9 (3-1-0) 4	4	13	2	2	17	16

TOTAL = 180.0

DC = 62, EAS = 21, BS = 20, HC = 2   (* either in 1st or 2nd sem.)

HU = 2@4 + 2@3 = 14 cr. from 4 courses.

Reqd. DE=28, plan DE = 8/9 courses (or 6/7 courses+Major Project Part 2) + 1V course.

Reqd. OC=33, plan OC = 6@4 + 3@3 = 33 cr. from 9 courses.

Programme Code: PH1 / (PH)
Bachelor of Technology in Engineering Physics
Department of Physics

The overall credits structure

Undergraduate Core (UC)		Undergraduate Elective (UE)	
Category	Credits	Category	Credits
DC	64	DE	26
BS	20	HM	14
EAS	20	OC	34
HU	2		
TOTAL	*106*	*TOTAL*	*74*

Total credits = 180

Basic Sciences (BS) Core

CYL110	Physical Chemistry: Concepts and Applications	3-1-0	**4**
CYP100	Chemistry Laboratory	0-0-4	**2**
MAL110	Mathematics - I	3-1-0	**4**
MAL120	Mathematics - II	3-1-0	**4**
PHL120	Physics of Materials	3-1-0	**4**
PHP100	Physics Laboratory	0-0-4	**2**
	TOTAL BS Core	**12-4-8**	**20**

Engineering Arts and Sciences (EAS) Core

CHL110	Transport Phenomena	3-1-0	**4**
CSL101	Introduction to Computers and Programming OR	3-0-2	**4**
CSL102	Introduction to Computer Science	3-0-2	**4**
EEL101	Fundamentals of Electrical Engineering	3-0-2	**4**
MEL110	Graphic Science	2-0-4	**4**
MEL120	Manufacturing Practices	2-0-4	**4**
	TOTAL EAS Core	**13-1-12**	**20**

Humanities and Social Sciences (HC) Core

HUN100	Introduction to Humanities and Social Sciences	0-0-4	**2**

Departmental Core (DC)

EPC410	Colloquium (PH)	0-3-0	**3**
EPD411	Major Project Part 1 (PH)	0-0-8	**4**
EPL101	Classical Mechanics and Relativity	3-1-0	**4**
EPL103	Mathematical Physics	3-1-0	**4**
EPL105	Optics	3-1-0	**4**
EPL107	Electromagnetics	3-1-0	**4**
EPL202	Quantum Mechanics and its Applications	3-1-0	**4**
EPL204	Thermal and Statistical Physics	3-1-0	**4**
EPL206	Solid State Physics	3-1-0	**4**
EPL208	Principles of Electrodynamics and Plasmas	3-1-0	**4**
EPL211	Principles of Material Synthesis	3-1-0	**4**
EPL213	Fundamentals of Semiconductors	3-1-0	**4**
EPN110	Introduction to Engineering Physics	0-0-4	**2**
EPP109	Physics Laboratory - I	0-0-6	**3**
EPP110	Physical System Design	0-0-4	**2**
EPP215	Physics Laboratory - II	0-0-6	**3**
EPP216	Physics Laboratory - III	0-0-6	**3**
EPP301	Design Laboratory	0-0-8	**4**
EPT410	Practical Training (PH)	—	**NC**
	TOTAL DC	**30-13-40**	**63**

Departmental Electives (DE)

EPD310	Mini Project (PH)	0-0-6	**3**
EPL331	Vacuum Technology and Surface Physics	3-0-0	**3**
EPL332	Nuclear Science and Engineering	3-0-0	**3**
EPL333	Computational Physics	3-0-2	**4**
EPL334	Lasers	3-0-0	**3**
EPL335	Low Dimensional Physics	3-1-0	**4**
EPL336	Semiconductor Optoelectronics	3-1-0	**4**
EPL337	Materials Science and Engineering	3-1-0	**4**
EPL338	Non-linear Phenomena in Physics and Engineering	3-1-0	**4**
EPL439	Microelectronic Devices	3-0-0	**3**
EPL440	Quantum Electronics	3-0-0	**3**
EPL441	Applications of Lasers in Technology	3-0-0	**3**
EPL442	Fiber and Integrated Optics	3-0-0	**3**
EPL443	Holography and Optical Information Processing	3-0-0	**3**
EPL444	Functional Nanostructures	3-0-0	**3**
EPL445	Engineering Optics	3-0-0	**3**
EPL446	Spintronics and Data Storage	3-0-0	**3**
EPR310	Professional Practices (PH)	0-1-2	**2**
EPS310	Independent Study (PH)	0-3-0	**3**
EPV430	Special Topics in Nano-Technology	1-0-0	**1**
EPV431	Special Topics in Photonics and Optoelectronics	1-0-0	**1**
EPV432	Special Topics in Emerging Processes	1-0-0	**1**
EPV433	Special Topics in Emerging Materials	1-0-0	**1**
EPV434	Special Topics in Emerging Devices	1-0-0	**1**
EPV450	Selected Topics in Nano-Technology	2-0-0	**2**
EPV451	Selected Topics in Photonics and Optoelectronics	2-0-0	**2**
EPV452	Selected Topics in Emerging Processes	2-0-0	**2**
EPV453	Selected Topics in Emerging Materials	2-0-0	**2**
EPV454	Selected Topics in Emerging Devices	2-0-0	**2**
EPD412	Major Project Part 2 (PH)	0-0-16	**8**

B.Tech. in Engineering Physics

Sem.	Courses								Lect Courses	L	T	P	Weekly contact	Credits
I	EPN110 Intro to Engg Phys (0-0-4)2	CSL101/102 Int Comp Prg/Sc (3-0-2)4	MEL120 Mfg Practices (2-0-4)4	MAL110 Mathematics-I (3-1-0)4	CYL110 Physical Chem (3-1-0)4	CYP100 Chemistry Lab (0-0-4)2	HUN100 * Intro Hu & So Sc (0-0-4)2		4	11	2	18	31	22
II	CHL110 Transp Phen (3-1-0)4	EEL101 Fund Elec Engg (3-0-2)4	MEL110 Graphic Science (2-0-4)4	MAL120 Mathematics-II (3-1-0)4	PHL120 Phy Materials (3-1-0)4	PHP100 Physics Lab (0-0-4)2			5	14	3	10	27	22
III	EPL101 Class Mech Relat. (3-1-0)4	EPL103 Math Physics (3-1-0)4	EPL105 Optics (3-1-0)4	EPL107 Electromagnetics (3-1-0)4	EPP109 Physics Lab-I (0-0-6)3	HUL2xx Hu. & So. Sc. #1 (3-1-0)4			5	15	5	6	26	23
IV	EPL202 Quant Mech Appl. (3-1-0)4	EPL204 Ther Stat Physics (3-1-0)4	EPL206 Solid State Phys (3-1-0)4	EPP110 Physical Sys Des (0-0-4)2	EPL208 Pr Elec-dyn Plas (3-1-0)4	OC-1 (3-1-0)4	HUL2xx Hu. & So. Sc. #2 (2-1-0)3		6	17	6	4	27	25
V	EPL211 Prin Material Syn. (3-1-0)4	EPL213 Fund Semicond. (3-1-0)4	EPP215 Physics Lab-II (0-0-6)3	OC-2 (3-0-0)3	OC-3 (3-1-0)4	OC-4 (3-0-0)3	HUL2xx Hu. & So. Sc. #3 (2-1-0)3		6	17	4	6	27	24
VI	EPP216 Physics Lab-III (0-0-6)3	DE-1 (3-1-0)4	DE-2 (3-1-0)4	OC-5 (3-1-0)4	OC-6 (3-1-0)4	HUL2xx Hu. & So. Sc. #4 (3-1-0)4			5	15	5	6	26	23
summer	EPT410 Practical Training (PH)								NC					
VII	EPC410 Colloquium (0-3-0)3	EPD411 Maj Proj Pt 1 (PH) (0-0-6)3	EPP301 Design Laboratory (0-0-8)4	DE-3 (3-0-0)3	DE-4 (3-0-0)3	OC-7 (3-0-0)3	OC-8 (3-0-0)3	OC-9 (3-0-0)3	5	15	3	14	32	25
VIII	DE-5 (3-0-0)3	DE-6 (3-0-0)3	DE-7 (3-0-2)4	DE-8 (3-0-0)3	OC-10 (3-0-0)3				5	15	0	2	17	16

DC = 63, EAS = 20, BS = 20, HC = 2   (* either in 1st or 2nd sem.)

HU = 2@4 + 2@3 = 14 cr. from 4 courses.

Reqd. DE=27, plan DE = 8 courses or 6 courses+Major Project Part 2.

Reqd. OC=34, plan OC = 4@4 + 6@3 = 34 cr. from 10 courses.

TOTAL = 180.0

Programme Code: ME1 / (ME)
Bachelor of Technology in Mechanical Engineering
Department of Mechanical Engineering

The overall credits structure

Undergraduate Core (UC)		Undergraduate Elective (UE)	
Category	**Credits**	**Category**	**Credits**
DC	60	DE	30
BS	20	HM	14
EAS	24	OC	30
HU	2		
TOTAL	*106*	*TOTAL*	*74*

Total credits = 180

Basic Sciences (BS) Core

CYL120	Inorganic and Organic Chemistry: Concepts and Applications	3-1-0	**4**
CYP100	Chemistry Laboratory	0-0-4	**2**
MAL110	Mathematics - I	3-1-0	**4**
MAL120	Mathematics - II	3-1-0	**4**
PHL120	Physics of Materials	3-1-0	**4**
PHP100	Physics Laboratory	0-0-4	**2**
	TOTAL BS Core	**12-4-8**	**20**

Engineering Arts and Sciences (EAS) Core

AML110	Engineering Mechanics	3-0-2	**4**
AML140	Mechanics of Solids	3-1-0	**4**
CSL101	Introduction to Computers and Programming OR	3-0-2	**4**
CSL102	Introduction to Computer Science	3-0-2	**4**
EEL102	Principles of Electrical Engineering	3-0-2	**4**
MEL110	Graphic Science	2-0-4	**4**
MEL120	Manufacturing Practices	2-0-4	**4**
	TOTAL EAS Core	**16-1-14**	**24**

Humanities and Social Sciences (HC) Core

HUN100	Introduction to Humanities and Social Sciences	0-0-4	**2**

Departmental Core (DC)

AML160	Mechanics of Fluids	3-1-0	**4**
AMP262	Fluids and Solids Laboratory	0-0-3	**1.5**
MEC410	Colloquium (ME)	0-3-0	**3**
MED411	Major Project Part 1 (ME)	0-0-8	**4**
MEL140	Engineering Thermodynamics	3-1-0	**4**
MEL211	Kinematics and Dynamics of Machines	3-0-2	**4**
MEL232	Casting, Welding and Forming	3-0-2	**4**
MEL233	Machining, Machine-tools and Metrology	3-0-2	**4**
MEL241	Energy Conversion	3-0-2	**4**
MEL242	Heat and Mass Transfer	3-1-0	**4**
MEL311	Machine Element Design	3-1-2	**5**
MEL312	Control Theory and Applications	3-1-2	**5**
MEL421	Production Management	3-0-2	**4**
MEN110	Introduction to Mechanical Engineering	0-0-4	**2**
MEP201	Mechanical Engineering Drawing	1-0-4	**3**
MEP202	Design Innovation and Manufacturing	0-0-4	**2**
MEP311	Mechanisms Laboratory	0-0-2	**1**
MEP341	Thermal Engineering Laboratory	0-0-3	**1.5**
MET410	Practical Training (ME)	—	**NC**
	TOTAL DC	**31-8-40**	**59**

Departmental Electives (DE)

MED310	Mini Project (ME)	0-0-8	**4**
MEL310	Concurrent Engineering	3-1-0	**4**
MEL314	Noise Engineering	3-0-2	**4**
MEL316	Mechanical Vibrations	3-0-2	**4**
MEL321	Ergonomics	3-0-2	**4**
MEL332	Design and Manufacturing of Composites	3-0-2	**4**
MEL333	Metrology	3-0-2	**4**
MEL334	Low Cost Automation	3-0-2	**4**
MEL341	Gas Dynamics and Propulsion	3-0-2	**4**
MEL342	Power Plant Technologies	3-0-2	**4**
MEL343	Fuels, Combustion and Pollution	3-0-2	**4**
MEL344	Refrigeration and Air-Conditioning	3-0-2	**4**
MEL345	Internal Combustion Engines	3-0-2	**4**
MEL346	Turbo-machinery	3-0-2	**4**
MEL410	Creativity in Engineering	3-1-0	**4**
MEL411	Mechatronics	3-0-2	**4**
MEL412	Advanced Mechanical Design	3-0-2	**4**
MEL413	Design of Mechanisms	3-1-0	**4**
MEL414	Computer Aided Mechanical Design	3-0-2	**4**
MEL415	Vibrations Engineering Design	3-0-2	**4**
MEL416	Robotics Engineering	3-1-0	**4**
MEL417	Lubrication	3-0-2	**4**
MEL420	Total Quality Management	3-0-2	**4**
MEL422	Project Management	3-0-2	**4**
MEL425	Flexible Manufacturing Systems	3-0-2	**4**
MEL431	CNC Machines and Programming	3-0-2	**4**
MEL432	Microprocessor Applications in Manufacturing	3-0-2	**4**
MEL433	Micro- and Nano- Manufacturing	3-0-2	**4**
MEL434	Design for Manufacturing and Assembly	3-0-2	**4**
MEL435	Geometric Modelling for Manufacturing	3-0-2	**4**
MEL436	Injection Moulding and Mould Design	2-0-4	**4**
MEL441	Modelling and Experiments in Heat Transfer	2-0-4	**4**
MEL442	Thermal Analysis of Bio-systems	3-0-2	**4**
MEL716	Micro/Nano Scale Heat Transfer	3-0-2	**4**
MED412	Major Project Part 2 (ME)	0-0-16	**8**

B.Tech. in Mechanical Engineering

Sem.								Lect Courses	L	T	P	Weekly contact	Credits
I	MEN110 Intro to Mech Engg (0 - 0 - 4) 2	AML110 Engg Mechanics (3 - 0 - 2) 4	MEL110 Graphic Science (2 - 0 - 4) 4	MAL110 Mathematics - I (3 - 1 - 0) 4	CYL120 Inorg & Org Chem (3 - 1 - 0) 4	CYP100 Chemistry Lab (0 - 0 - 4) 2	HUN100 * Intro Hu & So Sc (0 - 0 - 4) 2	4	11	2	18	31	22
II	MEL140 Engg Thermodyn (3 - 1 - 0) 4	CSL101/102 Int Comp Prg/Sc (3 - 0 - 2) 4	MEL120 Mfg Practices (2 - 0 - 4) 4	MAL120 Mathematics - II (3 - 1 - 0) 4	PHL120 Phy Materials (3 - 1 - 0) 4	PHP100 Physics Lab (0 - 0 - 4) 2		5	14	3	10	27	22
III	AML160 Mechanics Fluids (3 - 1 - 0) 4	MEL211 Kin. & Dynamics (3 - 0 - 2) 4	MEP201 Mech Engg Drwg. (1 - 0 - 4) 3	AML140 Mechanics Solids (3 - 1 - 0) 4	EEL102 Prin Elec Engg (3 - 0 - 2) 4		HUL2xx Hu. & So. Sc. #1 (3 - 1 - 0) 4	5	16	3	8	27	23
IV	MEL241 Energy Convn. (3 - 0 - 2) 4	MEP311 Mechanism Lab (0 - 0 - 2) 1	MEP202 Des Inno & Mfg (0 - 0 - 4) 2	AMP262 Fluid Solid Lab (0 - 0 - 3) 1.5	MEL232 Cast Weld Form (3 - 0 - 2) 4	OC-1 (3 - 0 - 0) 3 / OC-2 (3 - 0 - 2) 4	HUL2xx Hu. & So. Sc. #2 (3 - 1 - 0) 4	5	15	1	15	31	23.5
V	MEL242 Heat Mass Trnsf. (3 - 1 - 0) 4	MEL311 M/C Ele Design (3 - 1 - 2) 5	MEL233 M/cing, M/C tools (3 - 0 - 2) 4			OC-3 (3 - 0 - 0) 3 / OC-4 (3 - 0 - 2) 4	HUL2xx Hu. & So. Sc. #3 (2 - 1 - 0) 3	6	17	3	6	26	23
VI	MEP341 Ther. Engg. Lab (0 - 0 - 3) 1.5	MEL312 Control Th & Appl (3 - 1 - 2) 5		DE-1 (3 - 0 - 2) 4	OC-5 (3 - 0 - 0) 3 / OC-6 (3 - 0 - 0) 3 / OC-7 (3 - 0 - 0) 3		HUL2xx Hu. & So. Sc. #4 (2 - 1 - 0) 3	6	17	2	7	26	22.5
summer			MET410 Practical Training (ME)					NC					
VII	MEC410 Colloquium (ME) (0 - 3 - 0) 3	MED411 Maj Proj Pt 1 (ME) (0 - 0 - 6) 3	MEL421 Production Mgmt (3 - 0 - 2) 4	DE-2 (3 - 0 - 2) 4	DE-3 (3 - 0 - 2) 4	DE-4 (3 - 0 - 2) 4	OC-8 (3 - 0 - 0) 3	5	15	3	14	32	25
VIII				DE-5 (3 - 0 - 2) 4	DE-6 (3 - 0 - 2) 4	DE-7 (3 - 0 - 0) 3 / DE-8 (3 - 0 - 2) 4	OC-9 (3 - 0 - 2) 4	5	15	0	8	23	19

TOTAL = 180.0

DC = 59, EAS = 24, BS = 20, HC = 2   (* either in 1st or 2nd sem.)

Reqd. DE=31, plan DE = 8 courses or 6 courses+Major Project Part 2.

HU = 2@4 + 2@3 = 14 cr. from 4 courses.

Reqd. OC=30, plan OC = 3@4 + 6@3 = 30 cr. from 9 courses.

Programme Code: ME2 / (PE)
Bachelor of Technology in Production and Industrial Engineering
Department of Mechanical Engineering

The overall credits structure

Undergraduate Core (UC)		Undergraduate Elective (UE)	
Category	Credits	Category	Credits
DC	60	DE	30
BS	20	HM	14
EAS	24	OC	30
HU	2		
TOTAL	106	TOTAL	74

Total credits = 180

Basic Sciences (BS) Core

CYL120	Inorganic and Organic Chemistry: Concepts and Applications	3-1-0	**4**
CYP100	Chemistry Laboratory	0-0-4	**2**
MAL110	Mathematics - I	3-1-0	**4**
MAL120	Mathematics - II	3-1-0	**4**
PHL120	Physics of Materials	3-1-0	**4**
PHP100	Physics Laboratory	0-0-4	**2**
	TOTAL BS Core	**12-4-8**	**20**

Engineering Arts and Sciences (EAS) Core

AML110	Engineering Mechanics	3-0-2	**4**
AML120	Materials Science	3-0-2	**4**
CSL101	Introduction to Computers and Programming OR	3-0-2	**4**
CSL102	Introduction to Computer Science	3-0-2	**4**
EEL102	Principles of Electrical Engineering	3-0-2	**4**
MEL110	Graphic Science	2-0-4	**4**
MEL120	Manufacturing Practices	2-0-4	**4**
	TOTAL EAS Core	**16-0-16**	**24**

Humanities and Social Sciences (HC) Core

HUN100	Introduction to Humanities and Social Sciences	0-0-4	**2**

Departmental Core (DC)

AML150	Mechanics of Solids and Fluids	3-1-2	**5**
MEC420	Colloquium (PE)	0-3-0	**3**
MED421	Major Project Part 1 (PE)	0-0-8	**4**
MEL211	Kinematics and Dynamics of Machines	3-0-2	**4**
MEL221	Industrial Engineering and Operations Research	3-0-2	**4**
MEL231	Casting and Welding	3-0-2	**4**
MEL234	Metal Forming and Machining	3-1-2	**5**
MEL235	Metrology and Quality Assurance	3-0-2	**4**
MEL311	Machine Element Design	3-1-2	**5**
MEL322	Operations Planning and Control	3-0-2	**4**
MEL331	Machine-tools and CNC Manufacturing	3-0-2	**4**
MEL423	Computers in Manufacturing Enterprises	3-0-2	**4**
MEN120	Introduction to Production and Industrial Engineering	0-0-4	**2**
MEP201	Mechanical Engineering Drawing	1-0-4	**3**
MEP202	Design Innovation and Manufacturing	0-0-4	**2**
MEP331	Process Engineering and Tool Design Project	1-0-4	**3**
MET420	Practical Training (PE)	—	**NC**
TOTAL DC		**32-6-42**	**59**

Departmental Electives (DE)

MED320	Mini Project (PE)	0-0-8	**4**
MEL310	Concurrent Engineering	3-1-0	**4**
MEL312	Control Theory and Applications	3-1-2	**5**
MEL323	Investment Planning	3-0-2	**4**
MEL324	Value Engineering	3-0-2	**4**
MEL332	Design and Manufacturing of Composites	3-0-2	**4**
MEL334	Low Cost Automation	3-0-2	**4**
MEL335	Advances in Metal Forming	3-1-0	**4**
MEL336	Advances in Welding	3-0-2	**4**
MEL410	Creativity in Engineering	3-1-0	**4**
MEL411	Mechatronics	3-0-2	**4**
MEL414	Computer Aided Mechanical Design	3-0-2	**4**
MEL415	Vibrations Engineering Design	3-0-2	**4**
MEL416	Robotics Engineering	3-1-0	**4**
MEL420	Total Quality Management	3-0-2	**4**
MEL422	Project Management	3-0-2	**4**
MEL424	Knowledge Management for Competitiveness	3-0-2	**4**
MEL425	Flexible Manufacturing Systems	3-0-2	**4**
MEL426	Materials Management	3-0-2	**4**
MEL427	Manufacturing Economics and Analysis	3-0-2	**4**
MEL431	CNC Machines and Programming	3-0-2	**4**
MEL432	Microprocessor Applications in Manufacturing	3-0-2	**4**
MEL433	Micro- and Nano- Manufacturing	3-0-2	**4**
MEL434	Design for Manufacturing and Assembly	3-0-2	**4**
MEL435	Geometric Modelling for Manufacturing	3-0-2	**4**
MEL436	Injection Moulding and Mould Design	2-0-4	**4**
MED422	Major Project Part 2 (PE)	0-0-16	**8**

B.Tech. in Production and Industrial Engineering   (PE) ME2

Sem.								Lect Courses	L	T	P	Weekly contact	Credits
I	MEN120 Intor to P&I Engg (0-0-4) 2	AML110 Engg Mechanics (3-0-2) 4	MEL110 Graphic Science (2-0-4) 4	MAL110 Mathematics - I (3-1-0) 4	CYL120 Inorg & Org Chem (3-1-0) 4 / CYP100 Chemistry Lab (0-0-4) 2		HUN100 * Intro Hu & So Sc (0-0-4) 2	4	11	2	18	31	22
II	AML120 Materials Science (3-0-2) 4	CSL101/102 Int Comp Prg/Sc (3-0-2) 4	MEL120 Mfg Practices (2-0-4) 4	MAL120 Mathematics - II (3-1-0) 4	PHL120 Phy Materials (3-1-0) 4 / PHP100 Physics Lab (0-0-4) 2			5	14	2	12	28	22
III	MEL231 Casting & Welding (3-0-2) 4	MEL211 Kin. & Dynamics (3-0-2) 4	MEP201 Mech Engg Drwg. (1-0-4) 3	AML150 Mech Fluid Solid (3-1-2) 5	EEL102 Prin Elec Engg (3-0-2) 4		HUL2xx Hu. & So. Sc. #1 (3-1-0) 4	5	16	2	12	30	24
IV	MEL234 Met Form&M/c-ing (3-1-2) 5	MEL235 Metrology & QA (3-0-2) 4	MEP212 Des Inno & Mfg (0-0-4) 2		OC-1 (3-0-0) 3	OC-2 (3-0-2) 4	HUL2xx Hu. & So. Sc. #2 (3-1-0) 4	5	15	2	10	27	22
V	MEL331 M/c-tools & CNC (3-0-2) 4	MEL311 M/c Ele Design (3-1-2) 5	MEL221 Indstr Engg & OR (3-0-2) 4		OC-3 (3-0-0) 3	OC-4 (3-0-2) 4	HUL2xx Hu. & So. Sc. #3 (2-1-0) 3	6	17	2	8	27	23
VI	MEP331 PE & TD Project (1-0-4) 3	MEL322 Opm Plng Contrl (3-0-2) 4		DE-1 (3-0-2) 4	QC-5 (3-0-0) 3 / OC-6 (3-0-0) 3	OC-7 (3-0-0) 3	HUL2xx Hu. & So. Sc. #4 (2-1-0) 3	6	18	1	8	27	23
summer	MET420 Practical Training (PE) NC							NC					
VII	MEC420 Colloquium (PE) (0-3-0) 3	MED421 Maj Proj Pt 1 (PE) (0-0-6) 3	MEL423 Comp Mfg Entrp (3-0-2) 4	DE-2 (3-0-2) 4	DE-3 (3-0-2) 4	DE-4 (3-0-2) 4	OC-8 (3-0-0) 3	5	15	3	14	32	25
VIII				DE-5 (3-0-2) 4	DE-6 (3-0-2) 4	DE-7 (3-0-2) 4	DE-8 (3-0-0) 3 / OC-9 (3-0-2) 4	5	15	0	8	23	19

TOTAL = 180.0

DC = 59, EAS = 24, BS = 20, HC = 2   (* either in 1st or 2nd sem.)

Reqd. DE=31, plan DE = 8 courses or 6 courses+Major Project Part 2.

HU = 2@4 + 2@3 = 14 cr. from 4 courses.

Reqd. OC=30, plan OC = 3@4 + 6@3 = 30 cr. from 9 courses.

Programme Code: TT1 / (TT)
Bachelor of Technology in Textile Technology
Department of Textile Technology

The overall credits structure

Undergraduate Core (UC)		Undergraduate Elective (UE)	
Category	Credits	Category	Credits
DC	63	DE	27
BS	20	HM	14
EAS	20	OC	34
HU	2		
TOTAL	*105*	*TOTAL*	*75*

Total credits = 180

Basic Sciences (BS) Core

CYL120	Inorganic and Organic Chemistry: Concepts and Applications	3-1-0	**4**
CYP100	Chemistry Laboratory	0-0-4	**2**
MAL110	Mathematics - I	3-1-0	**4**
MAL140	Probability and Statistics	3-1-0	**4**
PHL110	Fields and Waves	3-1-0	**4**
PHP100	Physics Laboratory	0-0-4	**2**
	TOTAL BS Core	**12-4-8**	**20**

Engineering Arts and Sciences (EAS) Core

AML120	Materials Science	3-0-2	**4**
CSL101	Introduction to Computers and Programming OR	3-0-2	**4**
CSL102	Introduction to Computer Science	3-0-2	**4**
EEL102	Principles of Electrical Engineering	3-0-2	**4**
MEL110	Graphic Science	2-0-4	**4**
MEL120	Manufacturing Practices	2-0-4	**4**
	TOTAL EAS Core	**13-0-14**	**20**

Humanities and Social Sciences (HC) Core

HUN100	Introduction to Humanities and Social Sciences	0-0-4	**2**

Departmental Core (DC)

CYL230	Polymer Chemistry	2-1-0	**3**
TTC410	Colloquium (TT)	0-3-0	**3**
TTD411	Major Project Part 1 (TT)	0-0-8	**4**
TTL211	Structure and Physical Properties of Fibres	3-0-0	**3**
TTL212	Manufactured Fibre Technology	3-1-0	**4**
TTL221	Yarn Manufacture - I	3-1-0	**4**
TTL222	Yarn Manufacture - II	3-1-0	**4**
TTL231	Fabric Manufacture - I	3-1-0	**4**
TTL232	Fabric Manufacture - II	3-1-0	**4**
TTL241	Technology of Textile Preparation and Finishing	3-0-0	**3**
TTL242	Technology of Textile Colouration	3-1-0	**4**
TTL361	Textile Testing	3-0-0	**3**
TTL362	Theory of Textile Structures	3-2-0	**5**
TTN110	Introduction to Textile Technology	0-0-4	**2**
TTP200	Design of Textile Products and Processes	0-0-4	**2**
TTP211	Introduction to Fibres	1-0-2	**2**
TTP212	Manufactured Fibre Technology Laboratory	0-0-2	**1**
TTP221	Yarn Manufacture Laboratory - I	0-0-2	**1**
TTP222	Yarn Manufacture Laboratory - II	0-0-2	**1**
TTP231	Fabric Manufacture Laboratory - I	0-0-2	**1**
TTP232	Fabric Manufacture Laboratory - II	0-0-4	**2**
TTP241	Technology of Textile Preparation and Finishing Laboratory	0-0-3	**1.5**
TTP242	Technology of Textile Colouration Laboratory	0-0-3	**1.5**
TTP361	Textile Testing Laboratory	0-0-2	**1**
TTT410	Practical Training (TT)	—	**NC**
	TOTAL DC	**33-12-36**	**63**

Departmental Electives (DE)

BEL110	Molecular Cell Biology	3-0-0	**3**
CHL110	Transport Phenomena	3-1-0	**4**
TTD310	Mini Project (TT)	0-0-6	**3**
TTL311	High Performance and Specialty Fibres	3-0-0	**3**
TTL321	Mechanics of Spinning Machinery	2-1-0	**3**
TTL322	Mechanics of Spinning Processes	3-0-0	**3**
TTL323	Process Control in Spinning	3-0-0	**3**
TTL324	Spinning of Man-made Fibres and Blends	3-0-0	**3**
TTL331	Fabric Structure and Analysis	2-0-2	**3**
TTL332	Computer Aided Fabric Manufacturing	2-0-2	**3**
TTL333	Process Control in Weaving	3-0-0	**3**
TTL341	Polymers and Surfactants for Textiles	3-0-0	**3**
TTL351	Apparel Technology	2-0-2	**3**
TTL352	Clothing Science	3-0-0	**3**
TTL363	Technical Textiles	3-1-0	**4**
TTL364	Intelligent and Functional Textile	2-0-0	**2**
TTL365	Costing and its Application in Textiles	3-1-0	**4**
TTL724	Textured Yarn Technology	3-0-0	**3**
TTL740	Science and Applications of Nanotechnology in Textiles	3-0-0	**3**
TTL744	Environment Management in Textile and Allied Industries	3-0-0	**3**
TTL746	Medical Textiles	3-0-0	**3**
TTL750	Science of Clothing Comfort	3-0-0	**3**
TTL752	Functional Textile Envelops	2-0-2	**3**
TTL762	Management of Textile Production	3-0-0	**3**
TTL765	Product Development	2-1-0	**3**
TTL773	Design of Experiments and Statistical Techniques	3-0-0	**3**
TTL782	Nonwoven Science and Engineering	3-0-0	**3**
TTP311	Simulation of Fibre Production Processes	1-0-4	**3**
TTR310	Professional Practices (TT)	0-1-2	**2**
TTS310	Independent Study (TT)	0-3-0	**3**
TTV301	Special Module in Yarn Manufacture	1-0-0	**1**
TTV302	Special Module in Fabric Manufacture	1-0-0	**1**
TTV303	Special Module in Textile Chemical Processing	1-0-0	**1**
TTV304	Special Module in Fibre Science	1-0-0	**1**
TTV305	Special Module in Textile Technology	1-0-0	**1**
TTD412	Major Project Part 2 (TT)	0-0-16	**8**

B.Tech. in Textile Technology

Semester I (Lect Courses: 4 — L 11, T 2, P 18, Weekly contact 31 — Credits 22)

Code	Title	L-T-P	Cr.
TTN110	Intro to Tex Tech	(0 - 0 - 4)	2
CS101/102	Int Comp Prg/Sc	(3 - 0 - 2)	4
MEL120	Mfg Practices	(2 - 0 - 4)	4
MAL110	Mathematics - I	(3 - 1 - 0)	4
CYL120	Inorg & Org Chem	(3 - 1 - 0)	4
CYP100	Chemistry Lab	(0 - 0 - 4)	2
HUN100 *	Intro Hu & So Sc	(0 - 0 - 4)	2

Semester II (Lect Courses: 5 — L 14, T 2, P 12, Weekly contact 28 — Credits 22)

Code	Title	L-T-P	Cr.
AML120	Materials Science	(3 - 0 - 2)	4
EEL102	Prin Elec Engg	(3 - 0 - 2)	4
MEL120	Graphic Science	(2 - 0 - 4)	4
MAL140	Prob. & Stat.	(3 - 1 - 0)	4
PHL110	Fields & Waves	(3 - 1 - 0)	4
PHP100	Physics Lab	(0 - 0 - 4)	2

Semester III (Lect Courses: 5 — L 15, T 3, P 9, Weekly contact 27 — Credits 22.5)

Code	Title	L-T-P	Cr.
TTL211	Str Phy Prop Fibre	(3 - 0 - 0)	3
TTP211	Intro to Fibers	(1 - 0 - 2)	2
TTL221	Yarn Manf. - I	(3 - 1 - 0)	4
TTP221	Yarn Manf Lab - I	(0 - 0 - 2)	1
TTL231	Fabric Manf. - I	(3 - 1 - 0)	4
TTP231	Fabric Manf. Lab-I	(0 - 0 - 2)	1
TTL241	Tech Tex P&F	(3 - 0 - 0)	3
TTP241	Tech T P&F Lab-I	(0 - 0 - 3)	1.5
CYL230	Polym Chemistry	(2 - 1 - 0)	3

Semester IV (Lect Courses: 5 — L 15, T 5, P 11, Weekly contact 31 — Credits 25.5)

Code	Title	L-T-P	Cr.
TTL212	Mfd. Fibre Tech.	(3 - 1 - 0)	4
TTP212	Mfd Fibre Tech Lab	(0 - 0 - 2)	1
TTL222	Yarn Manf. - II	(3 - 1 - 0)	4
TTP222	Yarn Manf Lab - II	(0 - 0 - 2)	1
TTL232	Fabric Manf. - II	(3 - 1 - 0)	4
TTP232	Fabric Manf. Lab-II	(0 - 0 - 4)	2
TTL242	Tech Tex Col	(3 - 1 - 0)	4
TTP242	Tech Tex Col Lab	(0 - 0 - 3)	1.5
HUL2xx	Hu. & So. Sc. #1	(3 - 1 - 0)	4

Semester V (Lect Courses: 6 — L 18, T 3, P 6, Weekly contact 27 — Credits 24)

Code	Title	L-T-P	Cr.
TTL361	Tex. Testing	(3 - 0 - 0)	3
TTP361	Tex. Testing Lab	(0 - 0 - 2)	1
TTL362	Theo Tex Struct.	(3 - 2 - 0)	5
TTP200	Des Tex Prd Proc	(0 - 0 - 4)	2
DE-1		(3 - 1 - 0)	4
OC-1		(3 - 0 - 0)	3
OC-2		(3 - 0 - 0)	3
HUL2xx	Hu. & So. Sc. #2	(3 - 0 - 0)	3

Semester VI (Lect Courses: 6 — L 17, T 4, P 6, Weekly contact 27 — Credits 24)

Code	Title	L-T-P	Cr.
DE-2 / TTD310/TTS310		(0 - 0 - 6)	3
DE-3		(3 - 0 - 0)	3
OC-3		(3 - 1 - 0)	4
DE-4		(3 - 0 - 0)	3
OC-4		(3 - 1 - 0)	4
OC-5		(3 - 0 - 0)	3
HUL2xx	Hu. & So. Sc. #3	(3 - 0 - 0)	3

summer

Code	Title	Cr.
TTT410	Practical Training (TT)	NC

Semester VII (Lect Courses: 5 — L 15, T 5, P 8, Weekly contact 28 — Credits 24)

Code	Title	L-T-P	Cr.
TTC410	Colloquium (TT)	(0 - 3 - 0)	3
TTD411	Maj Proj Pt1 (TT)	(0 - 0 - 6)	3
DE-5		(3 - 0 - 2)	4
DE-6		(3 - 0 - 0)	3
OC-6		(3 - 0 - 0)	3
OC-7		(3 - 1 - 0)	4
HUL2xx	Hu. & So. Sc. #4	(3 - 1 - 0)	4

Semester VIII (Lect Courses: 4 — L 13, T 2, P 2, Weekly contact 17 — Credits 16)

Code	Title	L-T-P	Cr.
DE-7		(3 - 0 - 2)	4
DE-8 / TTV		(1 - 0 - 0)	1
DE-9		(3 - 1 - 0)	4
OC-8		(3 - 0 - 0)	3
OC-9		(3 - 1 - 0)	4

TOTAL = 180.0

DC = 63, EAS = 20, BS = 20, HC = 2   (* either in 1st or 2nd sem.)

Reqd. DE=27, plan DE = 8 courses (or 6 courses+Major Project Part 2) + 1V course.

HU = 2@4 + 2@3 = 14 cr. from 4 courses.

Reqd. OC=34, plan OC = 7@4 + 2@3 = 34 cr. from 9 courses.

Programme Code: BB5 / (BB)
Bachelor of Technology in Biochemical Engineering and Biotechnology, and
Master of Technology in Biochemical Engineering and Biotechnology
Department of Biochemical Engineering and Biotechnology

The overall credits structure

Undergraduate Core (UC)		Undergraduate Elective (UE)	
Category	Credits	Category	Credits
DC	60	DE	20
BS	20	HM	14
EAS	20	OC	34
HU	2		
TOTAL	102	TOTAL	68

Program Core (PC)		Program Elective (PE)	
Category	Credits	Category	Credits
PC	32	PE	16

Total credits = 218

Basic Sciences (BS) Core

CYL120	Inorganic and Organic Chemistry: Concepts and Applications	3-1-0	**4**
CYP100	Chemistry Laboratory	0-0-4	**2**
MAL110	Mathematics - I	3-1-0	**4**
MAL120	Mathematics - II	3-1-0	**4**
PHL110	Fields and Waves	3-1-0	**4**
PHP100	Physics Laboratory	0-0-4	**2**
	TOTAL BS Core	**12-4-8**	**20**

Engineering Arts and Sciences (EAS) Core

AML110	Engineering Mechanics	3-0-2	**4**
CHL110	Transport Phenomena	3-1-0	**4**
CSL101	Introduction to Computers and Programming OR	3-0-2	**4**
CSL102	Introduction to Computer Science	3-0-2	**4**
MEL110	Graphic Science	2-0-4	**4**
MEL120	Manufacturing Practices	2-0-4	**4**
	TOTAL EAS Core	**13-1-12**	**20**

Humanities and Social Sciences (HC) Core

HUN100	Introduction to Humanities and Social Sciences	0-0-4	**2**

Departmental Core (DC)

BEC450	Colloquium (BB)	0-3-0	**3**
BEL101	Biochemistry	3-1-3	**5.5**
BEL102	Bioprocess Calculations	3-1-0	**4**
BEL103	General Microbiology	3-0-3	**4.5**
BEL204	Molecular Biology and Genetics	3-0-3	**4.5**
BEL301	Bioprocess Engineering	3-0-0	**3**
BEL302	Fluid Solid Systems	3-0-0	**3**
BEL401	Bioprocess Technology	2-0-0	**2**
BEL403	Enzyme Engineering and Technology	3-0-2	**4**
BEN150	Introduction to Biochemical Engineering and Biotechnology	0-0-4	**2**
BEP303	Design of Bioprocesses	0-1-3	**2.5**
BET450	Practical Training (BB)	—	**NC**
CHL101	Introduction to Chemical Engineering Thermodynamics	2-1-0	**3**
CHL103	Chemical Reactor Analysis and Design	3-1-0	**4**
CHL202	Process Systems Analysis and Control	3-1-0	**4**
CHL203	Transport Processes - I	3-1-0	**4**
CHL204	Transport Processes - II	3-1-0	**4**
CHP304	Chemical Engineering Laboratory - I	0-0-3	**1.5**
CHP305	Chemical Engineering Laboratory - II	0-0-3	**1.5**
	TOTAL DC	**37-11-24**	**60**

Departmental Electives (DE)

BED350	Mini Project (BB)	0-0-6	**3**
BEL311	Physical and Chemical Properties of Biomolecules	2-1-0	**3**
BEL312	Carbohydrates and Lipids in Biotechnology	2-1-0	**3**
BEL411	Food Science and Engineering	3-0-0	**3**
BEL412	Immunology	3-0-2	**4**
BEL413	Modelling and Simulation of Bioprocesses	3-0-2	**4**
BEL414	Thermodynamics of Biological Systems	3-0-0	**3**
BEL415	Advanced Bioprocess Control	3-0-0	**3**
BEL416	Membrane Applications in Bioprocessing	3-0-0	**3**
BEL417	Biophysics	3-0-0	**3**
BEL418	Bioinformatics	2-0-2	**3**
BEL419	Enzyme Catalyzed Organic Synthesis	2-0-2	**3**
BEL420	Analytical Methods in Biotechnology	2-0-2	**3**
BEL421	Metabolic Regulation and Engineering	3-0-0	**3**
BEL422	Solid State Cultivation	3-0-0	**3**
BER350	Professional Practices (BB)	0-1-2	**2**
BES350	Independent Study (BB)	0-3-0	**3**
BEV330	Special Module in Biochemical Engineering and Biotechnology	1-0-0	**1**
CHL277	Materials of Construction	3-0-0	**3**
CHL332	Fluidization Engineering	3-1-0	**4**
CHL392	Polymer Science and Engineering	3-1-0	**4**

Program Core (PC)

BEC750	Seminar (BB)	1-0-0	**NC**
BED851	Major Project Part 1 (BB)	0-0-12	**6**
BED852	Major Project Part 2 (BB)	0-0-28	**14**
BED853	Major Project Part 1 (BB)	0-0-8	**4**
BED854	Major Project Part 2 (BB)	0-0-32	**16***
BEL701	Biotechnology Resource Planning and IPR Issues	2-0-0	**2 ***
BEL702	Bioprocess Plant Design	3-0-4	**5**
BEL703	Downstream Processing in Biotechnology	3-0-4	**5**
	TOTAL PC	**9-0-48**	**32**

* BED853 and BED854 together are alternatives to BED851 and BED852.

Program Electives (PE)

BEL711	Recombinant DNA Technology	2-0-4	**4**
BEL712	Plant Cell Technology	2-0-2	**3**
BEL713	Microbial Engineering	3-0-0	**3**
BEL714	Protein Science and Engineering	3-0-0	**3**
BEL715	Biological Waste Treatment	3-0-2	**4**
BEL716	High Resolution Methods in Biotechnology	2-0-2	**3**
BEL717	Animal Cell Technology	3-0-2	**4**
BEL718	Combinatorial Biotechnology	3-0-0	**3**
BEL719	Current Topics in Biochemical Engineering and Biotechnology	3-0-0	**3**
BEL720	Biotechnology in Food Processing	3-0-0	**3**
BEL721	Bionanotechnology	3-0-0	**3**
BEL722	Genomics and Proteomics	3-0-0	**3**
BEL723	Data Analysis for DNA Microarrays	3-0-2	**4**
BEL724	Advanced Biochemistry	3-0-0	**3**

B.Tech. + M.Tech. in Biochemical Engineering and Biotechnology (BB) **BB5**

Sem.	Code	Title	L	T	P	Cr	Code	Title	L	T	P	Cr	Code	Title	L	T	P	Cr	Code	Title	L	T	P	Cr	Code	Title	L	T	P	Cr	Code	Title	L	T	P	Cr	Code	Title	L	T	P	Cr	Code	Title	L	T	P	Cr	Code	Title	L	T	P	Cr	Lect cour	L	T	P	Week cont.	Cr.
I	BEN150	Intr Bioch Biotech	0	0	4	2	MEL120	Mfg Practices	2	0	4	4	AML110	Engg Mechanics	3	0	2	4	MAL110	Mathematics - I	3	1	0	4	CYL120	In & Or Chem	3	1	0	4	CYP100	Chemistry Lab	0	0	4	2	HUN100 *	Intro Hu & So Sc	0	0	4	2													4	11	2	18	31	22
II	CHL110	Transp. Phen.	3	1	0	4	CSL101/102	Int Comp Prg/Sc	3	0	2	4	MEL110	Graphic Science	2	0	4	4	MAL120	Mathematics - II	3	1	0	4	PHL110	Fields & Waves	3	1	0	4	PHP100	Physics Lab	0	0	4	2																				5	14	3	10	27	22
III	CHL101	Intr Ch E Thermo	2	1	0	3	CHL203	Transp Process-I	3	1	0	4	BEL101	Biochemistry	3	1	3	5.5	BEL103	Genrl Microbiology	3	0	3	4.5	HUL2xx	Hu. & So. Sc. #1	3	1	0	4																									5	14	4	6	24	21
IV	CHL204	Transp Process -II	3	1	0	4	BEL102	Bioprocess Calc	3	1	0	4	BEL302	Fluid Solid Syst	3	0	0	3	BEL204	Mol Bio Genetics	3	0	3	4.5	OC-1		3	1	0	4	HUL2xx	Hu. & So. Sc. #2	3	1	0	4																			6	18	4	3	25	23.5
V	CHL103	Ch React Ana Des	3	1	0	4	CHP304	Ch Engg Lab - I	0	0	3	1.5	BEL301	Bioprocess Engg	3	0	0	3	BEP303	Design Bioproc	0	1	3	2.5	DE-1a	Prof Prac BER350	0	0.5	1	1	OC-2		3	1	0	4	OC-3		3	1	0	4	HUL2xx	Hu. & So. Sc. #3	2	1	0	3							5	14	5.5	7	26.5	23
VI	CHL202	Proc Sys An Cntrl	3	1	0	4	CHP305	Ch Engg Lab - II	0	0	3	1.5	BEL401	Bioproc Technol	2	0	0	2	DE-1b	Prof Prac BER350	0	0.5	1	1	DE-2		3	0	0	3	DE-3		3	0	0	3	OC-4		3	1	0	4	HUL2xx	Hu. & So. Sc. #4	2	1	0	3							6	16	3.5	4	24	21.5
summer		BET450 Practical Training (BB)																																																											NC	
VII	BEC450	Colloquium (BB)	0	3	0	3	BEL403	Enzy Engg Tech	3	0	2	4	DE-4		3	0	0	3	DE-5		3	0	0	3	DE-6	BED/BES	0	0	6	3	OC-5		3	1	0	4	OC-6		3	0	0	3	OC-7		3	0	0	3							6	18	4	8	30	26
VIII	BEL702	Bioproc Plant Des	3	0	4	5	BEL703	D/str Proc Biotech	3	0	4	5	PE-1		3	0	0	3	PE-2		3	0	0	3	DE-7		3	0	0	3	OC-8		3	0	2	4																			6	18	0	10	28	23
summer		BED851 Major Project Part 1 (BB)																																																												
IX	BEL701	Biotech Res Plng	2	0	0	2	BED851	Maj Proj P-1 (BB)	0	0	12	6	PE-3		3	0	0	3	PE-4		2	0	4	4	PE-5		3	0	0	3	OC-9		3	1	0	4																			5	13	1	16	30	22
X	BEC750	Seminar (BB)	1	0	0	NC	BED852	Maj Proj P-2 (BB)	0	0	28	14																																																	0	1	0	28	29	14
summer		BED852 Major Project Part 2 (BB)																																																												

DC = 60, EAS = 20, BS = 20, HC = 2; PC = 32. (* either in 1st or 2nd sem.)   Reqd. OC=34, plan OC = 7@4 + 2@3 = 34 cr. from 9 courses.

Reqd. DE=20, plan DE = 7 courses.   HU = 2@4 + 2@3 = 14 cr. from 4 courses.   Reqd. PE=16, plan PE = 1@4 + 4@3 = 16 cr. from 5 courses.

TOTAL = 218.0

Programme Code: CH7

Bachelor of Technology in Chemical Engineering, and
Master of Technology in Chemical Engineering
Department of Chemical Engineering

The overall credits structure

Undergraduate Core (UC)		Undergraduate Elective (UE)	
Category	Credits	Category	Credits
DC	60	DE	20
BS	20	HM	14
EAS	20	OC	34
HU	2		
TOTAL	*102*	*TOTAL*	*68*

Program Core (PC)		Program Elective (PE)	
Category	Credits	Category	Credits
PC	32	PE	16

Total credits = 218

Basic Sciences (BS) Core*

CYL110	Physical Chemistry: Concepts and Applications	3-1-0	**4**
CYL120	Inorganic and Organic Chemistry: Concepts and Applications	3-1-0	**4**
CYP100	Chemistry Laboratory	0-0-4	**2**
MAL110	Mathematics - I	3-1-0	**4**
MAL120	Mathematics - II	3-1-0	**4**
PHP100	Physics Laboratory	0-0-4	**2**
	TOTAL BS Core	**12-4-8**	**20**

* In addition to the above BS core courses, either PHL110 or PHL120 has to be taken as an open category course for graduation.

Engineering Arts and Sciences (EAS) Core

AML120	Materials Science	3-0-2	**4**
CSL101	Introduction to Computers and Programming OR	3-0-2	**4**
CSL102	Introduction to Computer Science	3-0-2	**4**
EEL102	Principles of Electrical Engineering	3-0-2	**4**
MEL110	Graphic Science	2-0-4	**4**
MEL120	Manufacturing Practices	2-0-4	**4**
	TOTAL EAS Core	**13-0-14**	**20**

Humanities and Social Sciences (HC) Core

HUN100	Introduction to Humanities and Social Sciences	0-0-4	**2**

Departmental Core (DC)

CHC410	Colloquium (CH)	0-3-0	**3**
CHL110	Transport Phenomena	3-1-0	**4**
CHL111	Material and Energy Balance	2-2-0	**4**
CHL112	Chemical Process Technology	3-1-0	**4**
CHL121	Chemical Engineering Thermodynamics	3-1-0	**4**
CHL122	Chemical Reaction Engineering – I	3-1-0	**4**
CHL221	Chemical Reaction Engineering – II	3-1-0	**4**
CHL231	Fluid Mechanics for Chemical Engineers	3-1-0	**4**
CHL251	Heat and Mass Transfer	3-1-0	**4**
CHL261	Instrumentation and Process Control	3-1-0	**4**
CHL331	Fluid-particle Mechanics	3-1-0	**4**
CHL351	Mass Transfer Operations	3-1-0	**4**
CHL471	Process Equipment Design and Economics	3-0-3	**4.5**
CHN110	Introduction to Chemical Engineering	0-0-4	**2**
CHP301	Fluid Mechanics and Heat Transfer Laboratory	0-0-3	**1.5**
CHP302	Mass Transfer and Fluid Particle Mechanics Laboratory	0-0-3	**1.5**
CHP303	Chemical Reaction Engineering and Process Control Laboratory	0-0-3	**1.5**
CHP311	Design and Laboratory Practices	0-0-4	**2**
CHT410	Practical Training (CH)	—	**NC**
	TOTAL DC	**35-15-20**	**60**

Departmental Electives (DE)

CHL133	Powder Processing and Technology	3-1-0	**4**
CHL260	Application of Programming in Chemical Engineering	3-0-2	**4**
CHL275	Safety and Hazards in the Process Industries	3-1-0	**4**
CHL277	Materials of Construction	3-0-0	**3**
CHL291	Introduction to Biochemical Engineering	3-1-0	**4**
CHL296	Nano Engineering of Soft Materials	3-0-0	**3**
CHL332	Fluidization Engineering	3-1-0	**4**
CHL353	Modern Separation Processes	3-1-0	**4**
CHL390	Process Utilities and Pipeline Design	3-0-2	**4**
CHL392	Polymer Science and Engineering	3-1-0	**4**
CHL705	Electrokinetic Transport Phenomena	3-0-2	**4**
CHL707	Adsorption Separation Processes	3-0-0	**3**
CHL710	Process Dynamics and Control	3-1-2	**5**
CHL722	Fundamentals of Fuel Cell Technology	3-0-2	**4**
CHL724	Environmental Engineering and Waste Management	3-1-0	**4**
CHL727	Heterogeneous Catalysis and Catalytic Reactors	3-0-2	**4**
CHL743	Petrochemical Technology	3-0-0	**3**
CHL751	Multi-component Mass Transfer	3-0-0	**3**
CHL766	Interfacial Engineering	3-0-0	**3**
CHL768	Fundamentals of Computational Fluid Dynamics	2-0-2	**3**
CHL773	Planning of Experiments and Analysis of Engineering Data	3-0-2	**4**
CHL774	Process Optimization	3-0-2	**4**
CHL793	Membrane Science and Engineering	3-0-0	**3**
CHL794	Petroleum Refinery Engineering	3-0-2	**4**
CHR310	Professional Practices (CH)	0-1-2	**2**
CHS310	Independent Study (CH)	0-3-0	**3**

Program Core (PC)

CHL701	Process Engineering	3-0-2	**4**
CHL721	Advance Chemical Engg. Thermodynamics	3-1-0	**4**
CHD771	Minor Project	0-0-8	**4**
CHD871	Major Project Part 1 (CM)	0-0-12	**6**
CHD872	Major Project Part 2 (CM)	0-0-28	**14**
CHD873	Major Project Part 1 (CM)	0-0-8	**4***
CHD874	Major Project Part 2 (CM)	0-0-32	**16***
	TOTAL PC	**6-1-50**	**32**

*CHD873 and CHD874 together are alternatives to CHD871 and CHD872.

Program Electives (PE)

CHL704	Ploymer Matrix Composites- Processes and Process Modelling	3-1-0	**4**
CHL705	Electrokinetic Transport Phenomena	3-0-2	**4**
CHL710	Process Dynamics and Control	3-1-2	**5**
CHL711	Numerical Methods in Chemical Engineering	3-0-2	**4**
CHL717	Mechnical Design of Process Equipment	3-0-2	**4**
CHL724	Environmental Engineering & Waste Mgmt	3-1-0	**4**
CHL727	Heterogeneous Catalysis & Catalytic Process	3-0-2	**4**
CHL731	Introduction to Soft Matter	3-0-0	**3**
CHL732	Soft Lithographic Methods for Nano-Fabrication	3-0-0	**3**
CHL735	Design of Separation Processes	3-0-2	**4**
CHL740	Special Topics	3-0-0	**3**
CHL751	Multicomponent Mass Transfer	3-0-0	**3**
CHL761	Chemical Engineering Mathematics	3-0-0	**3**
CHL766	Interfacial Engineering	3-0-0	**3**
CHP768	Fundamentals of Computational Fluid Dynamics	2-0-2	**3**
CHL771	Process Operation Scheduling	3-0-2	**4**
CHL774	Process Optimization	3-0-2	**4**
CHL793	Membrane Science and Engineering	3-0-0	**3**
CHL794	Petroleium Refinery Engineering	3-0-2	**4**
CHL807	Population Balance Modelling	3-0-0	**3**
CHL869	Applications of Computational Fluid Dynamics	2-0-2	**3**

B.Tech. in Chemical Engg. + M.Tech. in Chemical Engineering (CM) CH7

Each course entry below is listed as: **Code — Name (L T P Cr)**

Sem. I — Lect cour 4 — (L 11, T 2, P 18, Week cont. 31, Cr 22)
Code	Name	L	T	P	Cr
CHN110	Intr to Chem Engg	0	0	4	2
CSL101/102	Int Comp Prg/Sc	3	0	2	4
MEL110	Graphic Science	2	0	4	4
MAL110	Mathematics - I	3	1	0	4
CYL120	Inorg & Org Chem	3	1	0	4
CYP100	Chemistry Lab	0	0	4	2
HUN100 *	Intro Hu & So Sc	0	0	4	2

Sem. II — Lect cour 5 — (L 14, T 3, P 10, Week cont. 27, Cr 22)
Code	Name	L	T	P	Cr
CHL110	Transp Phen	3	1	0	4
EEL102	Prin Elec Engg	3	0	2	4
MEL120	Mfg Practices	2	0	4	4
MAL120	Mathematics - II	3	1	0	4
CYL110	Physical Chem.	3	1	0	4
PHP100	Physics Lab	0	0	4	2

Sem. III — Lect cour 6 — (L 17, T 6, P 2, Week cont. 25, Cr 24)
Code	Name	L	T	P	Cr
CHL111	Matl Energy Bal.	2	2	0	4
CHL121	Ch Engg Thermo	3	1	0	4
CHL231	Fl Mech Ch Engr	3	1	0	4
CHL251	Heat Mass Transf	3	1	0	4
AML120	Materials Science	3	0	2	4
HUL2xx	Hu. & So. Sc. #1	3	1	0	4

Sem. IV — Lect cour 5 — (L 15, T 5, P 7, Week cont. 27, Cr 23.5)
Code	Name	L	T	P	Cr
CHL112	Chem Proc Techn	3	1	0	4
CHL122	Ch React Engg-I	3	1	0	4
CHL351	Mass Transf Oprns	3	1	0	4
CHP311	Des Lab Practices	0	0	4	2
CHP301	F M & H T Lab	0	0	3	1.5
OC-1		3	1	0	4
HUL2xx	Hu. & So. Sc. #2	3	1	0	4

Sem. V — Lect cour 6 — (L 17, T 6.0, P 3, Week cont. 26.0, Cr 24.5)
Code	Name	L	T	P	Cr
CHL221	Ch React Engg-II	3	1	0	4
CHL261	Instr Proc Control	3	1	0	4.0
CHL331	Fluid-particle Mech	3	1	0	4
CHP302	M T & F P M Lab	0	0	3	1.5
OC-2		3	1	0	4
OC-3		3	1	0	4
HUL2xx	Hu. & So. Sc. #3	3	1	0	4

Sem. VI — Lect cour 5 — (L 15, T 4, P 6, Week cont. 25, Cr 22)
Code	Name	L	T	P	Cr
CHL471	Proc Eq Des Eco	3	0	3	4.5
CHP303	Ch RE & PC Lab	0	0	3	1.5
DE-1		3	1	0	4
DE-2		3	1	0	4
OC-4		3	1	0	4
OC-5		3	1	0	4

summer — CHT410 Practical Training (CH) — Lect cour NC

Sem. VII — Lect cour 6 — (L 17, T 6, P 2, Week cont. 25, Cr 24)
Code	Name	L	T	P	Cr
CHC410	Colloquium (CH)	0	3	0	3
CHL701	Process Engg	3	0	2	4
DE-3		3	1	0	4
DE-4		3	1	0	4
OC-6		3	0	0	3
OC-7		3	0	0	3
HUL2xx	Hu. & So. Sc. #4	3	1	0	3

Sem. VIII — Lect cour 4 — (L 12, T 4, P 8, Week cont. 24, Cr 20)
Code	Name	L	T	P	Cr
CHL721	Adv Ch E Thermo	3	1	0	4
CHD771	Minor Project	0	0	8	4
DE-5		3	1	0	4
OC-8		3	1	0	4
OC-9		3	1	0	4

summer — CHD871 Major Project Part 1 (CM)

Sem. IX — Lect cour 4 — (L 12, T 4, P 12, Week cont. 28, Cr 22)
Code	Name	L	T	P	Cr
CHD871	Maj Proj P-1 (CM)	0	0	12	6
PE-1		3	1	0	4
PE-2		3	1	0	4
PE-3		3	1	0	4
PE-4		3	1	0	4

Sem. X — Lect cour 0 — (L 0, T 0, P 28, Week cont. 28, Cr 14)
Code	Name	L	T	P	Cr
CHD872	Maj Proj P-2 (CM)	0	0	28	14

summer — CHD872 Major Project Part 2 (CM)

TOTAL = 218.0

DC = 60, EAS = 20, BS = 20, HC = 2; PC = 32. (* either in 1st or 2nd sem.)

Reqd. DE=20, plan DE = 5 courses.

HU = 2@4 + 2@3 = 14 cr. from 4 courses.

Reqd. OC=34, plan OC = 7@4 + 2@3 = 34 cr. from 9 courses.

Reqd. PE=16, plan PE = 4@4 = 16 cr. from 4 courses.

Programme Code: CS5 / (CO)

Bachelor of Technology in Computer Science and Engineering, and
Master of Technology in Computer Science and Engineering
Department of Computer Science and Engineering

The overall credits structure

Undergraduate Core (UC)		Undergraduate Elective (UE)	
Category	Credits	Category	Credits
D C	54	DE	24
BS	24	HM	14
EAS	20	O C	30
HU	2		
TOTAL	*100*	*TOTAL*	*68*

Program Core (PC)		Program Elective (PE)	
Category	Credits	Category	Credits
PC	32	PE	16

Total credits = 216

Basic Sciences (BS) Core

CYL110	Physical Chemistry: Concepts and Applications	3-1-0	4
CYP100	Chemistry Laboratory	0-0-4	2
MAL111	Introduction to Analysis and Differential Equations	3-1-0	4
MAL124	Introduction to Algebra and Matrix Analysis	3-1-0	4
PHL110	Fields and Waves	3-1-0	4
PHL120	Physics of Materials	3-1-0	4
PHP100	Physics Laboratory	0-0-4	2
	TOTAL BS Core	**15-5-8**	**24**

Engineering Arts and Sciences (EAS) Core

AML110	Engineering Mechanics	3-0-2	4
CSL101	Introduction to Computers and Programming OR	3-0-2	4
CSL102	Introduction to Computer Science	3-0-2	4
EEL101	Fundamentals of Electrical Engineering	3-0-2	4
MEL110	Graphic Science	2-0-4	4
MEL120	Manufacturing Practices	2-0-4	4
	TOTAL EAS Core	**13-0-14**	**20**

Humanities and Social Sciences (HC) Core

HUN100	Introduction to Humanities and Social Sciences	0-0-4	2

Departmental Core (DC)

CSC410	Colloquium (CS)	0-3-0	3
CSL105	Discrete Mathematical Structures	3-1-0	4
CSL201	Data Structures	3-0-4	5
CSL211	Computer Architecture	3-1-2	5
CSL302	Programming Languages	3-0-4	5
CSL356	Analysis and Design of Algorithms	3-1-0	4
CSL373	Operating Systems	3-0-4	5
CSL374	Computer Networks	3-0-3	4.5
CSN110	Introduction to Computer Science and Engineering	0-0-4	2
CSP301	Design Practices in Computer Science	0-1-4	3
CST410	Practical Training (CS)	—	NC
EEL201	Digital Electronic Circuits	3-1-0	4
EEL205	Signals and Systems	3-1-0	4
EEP201	Electronics Laboratory - I	0-0-3	1.5
MAL250	Introduction to Probability Theory and Stochastic Processes	3-1-0	4
	TOTAL DC	**30-10-28**	**54**

Departmental Electives (DE)

CSL303	Logic for Computer Science	3-0-2	4
CSL316	Digital Hardware Design	3-0-4	5
CSL332	Introduction to Database Systems	3-0-3	4.5
CSL333	Artificial Intelligence	3-0-2	4
CSL361	Numerical and Scientific Computing	3-1-2	5
CSL705	Theory of Computation	3-1-0	4
CSL719	Synthesis of Digital Systems	3-0-2	4
CSL724	Advanced Computer Networks	3-0-2	4
CSL728	Compiler Design	3-0-3	4.5
CSL730	Modern Paralled Programming	3-0-2	4
CSL740	Software Engineering	3-0-2	4
CSL750	Foundations of Automatic Verification	3-0-2	4
CSL759	Cryptography and Computer Security	3-0-0	3
SIL765	Network & System Security	3-0-2	4
SIL769	Internet Traffic-Measurement, Modelling & Analysis	3-0-2	4
CSL771	Database Implementations	3-0-2	4
CSL781	Computer Graphics	3-0-3	4.5
CSL783	Digital Image Analysis	3-0-3	4.5
CSP315	Embedded System Design Laboratory	0-1-6	4
CSR310	Professional Practices (CS)	0-1-2	2
CSS310	Independent Study (CS)	0-3-0	3

Program Core (PC)

CSD750	Minor Project (CO)	0-1-6	4
CSD851	Major Project Part 1 (CO)	0-0-12	6
CSD852	Major Project Part 2 (CO)	0-0-28	14
CSD853	Major Project Part 1 (CO)	0-0-8	4*
CSD854	Major Project Part 2 (CO)	0-0-32	16*
CSL718	Architecture of High Performance Computers	3-0-2	4
CSL758	Advanced Algorithms	3-1-0	4
	TOTAL PC	**6-2-48**	**32**

* CSD853 and CSD854 together are alternatives to CSD851 and CSD852.

Program Electives (PE)

CSL719	Synthesis of Digital Systems	3-0-2	4
CSL724	Advanced Computer Networks	3-0-2	4
CSL728	Compiler Design	3-0-3	4.5
CSL730	Modern Paralled Programming	3-0-2	4
CSL740	Software Engineering	3-0-2	4
CSL750	Foundations of Automatic Verification	3-0-2	4
CSL759	Cryptography and Computer Security	3-0-0	3
SIL765	Network & System Security	3-0-2	4
SIL769	Internet Traffic-Measurement, Modelling & Analysis	3-0-2	4
CSL771	Database Implementations	3-0-2	4
CSL781	Computer Graphics	3-0-3	4.5
CSL783	Digital Image Analysis	3-0-3	4.5
CSL812	System Level Design and Modelling	3-0-0	3
CSL821	Reconfigurable Computing	3-0-0	3
CSL830	Distributed Computing	3-0-0	3
CSL831	Semantics of Programming Languages	3-0-0	3
CSL832	Proofs and Types	3-0-0	3
CSL840	Computer Vision	3-0-2	4
CSL847	Distributed Algorithms	3-0-0	3
CSL851	Algorithmic Graph Theory	3-0-0	3
CSL852	Computational Geometry	3-0-2	4
CSL853	Complexity Theory	3-0-0	3
CSL854	Approximation Algorithms	3-0-0	3
CSL855	Models of Computation	3-0-0	3
CSL856	Mathematical Programming	3-0-0	3
CSL858	Advanced Computer Networks	3-0-2	4
CSL859	Advanced Computer Graphics	3-0-2	4
CSL860	Special Topics in Parallel Computation	3-0-0	3
CSL861	Special Topics in Hardware Systems	3-0-0	3
CSL862	Special Topics in Software Systems	3-0-0	3
CSL863	Special Topics in Theoretical Computer Science	3-0-0	3
CSL864	Special Topics in Artificial Intelligence	3-0-0	3
CSL865	Special Topics in Computer Applications	3-0-0	3
CSL866	Special Topics in Algorithms	3-0-0	3
CSL867	Special Topics in High Speed Networks	3-0-0	3
CSL868	Special Topics in Database Systems	3-0-0	3
CSL869	Special Topics in Concurrency	3-0-0	3
CSV880	Special Module in Parallel Computation	1-0-0	1
CSV881	Special Module in Hardware Systems	1-0-0	1
CSV882	Special Module in Software Systems	1-0-0	1
CSV883	Special Module in Theoretical Computer Science	1-0-0	1
CSV884	Special Module in Artificial Intelligence	1-0-0	1
CSV885	Special Module in Computer Applications	1-0-0	1
CSV886	Special Module in Algorithms	1-0-0	1
CSV887	Special Module in High Speed Networks	1-0-0	1
CSV888	Special Module in Database Systems	1-0-0	1
CSV889	Special Module in Concurrency	1-0-0	1

B.Tech. + M.Tech. in Computer Science and Engineering (CO) CS5

Sem.	Courses (Code / Name / L T P Cr)	Lect cour	L	T	P	Week cont	Cr
I	CSN110 Intr Comp Sc Engg 0 0 4 2 · CSL101/102 Int Comp Prg/Sc 3 0 2 4 · MEL110 Graphic Science 2 0 4 4 · MAL111 Analysis Diff Eqns 3 1 0 4 · PHL110 Fields & Waves 3 1 0 4 · PHP100 Physics Lab 0 0 4 2 · HUN100 * Intro Hu & So Sc 0 0 4 2	4	11	2	18	31	22
II	CSL201 Data Structures 3 0 4 5 · EEL101 Fund Elec Engg 3 0 2 4 · MEL120 Mfg Practices 2 0 4 4 · MAL124 Alg Matrix Analys 3 1 0 4 · CYL110 Physical Chem. 3 1 0 4 · CYP100 Chemistry Lab 0 0 4 2	5	14	2	14	30	23
III	CSL105 Discrete Math Stru 3 1 0 4 · CSL211 Computer Arch 3 1 2 5 · CSP301 Des Pract in CS 0 1 4 3 · EEL201 Digital Electronics 3 1 0 4 · EEP201 Electronics Lab - I 0 0 3 1.5 · AML110 Engg Mechanics 3 0 2 4 · HUL2xx Hu. & So. Sc. #1 3 1 0 4	5	15	5	11	31	25.5
IV	CSL302 Programing Lang. 3 0 4 5 · MAL250 Prob Stoch Proc. 3 1 0 4 · PHL120 Phy Materials 3 1 0 4 · DE-1 3 0 4 5 · HUL2xx Hu. & So. Sc. #2 3 1 0 4	5	15	3	8	26	22
V	CSL356 Analy Des Algor 3 1 0 4 · EEL205 Signals Systems 3 1 0 4 · DE-2 3 0 0 3 · OC-1 3 0 0 3 · OC-2 3 0 2 4 · HUL2xx Hu. & So. Sc. #3 2 1 0 3	6	17	3	2	22.0	21
VI	CSL373 Operating Systems 3 0 4 5 · DE-3 · DE-4 OR Indep. Study 3 0 0 3 · OC-3 3 0 2 4 · OC-4 3 0 2 4 · HUL2xx Hu. & So. Sc. #4 2 1 0 3	6	17	1	10	28	23
summer	CST410 Practical Training (CS)	NC					
VII	CSC410 Colloquium (CS) 0 3 0 3 · CSL374 Compu Networks 3 0 3 4.5 · PE-1 3 0 0 3 · DE-5 3 0 2 4 · OC-5 3 0 2 4 · OC-6 3 0 2 4	5	15	3	9	27	22.5
VIII	CSL718 Arch Hi Perf Com 3 0 2 4 · CSL758 Advanced Algori 3 1 0 4 · CSD750 Minor Project (CO) 0 1 6 4 · PE-2 3 0 0 3 · DE-7 3 0 2 4 · OC-7 3 0 2 4 · OC-8 3 0 2 4	5	15	2	14	31	24
summer	CSD851 Major Project Part 1 (CO)						
IX	CSD851 Maj Proj P-1 (CO) 0 0 12 6 · PE-3 3 0 0 3 · PE-4 3 0 0 3 · PE-5 3 0 0 3 · PE-6 1 0 0 1	4	13	0	12	25	19
X	CSD852 Maj Proj P-2 (CO) 0 0 28 14	0	0	0	28	28	14
summer	CSD852 Major Project Part 2 (CO)						

DC = 54, EAS = 20, BS = 24, HC = 2; PC = 32.   (* either in 1st or 2nd sem.)

Reqd. DE=24, plan DE = 6 courses.   HU = 2@4 + 2@3 = 14 cr. from 4 courses.

Reqd. OC=31, plan OC = 6@4 + 2@3 = 30 cr. from 8 courses.

Reqd. PE=16, plan PE = 6@3 = 18 cr. from 6 courses.

TOTAL = 216.0

Programme Code: EE5 / (EI)
Bachelor of Technology in Electrical Engineering, and
Master of Technology in Information and Communication Technology
Department of Electrical Engineering

The overall credits structure

Undergraduate Core (UC)		Undergraduate Elective (UE)	
Category	**Credits**	**Category**	**Credits**
DC	59	DE	21
BS	20	HM	14
EAS	21	OC	33
HU	2		
TOTAL	*102*	*TOTAL*	*68*

Program Core (PC)		Program Elective (PE)	
Category	**Credits**	**Category**	**Credits**
PC	32	PE	16

Total credits = 218

Basic Sciences (BS) Core

CYP100	Chemistry Laboratory	0-0-4	**2**
MAL111	Introduction to Analysis and Differential Equations	3-1-0	**4**
MAL124	Introduction to Algebra and Matrix Analysis	3-1-0	**4**
MAL250	Introduction to Probability Theory and Stochastic Processes	3-1-0	**4**
PHL110	Fields and Waves	3-1-0	**4**
PHP100	Physics Laboratory	0-0-4	**2**
	TOTAL BS Core	**12-4-8**	**20**

* In addition to the above BS core courses, either CYL110 or CYL120 has to be taken as an open category course for graduation.

Engineering Arts and Sciences (EAS) Core

AML110	Engineering Mechanics	3-0-2	**4**
CSL101	Introduction to Computers and Programming OR	3-0-2	**4**
CSL102	Introduction to Computer Science	3-0-2	**4**
CSL201	Data Structures	3-0-4	**5**
EEL101	Fundamentals of Electrical Engineering	3-0-2	**4**
MEL120	Manufacturing Practices	2-0-4	**4**
	TOTAL EAS Core	**14-0-14**	**21**

Humanities and Social Sciences (HC) Core

HUN100	Introduction to Humanities and Social Sciences	0-0-4	**2**

Departmental Core (DC)

EEC410	Colloquium (EE)	0-3-0	**3**
EEL201	Digital Electronic Circuits	3-1-0	**4**
EEL202	Circuit Theory	3-1-0	**4**
EEL203	Electromechanics	3-1-0	**4**
EEL204	Analog Electronics Circuits	3-1-0	**4**
EEL205	Signals and Systems	3-1-0	**4**
EEL207	Engineering Electromagnetics	3-1-0	**4**
EEL301	Control Engineering - I	3-1-0	**4**
EEL303	Power Engineering - I	3-1-0	**4**
EEL306	Communication Engineering	3-1-0	**4**
EEL308	Computer Architecture	3-1-0	**4**
EEN110	Introduction to Electrical Engineering	0-0-4	**2**
EEP201	Electronics Laboratory - I	0-0-3	**1.5**
EEP203	Electromechanics Laboratory	0-0-3	**1.5**
EEP204	Electronics Laboratory - II	0-0-3	**1.5**
EEP211	Design (EE)	0-0-4	**2**
EEP301	Control Engineering Laboratory	0-0-3	**1.5**
EEP303	Power Engineering Laboratory	0-0-3	**1.5**
EEP306	Communication Engineering Laboratory	0-0-3	**1.5**
EEP307	Electromagnetics Laboratory	0-0-3	**1.5**
EEP308	Computer Technology Laboratory	0-0-3	**1.5**
EET410	Practical Training (EE)	—	**NC**
	TOTAL DC	**30-13-32**	**59**

Departmental Electives (DE)

The list of Departmental Elective courses for this dual degree program is identical to the list of Departmental Elective courses for the *4-year Bachelor of Technology in Electrical Engineering* program. Please refer to the list given on page no. 26.
Also see EE1 Programme for Elective streams DE-A, -B, -C.

Program Core (PC)

EED851	Major Project Part 1 (EI)	0-0-12	**6**
EED852	Major Project Part 2 (EI)	0-0-28	**14**
EED853	Major Project Part 1 (EI)	0-0-8	**4***
EED854	Major Project Part 2 (EI)	0-0-32	**16***
EEL703	Computer Networks	3-0-0	**3**
EEL707	Multimedia Systems	3-0-2	**4**
EEL711	Signal Theory	3-0-0	**3**
EEP702	Software Laboratory	0-0-4	**2**
	TOTAL PC	**9-0-46**	**32**

* EED853 and EED854 together are alternatives to EED851 and EED852.

Program Electives (PE)

CSL858	Advanced Computer Networks	3-0-2	**4**
CSL859	Advanced Computer Graphics	3-0-2	**4**
CSL867	Special Topics in High Speed Networks	3-0-0	**3**
EED750	Minor Project (EI)	0-0-6	**3**
EEL702	Computer System Software	3-0-2	**4**
EEL704	Robotics and Automation	3-0-0	**3**
EEL706	Soft Computing	3-0-0	**3**
EEL708	Information Retrieval	3-0-0	**3**
EEL709	Pattern Recognition	3-0-0	**3**
EEL710	Coding Theory	3-0-0	**3**
EEL714	Information Theory	3-0-0	**3**
EEL715	Image Processing	3-0-2	**4**
EEL718	Statistical Signal Processing	3-0-0	**3**
EEL754	Computer Graphics	3-0-2	**4**
EEL758	Intelligent and Knowledge Based Systems	3-0-0	**3**
EEL767	Telecommunication Systems	3-0-0	**3**
EEL768	Detection and Estimation Theory	3-0-0	**3**
EEL781	Neural Networks	3-0-0	**3**
EEL804	Scientific Visualization	3-0-0	**3**
EEL806	Computer Vision	3-0-0	**3**
EEL817	Access Networks	3-0-0	**3**
EEL851	Special Topics in Computers - I	3-0-0	**3**
EEL852	Special Topics in Computers - II	3-0-0	**3**
EEL853	Agent Technology	3-0-0	**3**
EEL854	Protocol Engineering	3-0-2	**4**
EEL855	Internet Technologies	3-0-2	**4**
EEL857	Network Security	3-0-2	**4**
EEL858	Mobile Computing	3-0-0	**3**
EEL859	Network Management	3-0-2	**4**
EEL861	Selected Topics in Communication Engineering - I	3-0-0	**3**
EEL862	Selected Topics in Communication Engineering - II	3-0-0	**3**
EEL863	Selected Topics in Communication Engineering - III	3-0-0	**3**
EEV704	Special Module in Computers	1-0-0	**1**

B.Tech. in Electrical Engg. + M.Tech. in Information and Communication Technology (EI) EE5

Each course cell shows: code / title / L T P Cr

Sem.	Courses (L T P Cr)							Lect cour	L	T	P	Week cont	Cr
I	EEN110 Intro to Elec Engg 0 0 4 2	EEL101 Fund Elec Engg 3 0 2 4	MEL120 Mfg Practices 2 0 4 4	MAL111 Analysis Diff Eqns 3 1 0 4	PHL110 Fields & Waves 3 1 0 4	PHP100 Physics Lab 0 0 4 2	HUN100 * Intro Hu & So Sc 0 0 4 2	4	11	2	18	31	22
II	EEL205 Signals Systems 3 1 0 4	EEL203 Electromechanics 3 1 0 4	AML110 Engg Mechanics 3 0 2 4	MAL124 Alg Matrix Analy 3 1 0 4	CSL101/102 Int Comp Prg/Sc 3 0 2 4	CYP100 Chemistry Lab 0 0 4 2		5	15	3	8	26	22
III	EEL201 Digital Electronics 3 1 0 4	EEP201 Electronics Lab - I 0 0 3 1.5	EEL202 Circuit Theory 3 1 0 4	EEP203 Electromech Lab 0 0 3 1.5	CSL201 Data Structures 3 0 4 5	MAL250 Prob Stoch Proc. 3 1 0 4	HUL2xx Hu. & So. Sc. #1 3 1 0 4	5	15	4	10	29	24
IV	EEL301 Control Engg - I 3 1 0 4	EEL204 Analog Elec Cir 3 1 0 4	EEP204 Electronics Lab - II 0 0 3 1.5	EEL306 Communic Engg 3 1 0 4	EEL308 Computer Arch 3 1 0 4	EEP211 Des Practice (EE) 0 0 4 2	HUL2xx Hu. & So. Sc. #2 3 0 0 3	5	15	4	10	29	24
V	EEL207 Engg Electromag 3 1 0 4	EEL303 Power Engg - I 3 1 0 4	EEP301 Control Engg Lab 0 0 3 1.5	EEP306 Comm Engg Lab 0 0 3 1.5	DE-1 / DE-A 3 0 0 3	OC-1 3 1 0 4	HUL2xx Hu. & So. Sc. #3 2 1 0 3	6	17	4.0	6	27.0	24
VI	EEP303 Power Engg Lab 0 0 3 1.5	EEP307 Electromag Lab 0 0 3 1.5	DE-2 / DE-B 3 0 2 4	DE-3 3 0 0 3	OC-2 3 0 0 3	OC-3 3 0 0 3	HUL2xx Hu. & So. Sc. #4 3 1 0 4	6	18	1	10	29	24
summer	EET410 Practical Training (EE)							NC					
VII	EEC410 Colloquium (EE) 0 3 0 3	EEL711 Signal Theory 3 0 0 3	DE-C 3 0 2 4	OC-4 3 1 0 4	OC-5 3 1 0 4	OC-6 3 0 0 3		5	15	5	2	22	21
VIII	EEL703 Compu Networks 3 0 0 3	EEL707 Multimedia Sys 3 0 2 4	EEP702 Software Lab 0 0 4 2	DE-5 / EEV 1 0 2 2	PE-1 3 0 0 3	PE-2 3 1 0 4	OC-7 3 0 0 3	5	16	0	8	24	20
summer	EED851 Major Project Part 1 (EI)												
IX	EED851 Maj Proj P-1 (EI) 0 0 12 6	PE-3 3 0 0 3	PE-4 3 0 0 3	PE-5 3 0 2 4	OC-8 3 1 0 4	OC-9 3 0 0 3		5	15	1	14	30	23
X	EED852 Maj Proj P-2 (EI) 0 0 28 14							0	0	0	28	28	14
summer	EED852 Major Project Part 2 (EI)												
											TOTAL =		**218.0**

DC = 59, EAS = 21, BS = 20, HC = 2; PC = 32.　　(* either in 1st or 2nd sem.)　　Reqd. OC=33, plan OC = 6@4 + 3@3 = 33 cr. from 9 courses.

Reqd. DE=21, plan DE = 6 courses + 1 V-course.　　HU = 2@4 + 2@3 = 14 cr. from 4 courses.　　Reqd. PE=16, plan PE = 4@3 + 1@4 = 16 cr. from 5 courses.

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Programme Code: MT5 / (MT)
Master of Technology in Mathematics and Computing
Department of Mathematics

The overall credits structure

Integrated Core (IC)		Integrated Elective (IE)	
Category	**Credits**	**Category**	**Credits**
DC	90	DE	40
BS	20	HM	14
EAS	21	OC	29
HU	2		
TOTAL	*133*	*TOTAL*	*83*

Total credits = 216

Basic Sciences (BS) Core

CYL110	Physical Chemistry: Concepts and Applications	3-1-0	**4**
CYP100	Chemistry Laboratory	0-0-4	**2**
MAL115	Multivariable Calculus and Matrix Theory	3-1-0	**4**
MAL122	Real and Complex Analysis	3-1-0	**4**
PHL120	Physics of Materials	3-1-0	**4**
PHP100	Physics Laboratory	0-0-4	**2**
	TOTAL BS Core	**12-4-8**	**20**

Engineering Arts and Sciences (EAS) Core

AML110	Engineering Mechanics	3-0-2	**4**
CSL101	Introduction to Computers and Programming OR	3-0-2	**4**
CSL102	Introduction to Computer Science	3-0-2	**4**
CSL201	Data Structures	3-0-4	**5**
EEL101	Fundamentals of Electrical Engineering	3-0-2	**4**
MEL110	Graphic Science	2-0-4	**4**
	TOTAL EAS Core	**14-0-14**	**21**

Humanities and Social Sciences (HC) Core

HUN100	Introduction to Humanities and Social Sciences	0-0-4	**2**

Integrated Core (IC)

EEL201	Digital Electronic Circuits	3-1-0	**4**
EEL308	Computer Architecture	3-1-0	**4**
EEP201	Electronics Laboratory - I	0-0-3	**1.5**
EEP308	Computer Technology Laboratory	0-0-3	**1.5**
MAC450	Colloquium (MT)	0-3-0	**3**
MAD851	Major Project Part 1 (MT)	0-0-12	**6**
MAD852	Major Project Part 2 (MT)	0-0-28	**14**
MAD853	Major Project Part 1 (MT)	0-0-8	**4***
MAD854	Major Project Part 2 (MT)	0-0-32	**16***
MAL180	Discrete Mathematical Structures	3-1-0	**4**
MAL230	Numerical Methods and Computation	3-1-0	**4**
MAL245	Topology and Functional Analysis	3-1-0	**4**
MAL250	Introduction to Probability Theory and Stochastic Processes	3-1-0	**4**
MAL255	Linear Algebra	3-1-0	**4**
MAL335	Differential Equations: Theory and Numerical Methods	3-1-0	**4**
MAL342	Analysis and Design of Algorithms	3-1-0	**4**
MAL358	Operating Systems	3-0-2	**4**
MAL390	Statistical Methods and Algorithms	3-1-0	**4**
MAL710	Database Management Systems	3-0-2	**4**
MAL715	Digital Image Processing	3-0-2	**4**
MAL745	Software Engineering	3-0-2	**4**
MAL754	Principles of Computer Graphics	3-0-2	**4**
MAN150	Introduction to Mathematics and Computing	0-0-4	**2**
MAP290	System Design Laboratory	0-0-4	**2**
MAT450	Practical Training (MT)	—	**NC**
	TOTAL IC	**45-13-64**	**90**

***** MAD853 and MAD854 together are alternatives to MAD851 and MAD852.

Integrated Electives (IE)

AML710	Computer Aided Design and Design Methods	3-0-2	**4**
ASL410	Numerical Simulation of Atmospheric and Oceanic Phenomenon	3-0-2	**4**
BEL413	Modelling and Simulation of Bioprocesses	3-0-2	**4**
CSL374	Computer Networks	3-0-3	**4.5**
CSL728	Compiler Design	3-0-3	**4.5**
CYL410	Computational Methods and Analysis	3-0-0	**3**
EEL375	Embedded Systems	3-0-4	**5**
EEL422	Computers in Biomedicine	3-0-0	**3**
EEL703	Computer Networks	3-0-0	**3**
EEL704	Robotics and Automation	3-0-0	**3**
EEL706	Soft Computing	3-0-0	**3**
EEL707	Multimedia Systems	3-0-2	**4**
EEL708	Information Retrieval	3-0-0	**3**
EEL709	Pattern Recognition	3-0-0	**3**
EEL758	Intelligent and Knowledge Based Systems	3-0-0	**3**
EEL804	Scientific Visualization	3-0-0	**3**
EEL806	Computer Vision	3-0-0	**3**
MAD350	Mini Project (MT)	0-0-6	**3**
MAL145	Number Theory	3-1-0	**4**
MAL146	Combinatorics	3-1-0	**4**
MAL210	Optimization Methods and Applications	3-1-0	**4**
MAL256	Modern Algebra	3-1-0	**4**
MAL260	Boundary Value Problems	3-1-0	**4**
MAL311	Parallel Algorithms	3-0-2	**4**
MAL341	File Structures and Information Systems Design	3-0-2	**4**
MAL353	Algebraic Methods in Computer Science	3-1-0	**4**
MAL355	Partial Differential Equations: Theory and Computation	3-1-0	**4**
MAL365	Mathematical Programming Techniques	3-1-0	**4**
MAL373	Wavelets and Applications	3-1-0	**4**
MAL375	Programming Languages	3-0-2	**4**
MAL376	Graph Algorithms	3-1-0	**4**
MAL380	Numerical Linear Algebra	3-1-0	**4**
MAL381	Finite Element Theory and Applications	3-0-2	**4**
MAL382	Theory of Automata	3-1-0	**4**
MAL465	Parallel Computing	3-1-0	**4**
MAL466	Multivariate Statistical Methods	3-1-0	**4**
MAL468	Graph Theory	3-1-0	**4**
MAL717	Fuzzy Sets and Applications	3-1-0	**4**
MAL720	Neurocomputing and Applications	3-0-0	**3**
MAL732	Financial Mathematics	3-1-0	**4**
MAL733	Stochastic of Finance	3-1-0	**4**
MAL736	Information Integrity	3-1-0	**4**
MAL755	Algebraic Geometry	3-1-0	**4**
MAL760	Advanced Algorithms	3-0-2	**4**
MAL780	Special Topics in Computer Applications	3-0-2	**4**
MAL782	Data Mining and Knowledge Discovery	3-0-2	**4**
MAL785	Natural Language Processing	3-0-2	**4**
MAL786	Cryptology	3-1-0	**4**
MAL790	Special Topics in Computer Science	3-0-2	**4**
MEL420	Total Quality Management	3-0-2	**4**
SML410	Computational Techniques for Management Applications	3-0-2	**4**

Integrated M.Tech. in Mathematics and Computing   (MT) MA5

Sem.	Course	Title	L	T	P	cr	Lect cour	L	T	P	Week cont.	Cr.
I	MAN150	Intr Math & Comp	0	0	4	2	4	11	2	18	31	22
	MEL101	Graphic Science	2	0	4	4						
	CSL101/102	Intro Comp Prog	3	0	2	4						
	MAL115	Multivar Calculus	3	1	0	4						
	CYL110	Physical Chem.	3	1	0	4						
	CYP100	Chemistry Lab	0	0	4	2						
	HUN100 *	Intro Hu & So Sc	0	0	4	2						
II	AML110	Engg Mechanics	3	0	2	4	5	15	2	12	29	23
	CSL201	Data Structures	3	0	4	5						
	EEL101	Fund Elec Engg	3	0	2	4						
	MAL122	Real & Complex	3	1	0	4						
	PHL120	Physics Materials	3	1	0	4						
	PHP100	Physics Lab	0	0	4	2						
III	MAL180	Discr Math Struct	3	1	0	4	5	15	5	3	23	21.5
	MAL255	Linear Algebra	3	1	0	4						
	EEL201	Signals Systems	3	1	0	4						
	EEP201	Electronics Lab - I	0	0	3	1.5						
	OC-1		3	1	0	4						
	HUL2xx	Hu. & So. Sc. #1	3	1	0	4						
IV	MAL230	Num Meth Comp	3	1	0	4	6	18	5	3	26	24.5
	MAL342	Analy Des Algor	3	1	0	4						
	MAL250	Int Pro Th Sto Pro	3	1	0	4						
	EEL308	Computer Arch	3	1	0	4						
	EEP308	Comp Tech Lab	0	0	3	1.5						
	OC-2		3	0	0	3						
	HUL2xx	Hu. & So. Sc. #2	3	1	0	4						
V	MAP290	Sys Design Lab	0	0	4	2	5	15	1.0	12	28.0	22
	MAL358	Operating Systems	3	0	2	4						
	MAL754	Prin Comp Graph	3	0	2	4						
	DE-1		3	0	2	4						
	DE-2		3	0	2	4						
	OC-3		3	1	0	4						
VI	MAL335	Diff Eqns Th N M	3	1	0	4	6	18	2	6	26	23
	MAL745	Software Engg	3	0	2	4						
	MAL710	D B M S	3	0	2	4						
	MAL715	Digital Image Proc	3	0	2	4						
	DE-3		3	0	0	3						
	HUL2xx	Hu. & So. Sc. #3	3	1	0	4						
summer	MAT410	Practical Training (MT)					NC					
VII	MAC410	Colloquium (MT)	0	3	0	3	6	18	6	0	24	24
	MAL245	Topo Func Analys	3	1	0	4						
	DE-4		3	1	0	4						
	DE-5		3	0	0	3						
	DE-6		3	1	0	4						
	OC-4		3	0	0	3						
	HUL2xx	Hu. & So. Sc. #4	3	0	0	3						
VIII	MAL390	Stat Meth Algo	3	1	0	4	6	18	5	0	23	23
	DE-7		3	1	0	4						
	DE-8		3	0	0	3						
	DE-9		3	1	0	4						
	OC-5		3	1	0	4						
	OC-6		3	1	0	4						
summer	MAD851	Major Project Part 1 (MT)										
IX	MAD851	Maj Proj P-1 (MT)	0	0	12	6	4	12	1	12	25	19
	DE-10		3	0	0	3						
	DE-11		3	0	0	3						
	OC-7		3	1	0	4						
	OC-8		3	0	0	3						
X	MAD852	Maj Proj P-2 (MT)	0	0	28	14	0	0	0	28	28	14
summer	MAD852	Major Project Part 2 (MT)										
										TOTAL =		**216.0**

IC = 90, EAS = 21, BS = 20, HC = 2.   (* either in 1st or 2nd sem.)

HU = 2@4 + 2@3 = 14 cr. from 4 courses.

Reqd. DE=40, plan DE = 7@4 + 4@3 = 40 cr. from 11 courses.

Reqd. OC=29, plan OC = 5@4 + 3@3 = 30 cr. from 8 courses.

7. MINOR AREA STRUCTURES

Minor Area in Computer Science and Engineering
Department of Computer Science and Engineering

Eligibility/Restrictions

This minor area is not available to students of the following programmes: (i) B. Tech. in Electrical Engineering, (ii) Dual degree B.tech. in Electrical Engineering + M.Tech. in (information and Communication Technology), and (iii) Integrated M.Tech. in Mathematics and Computing.

Core courses

CSL201	Data Structures	3-0-2	**4**
CSL211	Computer Architecture	3-1-2	**5**

Elective courses

CSL302	Programming Languages	3-0-4	**5**
CSL332	Introduction to Database Systems	3-0-3	**4.5**
CSL356	Analysis and Design of Algorithms	3-1-0	**4**
CSL373	Operating Systems	3-0-4	**5**
CSL374	Computer Networks	3-0-3	**4.5**
CSL433	Artificial Intelligence	3-0-2	**4**

Minor Area in Computational Mechanics
Department of Applied Mechanics

Eligible/Restrictions

As per section 3.12.

Core courses

Any one of the following

AML140	Mechanics of Solids	3-1-0	**4**
AML150	Mechanics of Solids and Fluids	3-1-2	**5**
AML160	Mehcanics of Fluids	3-1-0	**4**
AML170	Fluid Mehcanics	3-1-2	**5**
AML180	Solid Mechanics	3-1-2	**5**
CHL204	Transport Processes-II	3-1-0	**4**
CHL231	Fluid Mechanics for Chemical Engineers	3-1-0	**4**

And

AML310	Computational Mechanics	3-0-2	**4**

Elective courses

AML300	Constitutive Modelling and Application of New Materials	3-0-0	**3**
AML340	Chaos in Engineering Systems	3-0-0	**3**
AML360	Engineering Fluid Flows	3-1-0	**4**
AML410	Computational Methods in Fluid Dynamics	3-0-2	**4**
AML430	Advanced Computational Methods	3-1-0	**4**
AML440	Parallel Processing in Computational Mechanics	3-0-2	**4**
AML705	Finite Element Methods	3-0-2	**4**
AML710	Computer Aided Design and Design Methods	3-0-2	**4**

Minor Area in Biochemical Engineeirng and Biotechnology
Department of Biochemical Engineering and Biotechnology

Eligibility/Restrictions

As per section 3.12

Core Courses

BEL110	Molecular Cell Biology	3-0-0	**3**
CHL291	Introduction to Biochemical Engineering	3-1-0	**4**

Elective Courses

BEL401	Bioprocess Technology	3-0-0	**3**
BEL413	Modelling and Simulation of Bioprocesses	3-0-2	**4**
BEL416	Membrance Applications of Bioprocessing	3-0-0	**3**
BEL418	Bioinformatics	2-0-2	**3**
BEL422	Solid State Cultivation	3-0-0	**3**

BEL701	Biotechnology Resource Planning and IPR Issues	2-0-0	**2**
BEL713	Microbial Engineering	3-0-0	**3**
BEL714	Protein Science and Engineering	3-0-0	**3**
BEL715	Biological Waste Treatment	3-0-2	**4**
BEL720	Biotechnology in Food Processign	3-0-0	**3**
BEL721	Bionantechnology	3-0-0	**3**

Minor Area in Process Engineering
Department of Chemical Engineering

Eligibility/Restriction

This minor area is nor available to students of Dual degree B.Tech. and M.tech in Biochamical Engineering and Biotechnology.

CHL110	Transport Phenomena	3-1-0	**4**
CHL111	Materail and Energy Balance	2-2-0	**4**

Elective Courses

CHL112	Chemical Process Technology	3-1-0	**4**
CHL231	Fluid Mechanics for Chemical Engineers	3-1-0	**4**
CHL251	Heat and Mass Transfer	3-1-0	**4**
CHL122	Chemical Reaction Engineering-I	3-1-0	**4**
CHL261	Instrumentation and Process Control	3-1-0	**4**
CHL331	Fluid-particle Mechanics	3-1-0	**4**
CHL275	Safety and Hazards in the Process Industries	3-1-0	**4**

Minor Area in Business Management
Department of Management Studies

Eligibility/Restrictions

As per section 3.12.

Core courses

SML391	Organization and Human Resource Management	3-1-0	**4**
SML494	Management Accounting and Financial Management	3-1-0	**4**

Elective courses

SML720	Business Environment and Corporate Strategy	2-0-2	**3**
SML745	Operations Management	2-0-2	**3**
SML760	Marketing Management	2-0-2	**3**
SML740	Quantitative Methods in Management	2-0-2	**3**
SML780	Managerial Economics	2-0-2	**3**
SML710	Creative Problem Solving	2-0-2	**3**
SML713	Information Systems Management	2-0-2	**3**
SML887	Business Law	2-0-2	**3**

Minor Area in Energy Technology
Department of Mechanical Engineering

Eligibility/Restrictions

As per section 3.12.

Core Courses

MEL140	Engineering Thermodynamics	3-1-0	**4**
MEL241	Energy Conversion	3-0-2	**4**

Elective courses

MEL242	Heat and Mass Transfer	3-1-0	**4**
MEP341	Thermal Engineering Laboratory	0-0-3	**1.5**
MEL341	Bas Dynamics and Propulsion	3-0-2	**4**
MEL342	Power Plant Technologies	3-0-2	**4**
MEL343	Fuels, Combustion and Pollution	3-0-2	**4**
MEL345	I.C. Engines	3-0-2	**4**
MEL346	Turbo-machinery	3-0-2	**4**

Minor Area in **Systems Dynamics and Control**
Department of Mechanical Engineering

Eligibility/Restrictions

As per Section 3.12.

Core courses

MEL211	Kinematics and Dynamics of Machines	3-0-2	4

Elective courses

MEL312	Control Theory and Applications	3-1-2	5
MEL316	Mechanical Vibrations	3-0-2	4
MEL411	Mechatronics	3-0-2	4
MEL415	Vibrations Engineering Design	3-0-2	4
MEL416	Robotics Engineering	3-1-0	4

Minor Area in **Nano Science and Engineering**
Department of Physics

Eligibility/Restrictions

As per Section 3.12

Core courses

PHL120	Physics of Materials	3-1-0	4
EPL206	Solid State Physics	3-1-0	4

Elective courses

EPL211	Principles of Material Synthesis	3-1-0	4
EPL335	Low Dimensional Physics	3-1-0	4
EPL444	Functional Nanostructures	3-0-0	3
EPL446	Applied Electrodynamics and Radiation	3-0-0	3
CHL296	Nano Engineering of Soft Materials	3-0-0	3
BEL721	Bionanotechnology	3-0-0	3
PHL727	Quantum Heterostructures	3-0-0	3
EPV430	Special Topics in Nano-Technology	1-0-0	1
EPV450	Selected Topics in Nano-Technology	2-0-0	2

Minor Area in **Photonics**
Department of Physics

Eligibility/Restrictions

As per Section 3.12

Core courses

PHL110	Fields and Waves	3-1-0	4
EPL105	Optics	3-1-0	4

Elective Courses

EPL334	Lasers	3-0-0	3
EPL336	Semiconductor Optoelectronics	3-1-0	4
EPL440	Quantum Electronics	3-0-0	3
EPL442	Fiber and Integrated Optics	3-0-0	3
EPL443	Holography and Optical Information Processing	3-0-0	3
EPL445	Engineering Optics	3-0-0	3
EPV431	Special Topics in Photonics and Opto-electronics	1-0-0	1
EPV451	Selected Topics in Photonics and Opto-electronics	2-0-0	2

Minor Area in **Atmospheric Sciences**
Center for Atmospheric Sciences

Eligibility/Restrictions

As per Section 3.12

Core Courses

ASL310	Fundamentals of Atmosphere and Ocean	3-0-2	4
ASL320	Climate Change: Impacts. Adaptation and Mitigation	3-0-2	4

Elective Courses

ASL410	Numerical Simulation of Atmospheric and Oceanic Phenomena	3-0-2	4
ASL701	Dynamics of Atmosphere and Ocean	3-0-0	3
ASL703	Physics of Atmosphere and Ocean	3-0-0	3
ASL705	Boundary Layer Meteorology and Air Pollution	3-0-0	3
ASL706	Parameterization of Physical Processes	3-0-0	3
ASL707	Mathematical & Statistical Methods in Atmosphere Sciences	3-0-0	3
ASL710	Atmospheric Physics	3-0-0	3
ASL712	Air Sea Interaction	3-0-0	3
ASL715	Science of Climate change	3-0-2	4
ASL718	Tropical Meteorology	3-0-0	3
ASL720	Satellite Meteorology and Remote Sensing	3-0-0	3
ASL722	Biological Oceanography	3-0-0	3
ASL724	Atmospheric Diffusion and Air Pollution	3-0-0	3
ASL804	Air Quality Monitoring and Health Risk Assessment	2-0-2	3
ASL808	Atmospheric Chemistry and Aerosols	3-0-0	3
ASL819	High Performance Computing in Atmospheric Science	2-0-2	3

Minor Area in **Biological Sciences**
School of Biological Sciences

Eligibility/Restrictions :
As per Section 3.12

Core Courses

SBL101	Modern Biology for Engineers	3-0-0	3
SBL201	High-Dimensional Biology	3-0-0	3
SBP200	Introduction to Practical Modern Biology	0-0-4	2

Elective Courses

SBL701	Biometry	3-0-0	3
SBL702	Systems Biology	3-0-0	3
BEL421	Metabolic Regulation and Engineering	3-0-0	3
CYL726	Cheminformatics and Molecular Modeling	3-0-0	3
BEL412	Immunology	3-0-2	4
SBL704	Human Virology	3-0-0	3
SBL707	Bacterial Pathogenesis	3-0-0	3
SBL708	Epigenetics in Health and Disease	3-0-0	3
BEL311	Physical and Chemical Properties of Biomolecules	3-0-0	3
SBL705	Biology of Proteins	3-0-0	3
BEL714	Protein Science and Engineering	3-0-0	3
BEL722	Genomics and Proteomics	3-0-0	3
SBL703	Advanced Cell Biology	3-0-0	3
SBL706	Biologics	3-0-0	3
SBL709	Marine Bioprospecting	3-0-0	3
SBL710	Chemical Biology	3-0-0	3
BML700	Introduction to Basic Medical Sciences for Engineers	3-0-0	3
CHL291	Introduction to Biochemical Engineering	3-1-0	4
SBD301	Mini Project	0-0-6	3

Guidelines: It is expected that students would complete the requirements of the Minor Area by exploring any of the above elective courses to be able to explore a variety of areas within the diverse field of biological sciences. However, an option of focusing on a particular aspect of biological sciences in the Minor Area has also been provided based on grouping of electives. For example: Choosing any 3 electives from S.Nos. 1-4 will equip students with background in computational biology, S.Nos. 5-8 will equip students with background in infectious diseases, S.Nos. 9-12 will equip students with proteomics, and, S.Nos. 13-18 will equip students with background in applied biological sciences. On the same lines, S.Nos. 2, 3 and 12 will equip the students with background in systems biology.

8. COURSES OF "ENVIRONMENTAL STUDIES" CATEGORY

UG COURSES

CEL100   Earth and earth process
CEL110   Basic concepts in sustainable development
CEL120   Pollution, prevention and control
CEL140   Environmental studies
HUL262   Environment psychology
CHL274   Environmental Engineering and waste Management
CHL275   Safety and hazards in the process industries
HUL275   Environment, development and society
ESL330   Energy, Ecology and Environment
ESL340   Non-conservational sources of energy
RDL340   Technology and community development
CEL411   Industrial waste management
CEL412   Environmental assessment methodologies
CEL443   Transportation safety and environment

PG COURSES

ESL710   Energy, ecology and environment
ESL720   Energy conservation
ESL722   Integrated energy systems

ESL725   Energy auditing
ESL735   Hazardous waste management
ESL740   Non-conventional sources of energy
ESL745   Environmental audit and impact assessment
ESL777   Environmental science and engineering
ESL776   Industrial energy and environmental analysis
ESL778   Industrial waste management and recycling
ESL756   Energy policy and planning
ESL764   Environmental economics
ESL804   Pollution control in power plants
EEL746   Non-conventional energy systems and energy
         conservation
CEL736   Environmental dynamics and management
CEL744   Ground water flow and pollution
CEL745   Water management
CEL763   Environmental rock engineering
CEL705   Geo-environmental engineering
CEL714   Special topics in geo technical and geo environmental
         engineering
CHL724   Environmental engineering and waste management
BEL715   Biological waste treatment

9. POSTGRADUATE PROGRAMME STRUCTURES

The following pages give details of the programme definitions that includes courses in each category, for every M.Sc., M.B.A., M.Des., and M.Tech. programme.

The upper part lists the category-wise credits required, followed by a list of courses in each category.

The table on the lower part shows a typical plan for scheduling the courses. This plan is only suggestive and will vary from student-to-student. Each student is encouraged to make his/her individual plan in consultation with his/her programme coordinator.

Postgraduate Diploma in *Naval Construction*
Department of Applied Mechanics

The overall credits structure

Category	PC	PE	OC	Total
Credits	49	-	-	49

Programme Core (PC)

AML701	Engineering Mathematics & Mechanics	3-0-0	3
AML702	Applied Computational Method	3-0-2	4
AML706	Finite Elements Method & Its Application to Marine Structures	3-0-0	3
AML713	Applied Fluid Mechanics	3-1-0	4
AML732	Solid Mechanics	3-0-0	3
AML733	Dynamics	3-0-0	3
AML751	Materials for Marine Vehicles	3-0-0	3
AML791	Ship Resistance & Propulsion	3-0-0	3
AML792	Structural Design of Ships	3-0-0	3
AML793	Ship Dynamics	3-0-0	3
AML794	Warship Design	3-0-0	3
AML795	Submarine Design	3-0-0	3
AML832	Applications of Theory of Plates and Shells	2-0-0	2
AMD897	Minor Project	0-0-6	3
AMD899	Design Project	0-0-20	10
	Total PC	***38-1-28***	**53**

Postgraduate Diploma in Naval Construction   **AMX**

Sem.	Courses (Number, abbreviated title, L-T-P, credits)						Lecture Courses	Contact h/week				Credits
								L	T	P	Total	
I	AML713 Appl Fluid Mech (3 - 1 - 0) 4	AML701 Engg Maths & Mechanics (3 - 0 - 0) 3	AML732 Solid Mechanics (3 - 0 - 0) 3	AML791 Ship Resistance & Propulsion (3 - 0 - 0) 3	AML792 Structural Des of Ships (3 - 0 - 0) 3	AML794 Warship Design (3 - 0 - 0) 3	*6*	18	1	0	19	**19**
II	AML702 Applied Comp. ... Methods (3 - 0 - 2) 4	AML706 Finite .... Structures (3 - 0 - 0) 3	AML793 Ship Dynamics (3 - 0 - 0) 3	AML795 Submarine Design (3 - 0 - 0) 3	AML832 Applications ... . Shells (2 - 0 - 0) 2	AMD897 Minor Project (0 - 0 - 6) 3	*6*	14	0	8	22	**18**
III	AML733 Dynamics (3 - 0 - 0) 3	AML751 Materials for Marine Vehicles (3 - 0 - 0) 3	AMD899 Design Project (0 - 0 - 20) 10				*2*	6	0	12	18	**16**

TOTAL = **53**

Postgraduate Diploma in **Metro Rail Transport : Technology and Management**
Department of Civil Engineering

The overall credits structure

Category	PC	PE	Total
Credits	24	12	36

Programme Core (PC)

CEL767	Construction and Contract Management	3-0-0	3
CEL769	Project Planning and Control	3-0-0	3
CEL781	Urban and Regional Transportation Planning	2-0-2	3
CEP770	Construction Engineering and Information Technology Lab	0-0-6	3
SML731	Human Resources Management	3-0-0	3
CEC760	Seminar	0-0-6	3
CEN760	Metro Professional Practices	0-2-0	2
CET760	Practical Training	0-0-8	4
	Toral PC	***11-2-22***	***24***

Programme Electives (PE)

CEL773	Management of Quality and Safety in Construction	3-0-0	3
CEL774	Construction Engineering Practices	3-0-0	3
CEL788	Public Transportation Systems	3-0-0	3
CEL886	Environmental Systems Analysis	3-0-2	4
CEL898	Life Cycle Analysis and Design for Environment	3-0-0	3
CEL761	Underground Space Technology	3-0-0	3
CEL612	Construction Methods in Geotechnical Engineering	3-0-0	3
CEL756	Excavation Methods and Machinery	3-0-0	3
CEL747	Geographical Information System	2-0-2	3
EEL747	Electrical Systems for Construction Industries	3-0-2	4
EEL745	Electrical Drives System	3-0-0	3
EEL746	Nonconventional Energy Systems and Energy Conservation	3-0-0	3
MEL710	Air Conditioning	3-0-2	4
MEL711	Refrigeration and Air Conditioning Technologies	3-0-2	4
MEL746	Design for Noise, Vibration and Harshness	3-0-2	4
SML826	Business Ethics	3-0-0	3
SML835	Labour Legislation and Industrial Relations	2-0-2	3
SML845	Total Project Systems Management	2-0-2	3

P.G. Diploma in Metro Rail Transport   **CEX**

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	L	T	P	Total	Credits
I	CEL769 Project Plng & Control (3 - 0 - 0) 3	CEL781 Urban & Regional Transport Plng (2 - 0 - 2) 3	CEP770 Const. Engg. & Infn. Tech. Lab (0 - 0 - 6) 3	CEN760 Metro Profes'nal Practices (0 - 2 - 0) 2		PE-1 (3 - 0 - 0) 3	PE-2 (3 - 0 - 0) 3	5	15	0	6	21	18
II	CEL767 Const. & Contract Mgmt. (3 - 0 - 0) 3	SML731 Human Resources Mgmt. (3 - 0 - 0) 3	CEC760 Seminar (0-0-6)3			PE-3 (2 - 0 - 0) 3	PE-4 (3 - 0 - 0) 3	5	15	0	6	21	18
Summer	CET760 (Practical Training) (0 - 0 - 8) 4												

TOTAL = 36

Master of Science in *Chemistry*
Department of Chemistry

The overall credits structure

Category	PC	PE	OC	Total
Credits	72	12	6	90

Programme Core (PC)

CYD660	Project Part 1(CYS)	0-0-6	3
CYD670	Project Part 2 (CYS)	0-0-16	8
CYL501	Molecular Thermodynamics	3-0-0	3
CYL502	Stereochemistry and Organic Reaction Mechanisms	3-0-0	3
CYL503	Main Group Chemistry and Inorganic Solids	3-0-0	3
CYL504	Biochemistry I	3-0-0	3
CYL505	Instrumental Methods of Analysis	3-0-0	3
CYL561	Quantum Chemistry	3-0-0	3
CYL562	Organic Synthesis	3-0-0	3
CYL563	Transition and Inner Transition Metal Chemistry	3-0-0	3
CYL564	Biochemistry II	3-0-0	3
CYL565	Chemical Dynamics and Surface Chemistry	3-0-0	3
CYL566	Physical Methods of Structure Determination of Organic Compounds	3-0-0	3
CYL601	Group Theory and Spectroscopy	3-0-0	3
CYL602	Pericyclic Reactions and Photochemistry	3-0-0	3
CYL603	Basic Organometallic Chemistry	3-0-0	3
CYL604	Biochemistry III	3-0-0	3
CYP501	Physical Chemistry Laboratory Course I	0-0-4	2
CYP502	Organic Chemistry Laboratory Course I	0-0-4	2
CYP503	Inorganic Chemistry Laboratory Course I	0-0-4	2
CYP504	Biochemistry Laboratory Course I	0-0-4	2
CYP561	Physical Chemistry Laboratory Course II	0-0-4	2
CYP562	Organic Chemistry Laboratory Course II	0-0-4	2
CYP563	Inorganic Chemistry Laboratory Course II	0-0-4	2
CYP564	Biochemistry Laboratory Course II	0-0-4	2
	Total PC	**45-0-54**	**72**

Programe Elecives (PE)

CYL665	Solid State Chemistry	3-0-0	3
CYL666	Chemistry of Macromolecules	3-0-0	3
CYL667	Selected Topics in Spectroscopy	3-0-0	3
CYL668	Statistical Mechanics and Molecular Simulation Methods	3-0-0	3
CYL669	Biophysical Chemistry I	3-0-0	3
CYL675	Chemistry of Heterocyclic Compounds and Natural Products	3-0-0	3
CYL676	Bio-organic and Medicinal Chemistry	3-0-0	3
CYL677	Supramolecular Chemistry	3-0-0	3
CYL678	Recent Trends in Organic Chemistry	3-0-0	3
CYL685	Applied Organometallic Chemistry	3-0-0	3
CYL686	Inorganic Polymers	3-0-0	3
CYL687	Bioinorganic Chemistry	3-0-0	3
CYL688	Physical Methods in Inorganic Chemistry	3-0-0	3
CYL695	Applied Biocatalysis	3-0-0	3
CYL696	Non-aqueous Enzymology	3-0-0	3
CYL697	Selected Topics in Biochemistry	3-0-0	3

Semester-wise Breakup

Sem.	Lecture courses	Contact hours/Week			
		L	T	P	Total
I	5	15	0	16	31
II	6	18	0	16	34
III	6	18	0	6	24
IV	4	12	0	16	28

M.Sc. in Chemistry   CYS

Sem.	Courses (Number, abbreviated title, L-T-P, credits)											Credits
I	CYL501 Molecular Thermo-dynamics (3 - 0 - 0) 3	CYL502 Stereochem & Organic React Mech (3 - 0 - 0) 3	CYL503 Main Group Chem & Inorg Solids (3 - 0 - 0) 3	CYL504 Biochemistry I (3 - 0 - 0) 3	CYL505 Instrumental Methods of Analysis (3 - 0 - 0) 3	CYP501 Physical Chemistry Lab Course I (0 - 0 - 4) 2	CYP502 Organic Chemistry Lab Course I (0 - 0 - 4) 2	CYP503 Inorganic Chemistry Lab Course I (0 - 0 - 4) 2	CYP504 Biochemistry Lab Course I (0 - 0 - 4) 2			23
II	CYL561 Quantum Chemistry (3 - 0 - 0) 3	CYL562 Organic Synthesis (3 - 0 - 0) 3	CYL563 Trans & Inner Trans Metal Chemistry (3 - 0 - 0) 3	CYL564 Biochemistry II (3 - 0 - 0) 3	CYL565 Chemical Dynamics & Surf. Chem (3 - 0 - 0) 3	CYL566 Phy Meth of Str Det of Org Compounds (3 - 0 - 0) 3	CYP561 Physical Chemistry Lab Course II (0 - 0 - 4) 2	CYP562 Organic Chemistry Lab Course II (0 - 0 - 4) 2	CYP563 Inorganic Chemistry Lab Course II (0 - 0 - 4) 2	CYP564 Biochemistry Lab Course II (0 - 0 - 4) 2		26
Summer												
III	CYD660 Project Part I (CYS) (0 - 0 - 6) 3	CYL601 Group Theory & Spectroscopy (3 - 0 - 0) 3	CYL602 Pericyclic Reactions & Photochem (3 - 0 - 0) 3	CYL603 Basic Organo Metallic Chemistry (3 - 0 - 0) 3	CYL604 Biochemistry III (3 - 0 - 0) 3		**PE-I** (3 - 0 - 0) 3	**PE-II** (3 - 0 - 0) 3				21
IV	CYD670 Project Part 2 (CYS) (0 - 0 - 16) 8						**PE-III** (3 - 0 - 0) 3	**PE-IV** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3		20

TOTAL = 90

Master of Science in Mathematics
Department of Mathematics

The overall credits structure

Category	PC	PE	OC	Total
Credits	72	12	6	90

Programme Core (PC)

MAD703	Project Part 1	0-0-8	**4**
MAD704	Project Part 2	0-0-8	**4**
MAL503	Linear Algebra	3-1-0	4
MAL509	Probability Theory	3-1-0	4
MAL513	Real Analysis	3-1-0	4
MAL517	Differential Equations	3-1-0	4
MAL519	Introduction to Computers & Programming	3-0-2	4
MAL514	Complex Analysis	3-1-0	4
MAL516	Algebra	3-1-0	4
MAL518	Methods of Applied Mathematics	3-1-0	4
MAL522	Statistical Inference	3-1-0	4
MAL524	Numerical Analysis	3-1-0	4
MAL526	Computer Oriented Operations Research	3-0-2	4
MAL601	Topology	3-1-0	4
MAL602	Functional Analysis	3-1-0	4
MAL609	Basic Computer Science	3-0-2	4
MAL630	Partial Differential Equations	3-1-0	4
MAP701	Computing Lab. I	0-0-4	2
MAP702	Computing Lab-II	0-0-4	2
	Total PC	**45-12-30**	**72**

Programe Elecives (PE)

CYL665	Solid State Chemistry	3-0-0	**3**
MAL607	Mathematical Logic	3-1-0	4
MAL611	Principles of Fluid Mechanics	3-1-0	4
MAL614	Advanced Matrix Theory	3-1-0	4
MAL617	Combinational Methods	3-1-0	4
MAL621	Computational Methods for Ordinary Differential Equations	3-1-0	4
MAL638	Applied Nonlinear Programming	3-1-0	4
MAL656	Graph Theory	3-1-0	4
MAL658	Programming Languages	3-1-0	4
MAL725	Stochastic Processes and Applications	3-1-0	4
MAL726	Principles of Optimization Theory	3-1-0	4
MAL727	Applied Multivariate Data Analysis	3-1-0	4
MAL728	Category Theory	3-1-0	4
MAL729	Computational Algebra and its Applications	3-0-2	4
MAL730	Cryptography	3-1-0	4
MAL731	Introduction to Chaotic Dynamical Systems	3-1-0	4
MAL732	Financial Mathematics	3-1-0	4
MAL733	Stochastic of Finance	3-1-0	4
MAL734	Algebraic Geometry	3-1-0	4
MAL735	Number Theory	3-1-0	4
MAL737	Differential Geometry	3-1-0	4

M.Sc. in Mathematics   MAS

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	L	T	P	Total	Credits
I	MAL503 Linear Algebra (3 - 1 - 0) 4	MAL509 Probability Theroy (3 - 1 - 0) 4	MAL513 Real Analysis (3 - 1 - 0) 4	MAL517 Differential Equations (3 - 1 - 0) 4	MAL519 Introduction Computers & Programming (3 - 0 - 2) 4			5	15	5	0	20	20
II	MAL514 Complex Analysis (3 - 1 - 0) 4	MAL516 Algebra Mathematics (3 - 1 - 0) 4	MAL518 Meth of Applied (3 - 1 - 0) 4	MAL522 Statistical Inference (3 - 1 - 0) 4	MAL524 Numerical Analysis Research (3 - 1 - 0) 4	MAL526 Comp Oriented Operations (3 - 0 - 2) 4		6	18	5	2	25	24
Summer													
III	MAL601 Topology (3 - 1 - 0) 4	MAL609 Basic Comp Science (3 - 0 - 2) 4	MAL630 Partial Differential Equations (3 - 1 - 0) 4	MAP701 Computing Lab. 1 (0 - 0 - 4) 2	MAD703 Project Part 1* (0 - 0 - 8) 4	PE-1 (3 - 1 - 0) 4	OE-1 (3 - 0 - 0) 3	5	15	3	14	32	25
IV	MAL602 Functional Analysis (3 - 1 - 0) 4	MAD704 Project Part 2 (0 - 0 - 8) 4	MAP702 Computing Lab 2 (0 - 0 - 4) 2		PE-2 (3 - 1 - 0) 4	PE-3 (3 - 1 - 0) 4	OE-2 (3 - 0 - 0) 3	5	12	3	12	27	21

TOTAL = 90

Master of Science in *Physics*
Department of Physics

The overall credits structure

Category	PC	PE	OC	*Total*
Credits	69	15	06	*90*

Programme Core (PC)

PHD651	Project Part 1	0-0-6	3
PHD652	Project Part 2	0-0-12	6
PHL551	Classical Mechanics	3-1-0	4
PHL552	Electrodynamics	3-1-0	4
PHL553	Mathematical Physics	3-1-0	4
PHL554	Concepts of Solids	3-1-0	4
PHL555	Quantum Mechanics	3-1-0	4
PHL556	Statistical Mechanics	3-1-0	4
PHL557	Electronics	3-1-0	4
PHL558	Applied Optics	3-1-0	4
PHL565	Cooperative Phenomena in Solids	3-1-0	4
PHL567	Atomic & Molec. Spectroscopy	3-1-0	4
PHL569	Nuclear Physics	3-1-0	4
PHP561	Laboratory I	0-0-12	6
PHP562	Laboratory II	0-0-12	6
PHP563	Advanced Laboratory	0-0-8	4
	Total PC	**33-11-50**	**69**

Programe Elecives (PE)

				Stream
PHD658	Mini Project	0-0-6	3	C
PHL653	Semiconductor Electronics	3-0-0	3	A
PHL654	Experimental Methods	3-0-0	3	A
PHL655	Laser Physics	3-0-0	3	B
PHL656	Microwaves	3-0-0	3	C

Programe Elecives (PE) (Contd.)

				Stream
PHL657	Plasma Physics	3-0-0	3	C
PHL702	Science and Techn. of Thin Films	3-0-0	3	A
PHL723	Vacuum Science and Cryogenics	3-0-0	3	A
PHL725	Physics of Amorphous Materials	3-0-0	3	A
PHL726	Nanostructured Materials	3-0-0	3	A
PHL741	Quantum Electrodynamics and Particle Physics	3-0-0	3	C
PHL742	General Relativity and Introductory Astrophysics	3-0-0	3	C
PHL743	Group Theory and its Applications	3-0-0	3	C
PHL744	Adv. Topics in Quantum Mechanics	3-0-0	3	C
PHL755	Statistical and Quantum Optics	3-0-0	3	B
PHL758	Theory and Application of Holography	3-0-0	3	B
PHL790	Integrated Optics	3-0-0	3	B
PHL791	Fiber Optics	3-0-0	3	B
PHL792	Optical Electronics	3-0-0	3	B

NOTE: Students are required to take at least one course from each of the streams. A, B and C. Students are NOT allowed to take M.Tech. (PHM) and (PHA) programme courses as Open Electives.

PHL661	Selected Topics #	3-0-0	3
PHL662	Special Topics #	3-0-0	3
PHS663	Independent Study #	3-0-0	3

Independent Study and Selected / Special Topics will be permitted in Semester III or IV only. Students with CGPA of 8.0 and above will be permitted to do this course. It will be counted against a stream depending on the theme of the topics covered in the course.

M.Sc. in Physics   **PHS**

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	L	T	P	Total	Credits
I	PHL551 Classical Mechanics (3 - 1 - 0) 4	PHL553 Mathematical Physics (3 - 1 - 0) 4	PHL555 Quantum Mechanics (3 - 1 - 0) 4	PHL557 Electronics (3 - 1 - 0) 4	PHP561 Laboratory 1 (0 - 0 - 12) 6			4	12	4	12	28	22
II	PHL552 Electrodynamics (3 - 1 - 0) 4	PHL554 Concepts of Solids (3 - 1 - 0) 4	PHL556 Statistical Mechanics (3 - 1 - 0) 4	PHL558 Applied Optics (3 - 1 - 0) 4	PHP562 Laboratory 2 (0 - 0 - 12) 6	**PE-1** (3 - 0 - 0) 3		5	15	4	12	31	25
Summer													
III	PHD651 Project Part 1 (0 - 0 - 6) 3	PHL565 Cooperative Pheno Solids (3 - 1 - 0) 4	PHL567 Atomic & Molec. Spectroscopy (3 - 1 - 0) 4	PHL569 Nuclear Physics (3 - 1 - 0) 4	PHP563 Adv.Laboratory (0 - 0 - 8) 4	**PE-2** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	5	15	3	14	32	25
IV	PHD652 Project Part 2 (0 - 0 - 12) 6			**PE-3** (3 - 0 - 0) 3	**PE-4** (3 - 0 - 0) 3	**PE-5** (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3	4	12	0	12	24	18

TOTAL =   90

Master of Business Administration (Focus on Management Systems)
Department of Management Studies
The overall credits structure

Category	Programme core PC	Compulsory Audit* CA	Non-credit core NC	Cross Focus elective FE	Specialization elective SE	Non-credit elective NE	Open elective OE	Total
Credits	45	6.5*	0	3	12	0	12	72

CORE COURSES

Programme Core (PC)

SMD890	Major Project	0-0-12	**6**
SML710	Creative Problem Solving	2-0-2	**3**
SML713	Information Systems Management	2-0-2	**3**
SML715	Quality and Environment Management	2-0-2	**3**
SML716	Fundamentals of Management Systems	3-0-0	**3**
SML717	Business Systems Analysis and Design	2-0-2	**3**
SML720	Business Environment and Corporate Strategy	2-0-2	**3**
SML730	Organization Management	3-0-0	**3**
SML731	Human Resource Management	3-0-0	**3**
SML740	Quantitative Methods in Management	2-0-2	**3**
SML745	Operations Management	3-0-0	**3**
SML760	Marketing Management	2-0-2	**3**
SML770	Managerial Accounting and Financial Management	2-0-2	**3**
SML780	Managerial Economics	2-0-2	**3**
	Total PC	**30-0-30**	**45**

Compulsory Bridge Core Courses (credits not to be counted for SGPA/ CGPA calculation)

SMP791	Computer Laboratory	0-0-2	**1**
SMN793	Statistics for Management	1-0-0	**1**
SMN794	Communication Skills	1-0-1	**1.5**
SMN795	Systems Thinking	1-0-0	**1**
SMN895	Management Research Methodology	1-0-0	**1**
SMN896	Human Values in Management	1-0-0	**1**
	Total Compulsory Audit	**5-0-3**	**6.5**

Non-credit core (NC)

SMT893	Industrial Training	--	**NC**

ELECTIVE COURSES

Cross Focus Elective (FE)
A student must take one of these three courses:

SML700	Fundamentals of Management of Technology	3-0-0	**3**
SML723	Telecommunications Systems Management	3-0-0	**3**
SML802	Management of Intellectual Property Rights	3-0-0	**3**

Specialization Elective (SE)
A student must specialize in one stream; the specialization streams are: *Strategic Management, Organization Management, Manufacturing Management, Information Technology Management, Marketing, Finance, Public Sector Management, and Consultancy Management*. The courses under each stream are listed on page No. 76.

Students specializing in one particular stream should take 12 credits from that stream; and she/he is allowed to take at most 9 credits from any other stream as open electives. Electives outside the specialization streams also form part of the open electives.

Non-credit Elective (NE)

SMC891	Strategic Leadership Practice	0-0-2	**NC**

Open Elective (OE)

SML714	Organizational Dynamics and Environment	3-0-0	**3**
SML734	Management of Small Scale Industrial Enterprises	3-0-0	**3**
SMP783	Management Laboratory	0-0-6	**3**
SML816	Total Quality Management	2-0-2	**3**
SML817	Management of System Waste	2-0-2	**3**
SML818	Industrial Waste Management	2-0-2	**3**
SML819	Business Process Reengineering	2-0-2	**3**
SML880	Selected Topics in Management	2-0-2	**3**
SML887	Business Law	2-0-2	**3**

Note: Also see the stipulation under *Specialization Elective* above.

M.B.A. (Focus on Management Systems)   SMF

Sem.	Courses (Number, abbreviated title, L-T-P, credits)								Lecture Courses	Contact h/week				Credits
										L	T	P	Total	
I	SML710 Creative Prob Solving (2 - 0 - 2) 3	SML730 Organization Mgmt (3 - 0 - 0) 3	SML740 Quant Meth in Mgmt (2 - 0 - 2) 3	SML760 Marketing Mgmt (2 - 0 - 2) 3	SML770 Mngrl Actng & Finan Mgmt (2 - 0 - 2) 3	SML780 Managerial Economics (2 - 0 - 2) 3	SMP791 Computer Laboratory (0 - 0 - 2) 1	SMN795 Systems Thinking (1 - 0 - 0) 1	6	14	0	12	26	18
II	SML713 Info Systems Management (2 - 0 - 2) 3	SML716 Fund of Mgmt Systems (3 - 0 - 0) 3	SML717 Bus Sys Anly & Design (2 - 0 - 2) 3	SML720 Bus Environ & Corp Strategy (2 - 0 - 2) 3	SML731 Human Res Management (3 - 0 - 0) 3	SML745 Operations Management (3 - 0 - 0) 3	SMN793 Statistics for Management (1 - 0 - 0) 1	SMN794 Commn Skills (1 - 0 - 1) 1.5	6	17	0	7.5	24.5	18
Summer	SMT893 Industrial Training								0					
III	SML715 Quality & Env Management (2 - 0 - 2)3	SMN895 Mgmt Resrch Methodology (1 - 0 - 0) 1		FE Cross Focus Elective (3 - 0 - 0) 3	SE-1 Specialization Elective (3 - 0 - 0) 3	SE-2 Specialization Elective (3 - 0 - 0) 3	OE-1 (3 - 0 - 0) 3	OE-2 (3 - 0 - 0) 3	6	18	0	2	20	18
IV	SMD890 Major Project (0 - 0 - 12)6	SMN896 Human Values in (1 - 0 - 0) 1	SMC891 Strat Leader Practice (0 - 0 - 2) 1		SE-3 Specialization Elective (3 - 0 - 0) 3	SE-4 Specialization Elective (3 - 0 - 0) 3	OE-3 (3 - 0 - 0) 3	OE-4 (3 - 0 - 0) 3	4	13	0	14	27	18

Underlined = Compulsory audit; FE = Cross focus elective; SE=Specialization elective; OE=Open elective   **TOTAL =72**

Master of Business Administration in Telecommunication Systems Management
Department of Management Studies

The overall credits structure

Category	Programme core PC	Compulsory Audit* CA	Non-credit core NC	Cross Focus elective FE	Specialization elective SE	Non-credit elective NE	Open elective OC	Total
Credits	45	6.5*	0	3	12	0	12	72

CORE COURSES

Programme Core (PC)

SMD890	Major Project	0-0-12	6
SML710	Creative Problem Solving	2-0-2	3
SML720	Business Environment and Corporate Strategy	2-0-2	3
SML723	Telecommunication System	3-0-0	3
SML726	Telecom Systems Analysis Planning and Design	3-0-0	3
SML728	International Telecommunication Management	3-0-0	3
SML730	Organization Management	3-0-0	3
SML731	Human Resource Management	3-0-0	3
SML740	Quantitative Methods in Management	2-0-2	3
SML745	Operations Management	3-0-0	3
SML760	Marketing Management	2-0-2	3
SML770	Managerial Accounting and Financial Management	2-0-2	3
SML780	Managerial Economics	2-0-2	3
EEL767	Telecom Systems Management	3-0-0	3
	Total PC	***27-0-24***	***45***

Compulsory Bridge Core Courses (credits not to be counted for SGPA/CGPA calculation)

SMP791	Computer Laboratory	0-0-2	1
SMN793	Statistics for Management	1-0-0	1
SMN794	Communication Skills	1-0-1	1.5
SMN795	Systems Thinking	1-0-0	1
SMN895	Management Research Methodology	1-0-0	1
SMN896	Human Values in Management	1-0-0	1
	Total Compulsory Audit	***5-0-3***	***6.5***

Non-credit core (NC)

SMT893	Industrial Training	--	**NC**

ELECTIVE COURSES

Cross Focus Elective (FE)
A student must take one of these three courses:

SML700	Fundamentals of Management of Technology	3-0-0	3
SML715	Quality and Environment Management	2-0-2	3
SML802	Management of Intellectual Property Rights	3-0-0	3

Specialization Elective (SE)
A student must specialize in one stream; the specialization streams are: *Strategic Management, Organization Management, Manufacturing Management, Information Technology Management, Marketing, Finance, Public Sector Management, and Consultancy Management*. The courses under each stream are listed on the page No. 76.

Students specializing in one particular stream should take 12 credits from that stream; and she/he is allowed to take at most 9 credits from any other particular stream as open electives. Electives outside the specialization streams also form part of the open electives.

Non-credit Elective (NE)

SMC891	Strategic Leadership Practice	0-0-2	**NC**

Open Elective (OE)

SML714	Organizational Dynamics and Environment	3-0-0	3
SML734	Management of Small Scale Industrial Enterprises	3-0-0	3
SMP783	Management Laboratory	0-0-6	3
SML816	Total Quality Management	2-0-2	3
SML817	Management of System Waste	2-0-2	3
SML818	Industrial Waste Management	2-0-2	3
SML819	Business Process Reengineering	2-0-2	3
SML847	Advanced Methods for Management Research	2-0-2	3
SML880	Selected Topics in Management	2-0-2	3
SML887	Business Law	2-0-2	3

Note: Also see the stipulation under Specialization Elective above.

M.B.A. (Telecommunication Systems Management)   SMT

Sem.	Courses (Number, abbreviated title, L-T-P, credits)								Lecture Courses	Contact h/week				Credits
										L	T	P	Total	
I	EEL767 Telecom Syst Management (3 - 0 - 0) 3	SML730 Organization Mgmt (3 - 0 - 0) 3	SML740 Quant Meth in Mgmt (2 - 0 - 2) 3	SML760 Marketing Mgmt (2 - 0 - 2) 3	SML770 Mngrl Actng & Finan Mgmt (2 - 0 - 2) 3	SML780 Managerial Economics (2 - 0 - 2) 3	SMP791 Computer Laboratory (0 - 0 - 2) 1	SMN795 Systems Thinking (1 - 0 - 0) 1	6	15	0	10	25	18
II	SML720 Bus Environ& Corp Strategy (2 - 0 - 2) 3	SML723 Telecommuntin Systems (3 - 0 - 0) 3	SML726 Tele Sys Anly Plang & Desi (3 - 0 - 0) 3	SML728 International Telec Mgmt (3 - 0 - 0) 3	SML731 Human Reso Management (3 - 0 - 0) 3	SML745 Operations Management (3 - 0 - 0) 3	SMN793 Statistics for Management (1 - 0 - 0) 1	SMN794 Commn Skills (1 - 0 - 1) 1.5	6	19	0	3	22	18
Summer	SMT893 Industrial Training								0					
III	SML710 Creative Prol Solving (2 - 0 - 2)3	SMN895 Mgmt Resrch Methodology (1 - 0 - 0) 1		FE Cross Focus Elective (3 - 0 - 0) 3	SE-1 Specialization Elective (3 - 0 - 0) 3	SE-2 Specialization Elective (3 - 0 - 0) 3	OE-1 (3 - 0 - 0) 3	OE-2 (3 - 0 - 0) 3	6	18	0	2	20	18
IV	SMD890 Major Project (0 - 0 - 12)6	SMN896 Human Values in (1 - 0 - 0) 1	SMC891 Strat Leader Practice (0 - 0 - 2) 1		SE-3 Specialization Elective (3 - 0 - 0) 3	SE-4 Specialization Elective (3 - 0 - 0) 3	OE-3 (3 - 0 - 0) 3	OE-4 (3 - 0 - 0) 3	4	13	0	14	27	18

Underlined = Compulsory audit; FE =Cross focus elective; SE=Specialization elective; OE=Open elective   **TOTAL = 72**

Master of Business Administration in Focus on Technology Management (Part Time)
Department of Management Studies
The overall credits structure

Category	Programme Core PC	Compulsory Audit* CA	Cross Focus Elective FE	Specialization Elective SE	Open elective OE	Non-credit Core NC	Non-credit Elective NE	Total
Credits	45	6.5*	3	12	12	0	0	72

CORE COURSES
Programme Core (PC)

SMD890	Major Project	0-0-12	6
SML700	Fundamentals of Management of Technology	3-0-0	3
SML701	Strategic Technology Management	2-0-2	3
SML702	Management of Innovation and R & D	2-0-2	3
SML703	Management of Technology Transfer and Absorption	2-0-2	3
SML710	Creative Problem Solving	2-0-2	3
SML720	Business Environment and Corporate Strategy	2-0-2	3
SML730	Organization Management	3-0-0	3
SML731	Human Resource Management	3-0-0	3
SML740	Quantitative Methods in Management	2-0-2	3
SML745	Operations Management	3-0-0	3
SML760	Marketing Management	2-0-2	3
SML770	Managerial Accounting and Financial Management	2-0-2	3
SML780	Managerial Economics	2-0-2	3
	Total PC	**30-0-30**	**45**

Compulsory Bridge Core Courses (credits not to be counted for SGPA/CGPA calculation)

SMP791	Computer Laboratory	0-0-2	1
SMN793	Statistics for Management	1-0-0	1
SMN794	Communication Skills	1-0-0	1
SMN795	Systems Thinking	1-0-0	1
SMN895	Management Research Methodology	1-0-0	1
SMN896	Human Values in Management	1-0-0	1
	Total Compulsory Audit	**5-0-3**	**6**

Non-credit core (NC)

SMC894	Seminar	0-0-2	**NC**

ELECTIVE COURSES
Cross Focus Elective (FE)
A student must take one of these three courses:

SML717	Busniess Systems Analysis and Design	2-0-2	3
SML723	Telecommunications Systems Management	3-0-0	3
SML802	Management of Intellectual Property Rights	3-0-0	3

Specialization Elective (SE)
A student must specialize in one stream; the specialization streams are: *Strategic Management, Organization Management, Manufacturing Management, Information Technology Management, Marketing, Finance, Public Sector Management, and Consultancy Management.* The courses under each stream are listed on the page No. 76.

Students specializing in one particular stream should take 12 credits from that stream; and she/he is allowed to take at most 9 credits from any other stream as open electives. Electives outside the specialization streams also form part of the open electives.

Non-credit Elective (NE)

SMC891	Strategic Leadership Practice	0-0-2	**NC**

Open Elective (OE)

SML714	Organizational Dynamics and Environment	3-0-0	3
SML734	Management of Small Scale Industrial Enterprises	3-0-0	3
SMP783	Management Laboratory	0-0-6	3
SML816	Total Quality Management	2-0-2	3
SML817	Management of System Waste	2-0-2	3
SML818	Industrial Waste Management	2-0-2	3
SML819	Business Process Reengineering	2-0-2	3
SML880	Selected Topics in Management	2-0-2	3
SML887	Business Law	2-0-2	3

Note: Also see the stipulation under *Specialization Elective* above.

M.B.A. in Foucs on Technology Management (Part Time) SMN

Sem.	Courses (Number, abbreviated title, L-T-P, credits)						Lecture Courses	L	T	P	Total	Credits
I	SML710 Creative Prob Solg (2 - 0 - 2) 3	SML730 Organization Mgmt (3 - 0 - 0) 3	SML731 Hum Resuc Mgmt (3 - 0 - 0) 3	SML740 Quant. Meth Mgmt (2 - 0 - 2) 3	CA-1 (0 - 0 - 2) 1	CA-2 (1 - 0 - 0) 1	6	11	0	6	17	12
II	SML702 Mgmt Innov R&D (3 - 0 - 0) 3	SML745 Operations Mgmt (3 - 0 - 0) 3	SML770 Mgrl Acc & FM (2 - 0 - 2) 3	SMC894 Seminar (0- 0 - 2) 1	FE (3 - 0 - 0) 3	CA-3 (1 - 0 - 0) 1	5	12	0	4	16	12
Summer												
III	SML700 Fund of Mgmt Tech (3 - 0 - 0) 3	SML720 Buss Env & CS (2 - 0 - 2) 3	SML760 Marketing Mgmt (2 - 0 - 2) 3	SML780 Managerial Econo (2 - 0 - 2) 3		CA-4 (1 - 0 - 0) 1	5	11	0	6	17	12
IV	SML701 Strategic Tech Mgmt (2 - 0 - 2) 3	SML703 Mgmt Tech T & A (2 - 0 - 2) 3	SE-1 (3 - 0 - 0) 3	CA-5 (1 - 0 - 0) 1	OE-1 (3 - 0 - 0) 3		5	11	0	4	15	12
Summer	SMD801 Major Project Part (SMN)											
V			SE-2 (3 - 0 - 0) 3	SE-3 (3 - 0 - 0) 3	OE-2 (3 - 0 - 0) 3	OE-3 (3 - 0 - 0) 3	4	12	0	0	12	12
VI	SMD890 Major Proj (SMN) (0 - 0 - 12) 6		SE-4 (3 - 0 - 0) 3	CA-6 (1 - 0 - 0) 1	OE-4 (3 - 0 - 0) 3		3	7	0	12	19	12

TOTAL = 72

LIST OF SPECIALISATION ELECTIVES for SMF, SMT and SMN programmes.

Specialization- Strategic Management

SML820	Global Business Environment	3-0-0	3
SML821	Strategic Management	2-0-2	3
SML822	International Business	2-0-2	3
SML823	Strategic Change and Flexibility	2-0-2	3
SML824	Policy Dynamics and Learning Organization	2-0-2	3
SML825	Strategies in Functional Management	3-0-0	3
SML826	Business Ethics	3-0-0	3
SML827	International Competitiveness	3-0-0	3
SML828	Global Strategic Management	2-0-2	3
SML829	Current and Emerging Issues in Strategic Management	3-0-0	3

Specialization- Organization Management

SML830	Organization Structure and Processes	3-0-0	3
SML831	Management of Change	2-0-2	3
SML832	Managing Innovation for Organizational Effectiveness	3-0-0	3
SML833	Organization Development	3-0-0	3
SML835	Labour Legislation and Industrial Relations	2-0-2	3
SML839	Current and Emerging Issues in Organization Management	3-0-0	3
HUL710	Personality Structure and Dynamics	2-1-0	3

Specialization- Manufacturing Management

SML840	Manufacturing Strategy	3-0-0	3
SML843	Supply Chain Logistics Management	3-0-0	3
SML844	Systems Reliability, Safety and Maintenance Management	3-0-0	3
SML845	Total Project Systems Management	2-0-2	3
SML846	Total Productivity Management	3-0-0	3
SML849	Current and Emerging Issues in Manufacturing Management	3-0-0	3

Specialization-Information Technology Management

SML815	Decision Support and Expert Systems	2-0-2	3
SML850	Management of Information Technology	3-0-0	3
SML851	Database Design and Data Management	2-0-2	3
SML852	Network Systems: Application and Management	3-0-0	3
SML853	Software Project Management	3-0-0	3
SML855	Electronic Commerce	2-0-2	3
SML856	Business Intelligence	3-0-0	3
SML857	Database Management Information System	3-0-0	3
SML859	Current and Emerging Issues in Information Technology Management	3-0-0	3

Specialization- Marketing

SML861	Market Research	2-0-2	3
SML862	Product Management	3-0-0	3
SML863	Advertising and Sales Promotion Management	3-0-0	3
SML865	Sales Management	2-0-2	3
SML866	International Marketing	3-0-0	3
SML867	Industrial Marketing Management	3-0-0	3
SML869	Current and Emerging Issues in Marketing	3-0-0*	3

Specialization- Finance

SML811	Management Control Systems	3-0-0	3
SML870	Advanced Financial Management	2-0-2	3
SML871	Accounting for Decision Making	2-0-2	3
SML872	Working Capital Management	3-0-0	3
SML873	Security Analysis and Portfolio Management	3-0-0	3
SML874	Indian Financial System	3-0-0	3
SML875	International Financial Management	3-0-0	3
SML879	Current and Emerging Issues in Finance	3-0-0	3

Specialization- Public Sector Management

SML881	Management of Public Sector Enterprises in India	3-0-0	3
SML889	Current and Emerging Issues in Public Sector Management	3-0-0	3

Specialization- Consultancy Management

SML822	International Business	2-0-2	3
SML833	Organization Development	3-0-0	3
SML845	Total Project Systems Management	2-0-2	3
SML897	Consultancy Process and Skill	3-0-0	3
SML898	Consultancy and Professional Practices	3-0-0	3
SML899	Current and Emerging Issues in Consultancy Management	3-0-0	3

Open Electives**

SML704	Science and Technology Policy Systems	3-0-0	3
SML714	Organization Dynamics and Environment	3-0-0	3
SML734	Management of Small Scale Industrial Enterprises	3-0-0	3
SML783	Management Laboratory	0-0-6	3
SML801	Technology Forecating and Assessment	2-0-2	3
SML802	Management of intellectual Property Rights	3-0-0	3
SML803	Technical Enterpreneurship	3-0-0	3
SML816	Total Quality Management	2-0-2	3
SML817	Management of System Waste	2-0-2	3
SML818	Industrial Waste Management	2-0-2	3
SML819	Business Process Reengineering	2-0-2	3
SML880	Selected Topics in Management	2-0-2	3
SML887	Business Law	2-0-2	3

Master of Design in *Industrial Design*
Interdisciplinary Programme

The overall credits structure

Category	PC	PE	OC	*Total*
Credits	81.5	2.5	7.5	*91.5*

Programme Core (PC)

DIC701	Seminars	0-0-2	1
DIL711	Framework of Design	2-0-4	4
DIP721	Exploratory Product Design Methods	1-0-4	3
DIL731	Applied Ergonomics	2-0-3	3.5
DIP781	Engineering Function, Materials and Processes	1-0-4	3
DIP751	Communication and Presentation Skills	1-0-6	4
DIP741	Product Form and Aesthetics	1-0-4	3
DIP791	Product Interface Design (Project-I)	1-0-6	4
DIL782	Advance Materials, Mfg. Process and Finishes	2-0-3	3.5
DIP742	Studies in Product Config. and Detailing	1-0-5	3.5
DIL752	Computer Aided Product Design	1-0-4	3
DIL762	Prototype and Die Development	1-0-3	2.5
DIC702	Seminar (Product in Usage)	0-0-2	1
DID792	Project-II	0-1-9	5.5
DIP811	Product Systems Services and Environment	1-0-4	3
DIP841	Advanced Form Studies	1-0-5	3.5
DID891	Project -III	0-1-15	8.5
DIS802	Invited Faculty Seminars	0-0-2	1
DIS812	Placement/Degree Show	0-0-4	2
DID892	Major project	0-1-36	19
	Total PC	**16-3-125**	**81.5**

Programe Elecives (PE)

DIR853	Computer Aided Industrial Design	1-0-3	2.5
DIR843	Exhibitions and Environment Design	1-0-3	2.5
DIR855	Creative Marketing Communication	1-0-3	2.5
DIR857	Animation	1-0-3	2.5
DIR859	Media Studies	1-0-3	2.5
DIR813	Designing for Sustainable Development	1-0-3	2.5
DIR833	Designing for Export	1-0-3	2.5
DIR821	Design Management and Profess. Practice	1-0-3	2.5

M.Des. in Industrial Design   JDS

Sem.	Courses (Number, abbreviated title, L-T-P, credits)								Lecture Courses	Contact h/week L	T	P	Total	Credits
I	DIC701 Seminars (0-0-2)1	DIL711 Framework of Design (2-0-4)4	DIL731 Applied Ergonomics (2-0-3)3.5	DIP721 Expl Product Design Meth (1-0-4)3	DIP741 Product Form & Aesthetics (1-0-4)3	DIP751 Commn & Presntation Skills (1-0-6)4	DIP781 Engg Function Maths & Proc (1-0-4)3	DIP791 Prod Interface Design (Project 1) (1-0-6)4	2	9	0	33	42	25.5
II	DIC702 Siminar (Product in Usage) (0-0-2)1	DIL752 Comp Aided Product Design (1-0-4)3	DIL762 Prototype Die Developemt (1-0-3)2.5	DIL782 Adv Matls, Mfg Proc & Finishes (2-0-3)3.5	DIP742 Stud in Prod Config & Detailing (1-0-5)3.5	DID792 Project 2 (0-1-9)5.5		OE-1	2	8	1	26	35	22
Summer														
III	DID891 Project 3 (0-1-15)8.5	DIP811 Product Sys Services & Environment (1-0-3)2.5	DIP841 Advanced Form Studies (1-0-5)3.5			**PE-1** (1-0-3)2.5	OE-2 (3-0-0)3	OE-3 (0-0-3)1.5	2	9	1	26	36	23
IV	DID892 Major Project (0-1-36)19	DIC802 Individual Faculty Seminars (0-0-2)1	DIS812 Placement/ Degree Show (0-0-4)2						0	0	1	42	43	22

TOTAL = 93.5

Master of Technology in *Engineering Mechanics*
Department of Applied Mechanics

The overall credits structure

Category	PC	PE	OC	Total
Credits	45	9	6	60

Programme Core (PC)

AMD811	Major Project Part 1 (AME)	0-0-12	6
AMD812	Major Project Part 2 (AME)	0-0-24	12
AML700	Experimental Methods for Solids and Fluids	3-0-2	4
AML702	Applied Computational Method	3-0-2	4
AML705	Finite Element Methods	3-0-2	4
AML711	Advanced Fluid Mechanics	3-1-0	4
AML731	Applied Elasticity	3-1-0	4
AML734	Advanced Dynamics	3-1-0	4
AML750	Modern Engineering Materials	3-0-0	3
	Total PC	***21-3-42***	***45***

Programme Electives (PE)

AML712	Numerical Methods In Fluid Flows	3-0-0	3
AML811	Advanced Computation Fluid Dynamics	3-0-0	3
AML812	Turbulent Shear Flows	3-0-0	3
AML814	Fluid Transportation Systems	3-0-0	3
AML831	Theory of Plates and Shells	3-0-0	3
AML833	Applied Plasticity	3-0-0	3
AML835	Mechanics of Composite Materials	3-0-0	3
AML851	Fracture Mechanics	3-0-0	3
AMS801	Independent Study (AME)	0-3-0	3

M.Tech. in Engineering Mechanics   **AME**

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	L	T	P	Total	Credits
I	AML711 Adv Fluid Mech (3 - 1 - 0) 4	AML731 Applied Elasticity (3 - 1 - 0) 4	AML750 Modern Engg Materials (3 - 0 - 0) 3	AML702 Applied Comp Methods (3 - 0 - 2) 4	AML734 Adv Dynamics (3 - 1 - 0) 4			5	15	3	2	20	19
II	AML705 FEM (3 - 0 - 2) 4	AML700 Exp Methods Fluids & Solids (3 - 0 - 2) 4			**PE-1** (3 - 0 - 0) 3	**PE-2** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	5	15	0	4	19	17
Summer	AMD811 Major Project Part 1(AME)												
III	AMD811 Maj Proj Part 1 (AME) (0 - 0 - 12) 6					**PE-3** (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3	2	6	0	12	18	12
IV	AMD812 Maj Proj Part 2 (AME) (0 - 0 - 24) 12							0	0	0	24	24	12

TOTAL = 60

Master of Technology in *Design Engineering*
Department of Applied Mechanics

The overall credits structure

Category	PC	PE	OC	Total
Credits	45	9	6	60

Programme Core (PC)

AMD813	Major Project Part 1 (AMD)	0-0-12	6
AMD814	Major Project Part 2 (AMD)	0-0-24	12
AML710	Computer Aided Design	3-0-2	4
AML771	Decision Theory and Design Optimization	3-0-0	3
AML773	Modelling and Analysis 1	3-0-0	3
AML774	Modelling and Analysis 2	3-0-0	3
AML775	Design Methods	3-0-0	3
AML883	Properties and Selection of Engineering Materials	3-0-0	3
AMP772	Feasibility Study	1-0-4	3
AMP776	Product Design Project 1	1-0-4	3
AMP777	Product Design Project 2	0-0-4	2
	Total PC	**20-0-50**	**45**

Programme Electives (PE)

AML700	Experimental Methods for Solid and Fluids	3-0-2	4
AML734	Advanced Dynamics	3-1-0	4
AML835	Mechanics of Composite Materials	3-0-0	3
AML852	Engineering Failure Analysis and Prevention	3-0-0	3
AML871	Product Reliability and Maintenance	3-0-0	3
AML873	Design for Production	3-0-0	3
AMS802	Independent Study (AMD)	0-3-0	3
CEL717	Advanced Structural Analysis	3-0-0	3
DIP741	Product Form and Aesthetics	1-0-4	3
DIR813	Designing for Sustainable Development	1-0-3	2.5
EEL723	Microprocessor Based Industrial Control	3-0-0	3
EEL781	Neural Networks	3-0-0	3
MEL731	Design of Mechanisms and Manipulators	3-0-2	4
MEL749	Mechatronic Product Design	3-0-2	4

M.Tech. in Design Engineering   AMD

Sem.	Courses (Number, abbreviated title, L-T-P, credits)						Lecture Courses	Contact h/week				Credits
								L	T	P	Total	
I	AML771 Decision Theory & Des Optimiz (3 - 0 - 0) 3	AMP772 Feasibility Study (1 - 0 - 4) 3	AML773 Modelling & Analysis 1 (3 - 0 - 0) 3	AML775 Design Methods (3 - 0 - 0) 3	AMP776 Products Design Proj 1 (1 - 0 - 4) 3	AML710 Computer Aided Design (3 - 0 - 2) 4	4	14	0	10	24	19
II	AML774 Modelling & Analysis 2 (3 - 0 - 0) 3	AMP777 Product Design Proj-2 (0 - 0 - 4) 2	AML883 Prop & Select of Engg Matr (3 - 0 - 0) 3		**PE-1** (3 - 0 - 0) 3	**PE-2** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	5	15	0	4	19	17
Summer	AMD813 Major Project Part 1(AMD)						0					
III	AMD813 Maj Proj Part 1 (AMD) (0 - 0 - 12) 6					**PE-3** (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3	2	6	0	12	18	12
IV	AMD814 Maj Proj Part 2 (AMD) (0 - 0 - 24) 12							0	0	0	24	24	12

TOTAL = 60

Master of Technology in *Chemical Engineering*
Department of Chemical Engineering

The overall credits structure

Category	PC	PE	OC	Total
Credits	36	18	6	60

Programme Core (PC)

CHD771	Minor Project	0-0-8	4
CHD781	Major Project Part 1 (CHC)	0-0-12	6
CHD782	Major Project Part 2 (CHC)	0-0-24	12
CHL603	Transport Phenomena	3-0-0	3
CHL701	Process Engineering	3-0-2	4
CHL721	Advanced Chemical Engineering Thermodynamics	3-1-0	4
CHL723	Chemical Reaction and Reactor Engineering	3-0-0	3
	Total PC	***12-1-46***	***36***

Programme Electives (PE)

CHL704	Polymer Matrix Composites – Processes and Process Modeling	3-1-0	4
CHL705	Electrokinetic Transport Phenomena	3-0-2	4
CHL710	Process Dynamics and Control	3-1-2	5
CHL711	Numerical Methods in Chemical Engineering	3-0-2	4
CHL717	Mechanical Design of Process Equipment	3-0-2	4
CHL722	Fundamentals of Fuel Cell Technology	3-0-2	4
CHL724	Environmental Engineering and Waste Management	3-1-0	4
CHL727	Heterogeneous Catalysis and Catalytic Processes	3-0-2	4
CHL731	Introduction to Soft Matter	3-0-0	3
CHL732	Soft Lithographic Methods for Nano-Fabrication	3-0-0	3
CHL735	Design of Separation Processes	3-0-2	4
CHL740	Special Topics	3-0-0	3
CHL751	Multicomponent Mass Transfer	3-0-0	3
CHL761	Chemical Engineering Mathematics	3-0-0	3
CHL766	Interfacial Engineering	3-0-0	3
CHL768	Fundamentals of Computational Fluid Dynamics	2-0-2	3
CHL771	Process Operations Scheduling	3-0-2	4
CHL774	Process Optimization	3-0-2	4
CHL793	Membrane Science and Engineering	3-0-0	3
CHL794	Petroleum Refinery Engineering	3-0-2	4
CHL807	Population Balance Modeling	3-0-0	3
CHL869	Applications of Computational Fluid Dynamics	2-0-2	3
CHL702	Plant Design	3-0-2	4

M.Tech. in Chemical Engineering   **CHE**

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	L	T	P	Total	Credits
I	CHL603 Transp Phenom. (3 - 0 - 0) 3	CHL701 Process Engg (3 - 0 - 2) 4	CHL723 Ch Rea Rctr Eng (3 - 0 - 0) 3		**PE-1** (3 - 0 - 0) 3	**PE-2** (3 - 0 - 0) 3		5	15	0	2	17	16
II		CHL721 Adv ChE Thermo (3 - 1 - 0) 4	CHD771 Minor Project (0 - 0 - 8) 4	**PE-5** (3 - 0 - 0) 3	**PE-3** (3 - 0 - 0) 3	**PE-4** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	5	15	1	8	24	20
Summer	CHD781 Major Project Part 1(CHC)							0					
III	CHD781 Maj Proj Part 1 (CHC) (0 - 0 - 12) 6					**PE-6** (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3	2	6	0	12	18	12
IV	CHD782 Maj Proj Part 2 (CHC) (0 - 0 - 24) 12							0	0	0	24	24	12

TOTAL = 60

Master of Technology in Molecular Engineering : Chemical Synthesis and Analysis
Department of Chemistry

The overall credits structure

Category	PC	PE	OC	Total
Credits	41	13	6	60

Programme Core (PC)

CYL721	Design, Synthesis, and Characterization of Organic Molecules	3-0-0	3
CYP722	Laboratory on Design, Synthesis and Characterization of Organic Molecules	0-0-6	3
CYL725	Molecules to Materials	3-0-0	3
CYL727	Inorganic Synthesis and Analysis	3-0-0	3
CYP728	Inorganic Synthesis and Analysis Lab	0-0-4	2
CYL729	Materials Characterization : Diffraction, Microscopy, and Thermal Analysis	3-0-0	3
CYL695	Applied Biocatalysis	3-0-0	3
CYD799	Minor Project	0-0-6	3
CYD801/ CYD803	Major Project (Part I)*	0-0-12/ 0-0-8	6/ 4
CYD802/ CYD804	Major Project (Part II)**	0-0-24/ 0-0-28	12/ 14

Programme Electives (PE)

BML820	Biomaterials	3-0-0	3
BML830	Biosensor Technology	3-0-2	4
CHL634	Management of R&D in Chemical Industries	3-0-0	3
CHL705	Electrokinetic Transport in Chemical Engg.	3-0-2	4
CHL727	Heterogeneous Catalysis and Catalytic Proc	3-0-2	4

Programme Electives (PE)

CHL731	Introduction to Soft Matter	3-0-0	3
CHL743	Petrochemical Technology	3-0-0	3
CHL766	Interfacial Engineering	3-0-0	3
CHL773	Planning of Experiments and Analysis of Engineering Data	3-0-2	4
CHL794	Petroleum Refinery Engineering	3-0-2	4
CHL807	Population Balance Modelling	3-0-0	3
CYL668*	Statistical Mechanics and Molecular Simulations Methods	3-0-0	3
CYL677*	Supramolecular Chemistry	3-0-0	3
CYL685*	Applied Organometallic Chemistry	3-0-0	3
CYL686*	Inorganic Polymers	3-0-0	3
CYL715	Bioanalytical Chemistry	3-0-0	3
CYL717	Principles of Chemical and Biosensors	3-0-0	3
CYL726	Cheminformatics and Molecular Modelling	3-0-0	3
CYS801	Independent Study***	0-4-0	4
MEL674	Principles of Management	3-0-0	3
PTL701	Polymer Chemistry	3-0-0	3
PTL705	Polymer Characterization	2-0-2	3
PTL711	Engineering Plastics and Speciality Polymers	3-0-0	3
SML802	Management of Intellectual Property Rights	3-0-0	3
TTL773	Design of Experiments and Statistical Techniques	3-0-0	3

* Students opting for CYT735 in the summer of the first year register for CYD803 while the others do CYD802.
** CYD804 for students who registered for CYD803 and CYD802 for those who registered for CYD801 in III Semester.
*** Students choose between CYT735 during the summer or CYS801 in the III Semester.

M.Tech. in Molecular Engineering : Chemical Synthesis and Analysis   **CYM**

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	L	T	P	Total	Credits
I	CYL721 Design, Synth. .... Molecules (3 - 0 - 0) 3	CYP722 Lab on Design ..... Molecules (0 - 0 - 6) 3	CYL725 Molecules to Materials (3 - 0 - 0) 3		**PE-1** (3 - 0 - 0) 3	**PE-2** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	*5*	15	0	6	21	18
II	CYL727 Inorganic Synth and Analysis (3 - 0 - 0) 3	CYP728 Inorganic Synth and Analysis Lab (0 - 0 - 4) 2	CYL729 Materials Char ... Analysis (3 - 0 - 0) 3	CYL695 Applied Biocatalysis (3 - 0 - 0) 3	**PE-3** (3 - 0 - 0) 3		*OE-2* (3 - 0 - 0) 3	*5*	15	0	4	19	17
Summer	CYT735* Industrial Training (0 - 0 - 8) 4							*0*					*4*
III	CYD799 Minor Proj Part-I (0 - 0 - 6) 3	CYS801 Independent Study*** (0 - 0 - 8) 4	CYD801/CYD803* Major Project Part-I (0 - 0 - 12) 6/ (0 - 0 - 8) 4					*0*	0	0	21/ 22	22/ 26	13/7
IV	CYD802/CYD804** Major Project Part-II (0 - 0 - 24) 12/ (0 - 0 - 28) 14							*0*	0	0	24/ 28	24/ 28	12/14

*Optional   **TOTAL = 60**

Master of Technology in **Geotechnical and Geoenvironmental Engineering**
Department of Civil Engineering

The overall credits structure

Category	PC	PE	OC	Total
Credits	45	9	6	60

Programme Core (PC)

CED701	Minor Project (CEG)	0-0-6	3
CED811	Major Project Part 1 (CEG)	0-0-12	6
CED812	Major Project Part 2 (CEG)	0-0-24	12
CEL701	Engineering Behaviour of Soils	3-0-0	3
CEL702	Slope Stability and Earth Dams	3-0-0	3
CEL703	Site Investigations and Ground Improvement	3-0-0	3
CEL704	Shallow and Deep Foundations	3-0-0	3
CEL705	Geoenvironmental Engineering	3-0-0	3
CEL706	Geosynthetics	3-0-0	3
CEL708	Earth Pressures and Retaining Structures	3-0-0	3
CEP701	Soil Engineering Laboratory	0-0-6	3
CEP702	Geoenvironmental and Geotechnical Engineering Laboratory	0-0-6	3
	Toral PC	***21-0-54***	***48***

Programme Electives (PE)

CEL610	Foundation Engineering *	3-0-0	3
CEL612	Construction Methods in Geotechnical Engineering *	3-0-0	3
CEL614	Geoenvironmental and Geohazards Engineering *	3-0-0	3
CEL707	Soil Dynamics and Geotechnical Earthquake Engineering	3-0-0	3
CEL709	Offshore Geotechnical Engineering	3-0-0	3
CEL712	Landfills and Ash Ponds	3-0-0	3
CEL714	Special Topics in Geotechnical and Geoenvironmental Engineering	3-0-0	3
CEL715	Soil Structure Interaction Analysis	3-0-0	3
CEL760	Finite Element Method in Geotechnical Engineering	3-0-0	3
CES810	Independent Study (CEG)	0-3-0	3

*To be offered for other specialisations only.

M.Tech. in Geotechnical and Geoenvironmental Engineering   CEG

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	Contact h/week				Credits
									L	T	P	Total	
I	CEL701 Engg Behaviour of Soils (3 - 0 - 0) 3	CEL703 Site Investigation & Grou Improv (3 - 0 - 0) 3	CEL705 Geoenvironmet Engineering (3 - 0 - 0) 3	CEP701 Soil Engg Lab (0 - 0 - 6) 3		**PE-1** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	5	15	0	6	21	18
II	CEL704 Shallow & Deep Foundations (3 - 0 - 0) 3	CEL702 Slope Stability & Earth Dams (3 - 0 - 0) 3	CEL708 Earth Pressures & Retaining Str (3 - 0 - 0) 3	CEL706 Geosynthetics (3 - 0 - 0) 3	CEP702 Geoenv & Geo tech Eng Lab (0 - 0 - 6) 3	CED701* Minor Project (CEG) (0 - 0 - 6) 3	**PE-2** (3 - 0 - 0) 3	5	15	0	6	21	18
Summer	CED811 Major Project Part 1(CEG)							0					
III	CED811 Maj Proj Part 1 (CEG) (0 - 0 - 12) 6					**PE-3** (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3	2	6	0	12	18	12
IV	CED812 Maj Proj Part 2 (CEG) (0 - 0 - 24) 12							0	0	0	24	24	12

TOTAL = 60

* CED701 (For Part time students only)

Master of Technology in *Rock Engineering and Underground Structures*
Department of Civil Engineering

The overall credits structure

Category	PC	PE	OE	Total
Credits	45	9	6	60

Programme Core (PC)

CED851	Major Project Part 1 (CEU)	0-0-12	6
CED852	Major Project Part 2 (CEU)	0-0-24	12
CEL751	Engineering Properties of Rocks and Rock Masses	3-0-0	3
CEL752	Slopes and Foundations	3-0-0	3
CEL753	Structural Geology	2-0-2	3
CEL754	Geotechnical Processes in Rock Engineering	3-0-0	3
CEL756	Excavation Methods and Machinery	3-0-0	3
CEL757	Field Exploration and Insitu Measurements	3-0-0	3
CEL758	Analysis and Design of Under Ground Structures	3-0-0	3
CEP751	Rock Mechanics Laboratory 1	0-0-6	3
CEP752	Rock Mechanics Laboratory 2	0-0-6	3
	Total PC	**20-0-50**	**45**

Programme Electives (PE)

CED760	Minor Project in Rock Engineering and Underground Structures (CEU)	0-0-6	3
CED792	Minor Project in Rock Engineering and Underground Structures (CEU)	0-0-6	3
CEL651*	Rock Engineering	3-0-0	3
CEL760	Finite Element Method in Geotechnical Engineering	3-0-0	3
CEL761	Underground Space Technology	3-0-0	3
CEL762	Special Topics in Rock Engineering	3-0-0	3
CEL763	Environmental Rock Engineering	3-0-0	3
CEL801	Advanced Rock Mechanics	3-0-0	3
CES850	Independent Study (CEU)	0-3-0	3

* To be offered to other specialisations in Civil Engineering.

M.Tech. in Rock Engineering and Underground Structures   CEU

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	Contact h/week				Credits
									L	T	P	Total	
I	CEL751 Eng Prop Rock & Rock Masses (3 - 0 - 0) 3	CEL753 Structural Geology (2 - 0 - 2) 3	CEL757 Field Explortn & ... Measurment (3 - 0 - 0) 3	CEP751 Rock Mech Lab 1 (0 - 0 - 6) 3	CEL754 Geotech Proces in Rock Engg (3 - 0 - 0) 3	PE-1 (3 - 0 - 0) 3		5	14	0	8	22	18
II	CEL752 Slopes and Foundations (3 - 0 - 0) 3	CEL758 Anal & Design Undergrnd Str (3 - 0 - 0) 3	CEL756 Excav Methods & Machinery (3 - 0 - 0) 3	CEP752 Rock Mech Lab 2 (0 - 0 - 6) 3		PE-2 (3 - 0 - 0) 3	OE-1 (3 - 0 - 0) 3	5	15	0	6	21	18
Summer	CED851 Major Project Part 1(CEU)												
III	CED851 Maj Proj Part 1 (CEU) (0 - 0 - 12) 6					PE-3 (3 - 0 - 0) 3	OE-2 (3 - 0 - 0) 3	2	6	0	12	18	12
IV	CED852 Maj Proj Part 2 (CEU) (0 - 0 - 24) 12							0	0	0	24	24	12

TOTAL = 60

Master of Technology in *Structural Engineering*
Department of Civil Engineering

The overall credits structure

Category	PC	PE	OC	Total
Credits	42	12	6	60

Programme Core (PC)

CED821	Major Project Part 1 (CES)	0-0-12	6
CED822	Major Project Part 2 (CES)	0-0-24	12
CEL717	Advanced Structural Analysis	3-0-0	3
CEL718	Design of Steel Structures	2-1-0	3
CEL719	Structural Dynamics	3-0-0	3
CEL721	Design of Concrete Structures	2-1-0	3
CEL722	Solid Mechanics in Structural Engineering	3-0-0	3
CEL724	Earthquake Analysis and Design	3-0-0	3
CEL733	Finite Element Method in Structural Engineering	2-1-0	3
CEP726	Structural Engineering Laboratory	0-0-6	3
	Total PC	***18-3-42***	***42***

Programme Electives (PE)

CEL727	Design of industrial Structures	2-1-0	3
CEL729	Advanced Design of Bridges	2-1-0	3
CEL731	Prestressed/Composite Structures	3-0-0	3
CEL734	Mathematical and Numerical Methods	2-1-0	3
CEL771	Civil Engineering Materials	3-0-0	3
CEL817	Structural Safety and Reliability	3-0-0	3
CEL818	Design of Plates and Shells	2-1-0	3
CEL819	Concrete Mechanics	3-0-0	3
CEL822	Stability Theory in Structural Engineering	3-0-0	3
CEL824	Design of Offshore Structures	2-1-0	3
CEL826	Advance Finite Element Method and Programming	2-0-2	3
CEL828	Wind Resistant Design of Structures	3-0-0	3
CEL832	Design of Tall Buildings	2-1-0	3
CES820	Independent Study	0-3-0	3
CEL836	Structural Health Monitoring	2-0-2	3

M.Tech. in Structural Engineering   CES

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	Contact h/week				Credits
									L	T	P	Total	
I	CEL717 Adv Structural Analysis (3 - 0 - 0) 3	CEL719 Structural Dynamics (3 - 0 - 0) 3	CEL721 Design of Concreate Str (2 - 1 - 0) 3	CEL733 Finite Ele Meth Struct Engg (3 - 0 - 0) 3		**PE-1** (3 - 0 - 0) 3	**PE-2** (3 - 0 - 0) 3	*6*	17	1	0	18	18
II	CEL718 Design of Steel Structures (2 - 1 - 0) 3	CEL722 Solid Mech in Structural Engg (3 - 0 - 0) 3	CEL724 Earthquake Anal & Design (3 - 0 - 0) 3	CEP726 Structural Engg Lab (0 - 0 - 6) 3		**PE-3** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	*5*	14	1	6	21	18
Summer	CED821 Major Project Part 1(CES)							*0*					
III	CED821 Maj Proj Part 1 (CES) (0 - 0 - 12) 6					**PE-4** (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3	*2*	6	0	12	18	12
IV	CED822 Maj Proj Part 2 (CES) (0 - 0 - 24) 12							*0*	0	0	24	24	12

TOTAL = 60

Master of Technology in *Water Resources Engineering*
Department of Civil Engineering

The overall credits structure

Category	PC	PE	OC	Total
Credits	40	15	6	61

Programme Core (PC)

CED841	Major Project Part 1 (CEW)	0-0-12	6
CED842	Major Project Part 2 (CEW)	0-0-24	12
CEL735	Hydrologic Processes and Modeling	3-0-0	3
CEL737	Optimization Techniques in Water Resources	3-0-0	3
CEL738	Advanced Hydraulics	3-0-0	3
CEL739	Groundwater Hydrology	3-0-0	3
CEL741	Surface Water Quality Modelling and Control	3-0-0	3
CEL742	Finite Elements in Water Resources	3-0-0	3
CEP740	Simulation Laboratory	1-0-6	4
	Total PC	***19-0-42***	***40***

Programme Electives (PE)

CEL736	Environmental Dynamics and Management	3-0-0	3
CEL743	Economics Aspects of Water Resources Development	3-0-0	3
CEL744	Ground Water Flow and Pollution Modelling	3-0-0	3
CEL745	Water Management	3-0-0	3
CEL746	Hydroelectric Engineering	3-0-0	3
CEL747	Geographic information Systems	2-0-2	3
CEL748	Hydrologic Applications of Remote Sensing	3-0-0	3
CEL749	Water Resources Systems	3-0-0	3
CEL840	Stochastic Hydrology	3-0-0	3
CEP724	Water Resources Management Laboratory	1-0-4	3
CES840	Independent Study (CEW)	0-3-0	3

M.Tech. in Water Resources Engineering   CEW

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	L	T	P	Total	Credits
I	CEL735 Hydrol Process & Modeling (3 - 0 - 0) 3	CEL737 Optmz. Tech in Water Resour (3 - 0 - 0) 3	CEL739 Groundwater Hydrology (3 - 0 - 0) 3	CEP740 Simulation Lab I (1 - 0 - 6) 4	CEL741 Surf Water Quty Model & Cntrl (3 - 0 - 0) 3	**PE-1** (3 - 0 - 0) 3	**PE-2** (3 - 0 - 0) 3	*6*	19	0	6	25	**22**
II	CEL738 Advanced Hydraulics (3 - 0 - 0) 3	CEL742 Finite Elements in Water Resour (3 - 0 - 0) 3		**PE-3** (3 - 0 - 0) 3	**PE-4** (3 - 0 - 0) 3	**PE-5** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	*6*	18	0	0	18	**18**
Summer	CED841 Major Project Part 1(CEW)							*0*					
III	CED841 Maj Proj Part 1 (CEW) (0 - 0 - 12) 6					**PE-6** (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3	*2*	6	0	12	18	**12**
IV	CED842 Maj Proj Part 2 (CEW) (0 - 0 - 24) 12							*0*	0	0	24	24	**12**

TOTAL =64

Master of Technology in *Construction Engineering and Management*
Department of Civil Engineering

The overall credits structure

Category	PC	PE	OC	Total
Credits	42	12	6	60

Programme Core (PC)

CED871	Major Project Part 1 (CET)	0-0-12	6
CED872	Major Project Part 2 (CET)	0-0-24	12
CEL767	Construction and Contract Management	3-0-0	3
CEL769	Project Planning and Control	2-1-0	3
CEL771	Civil Engineering Materials	3-0-0	3
CEL772	Quantitative Methods in Construction Management	2-1-0	3
CEL774	Construction Engineering Practices	3-0-0	3
CEL778	Construction Methods and Equipment	3-0-0	3
CEL779	Construction Economics and Finance	3-0-0	3
CEP775	Construction Engineering and Information Technology Laboratory	0-0-6	3
	Total PC	**19-2-48**	**45**

Programme Electives (PE)

CEL766	Systems Design and Value Analysis	3-0-0	3
CEL768	Recent Advances in Construction Materials	3-0-0	3
CEL773	Management of Quality and Safety in Construction	2-1-0	3
CEL776	Functional Planning, Building Services and Maintenance Management	3-0-0	3
CEL777	Building Science	3-0-0	3
CES870	Independent Study (CET)	0-3-0	3
CEL866	Infrastructure Development and Management	3-0-0	3

M.Tech. in Construction Engineering and Management   **CET**

Sem.	Courses (Number, abbreviated title, L-T-P, credits)						Lecture Courses	Contact h/week				Credits
								L	T	P	Total	
I	CEL769 Proj Planning & Control (2 - 1- 0) 3	CEL772 Quant. Methods in Const Mgmt (2 - 1- 0) 3	CEL771 Civil Engg Materials (3 - 0 - 0) 3	CEL774 Construction Engg Practices (3 - 0 - 0) 3	**PE-1** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	*6*	16	2	0	18	**18**
II	CEL778 Const Methods & Equipments (3 - 0 - 0) 3	CEL767 Construction & Contract Mgmt (3 - 0 - 0) 3	CEL779 Construction Econ & Finan (3 - 0 - 0) 3	CEP775 Const Engg & Info Tech Lab (0 - 0 - 6) 3	**PE-2** (3 - 0 - 0) 3	**PE-3** (3 - 0 - 0) 3	*5*	15	0	6	21	**18**
Summer	CED871 Major Project Part 1(CET)						*0*					
III	CED871 Maj Proj Part 1 (CET) (0 - 0 - 12) 6				**PE-4** (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3	*2*	6	0	12	18	**12**
IV	CED872 Maj Proj Part 2 (CET) (0 - 0 - 24) 12						*0*	0	0	24	24	**12**

TOTAL =60

Master of Technology in *Construction Technology and Management*
Department of Civil Engineering

The overall credits structure

Category	PC	PE	OC	Total
Credits	**42**	**09**	**09**	**60**

Programme Core (PC)

CED701	Minor Project (CEC)	0-0-6	3
CED875	Major Project Part 1 (CEC)	0-0-12	6
CED876	Major Project Part 2 (CEC)	0-0-24	12
CEL767	Construction and Contract Management	3-0-0	3
CEL769	Project Planning and Control	2-1-0	3
CEL772	Quantitative Methods in Construction Management	2-1-0	3
CEL773	Management of Quality and Safety in Construction	2-1-0	3
CEL774	Construction Engineering Practices*	3-0-0	3
CEL778	Construction Methods and Equipment	3-0-0	3
CEL779	Construction Economics and Finance	3-0-0	3
CEP770	Computation Laboratory for Construction Management	0-0-6	3
EEL792	Power System Protection #	3-0-0	3
ITL709	Maintenance Planning and Control **	3-0-0	3
	Total PC	**18-3-42**	**42**

Programme Electives (PE)

CEL612	Construction Methods in Geotechnical Engineering*	3-0-0	3
CEL766	Systems Design and Value Analysis*	3-0-0	3
CEL768	Recent Advances in Construction Materials*	3-0-0	3
CEL771	Civil Engineering Materials*	3-0-0	3
CEL776	Functional Planning, Building Services and Maintenance Management*	3-0-0	3

Programme Electives (PE)

CEL777	Building Science*	3-0-0	3
CES874	Independent Study (CEC)*	0-3-0	3
EEL743	Power Electronic Devices and Dc Converters#	3-0-0	3
EEL744	AC Controllers#	3-0-0	3
EEL745	Electrical Drives System#	3-0-0	3
EEL746	Nonconventional Energy Systems and Energy Conservation#	3-0-0	3
EEL747	Electrical Systems for Construction Industries#	3-0-2	4
EEL790	Optoelectronic Instrumentation#	3-0-0	3
EEL794	High Voltage DC Transmission#	3-0-0	3
EEL841	Solid State Controllers of Drives#	3-0-0	3
EEL845	Special Electromechanical Devices#	3-0-0	3
EEL891	Selected Topics in Power System#	3-0-0	3
EEL899	Distribution Automation#	3-0-0	3
EEP841	Electrical Machines Laboratory#	0-0-3	1.5
EEP842	Power Electronics Laboratory#	0-0-3	1.5
EEP843	Electric Drives Laboratory#	0-0-3	1.5
ITL752	Bulk Materials Handling**	2-0-2	3
MEL661	Materials Management**	2-0-2	3
MEL674	Principles of Management**	3-0-0	3
MEL710	Air Conditioning**	3-0-2	4
MEL711	Refrigeration and Air Conditioning Technologies**	3-0-2	4
MEL752	Quality Assurance**	3-0-2	4
MEL754	Operations Planning and Control**	3-0-2	4
MEL778	Design and Metallurgy of Welded Joints**	3-0-2	4
MEL787	Welding and Allied Processes**	3-0-2	4
MEL808	Refrigeration Systems and Components Design**	2-0-4	4
MEL866	Maintenance Management**	3-0-0	3

* For Civil Engg. background students
\# For Electrical Engg. background students
** For Mechanical Engg. background students
Note : Students may take a course as OC from the above list of PE courses provided the course is not from their own background.

M.Tech. in Construction Technology and Management   **CEC**

Sem.	Courses (Number, abbreviated title, L-T-P, credits)						Lecture Courses	Contact h/week				Credits
								L	T	P	Total	
I	CEL773 Mgmt Qty & Safety Constn. (2 - 1- 0) 3	CEL769 Project Planning and Control (2 - 1- 0) 3	CEL772 Quant Math Const Mgmt. (2 - 1- 0) 3	CEL774*/ EEL792#/ ITL709** (3 - 0 - 0) 3	**PE-1** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	6	15	3	0	18	**18**
II	CEL778 Const Methods & Equipments (3 - 0 - 0) 3	CEL767 Construction & Contract Mgmt (3 - 0 - 0) 3	CEL779 Construction Econ & Finan (3 - 0 - 0) 3	CEP770 Const Engg & Info Tech Lab (0 - 0 - 6) 3	**PE-2** (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3	*5*	15	0	6	21	**18**
Summer	CED875 Major Project Part 1(CEC)						*0*					
III	CED875 Maj Proj Part 1 (CEC) (0 - 0 - 12) 6				**PE-3** (3 - 0 - 0) 3	*OE-3* (3 - 0 - 0) 3	*2*	6	0	12	18	**12**
IV	CED876 Maj Proj Part 2 (CEC) (0 - 0 - 24) 12						*0*	0	0	24	24	**12**

TOTAL = 60

Master of Technology in *Environmental Engineering and Management*
Department of Civil Engineering

The overall credit structure

Category	PC	PE	OC	Total
Credits	42	12	6	60

Programme Core (PC)

CED891	Major Project Part 1 (CEV)	0-0-12	6
CED892	Major Project Part 2 (CEV)	0-0-24	12
CEL793	Air Pollution and Control	3-0-2	4
CEL794	Solid and Hazardous Waste Management	3-0-0	3
CEL795	Water and Waste-Water Treatment Processes	3-0-0	3
CEL796	Advanced Waste Water Treatment	3-0-0	3
CEL886	Environmental Systems Analysis	3-0-2	4
CEP789	Environmental Chemistry and Microbiology	1-0-4	3
CEP790	Advanced Environmental Engineering Laboratory	1-0-6	4
	Total PC	**17-0-50**	**42**

Programme Electives (PE)

CEL797	Environmental Impact Assessment	3-0-0	3
CEL879	Industrial Waste Management and Audit	3-0-0	3
CEL889	Emerging Technologies for Environmental Management	3-0-0	3
CEL891	Thermal Techniques for Waste Management	3-0-0	3
CEL892	Air Quality Modelling	3-0-0	3
CEL894	Management of Water, Waste and Sanitation Utilities	3-0-0	3
CEL895	Ecology and Eco-System Dynamics	3-0-0	3
CEL896	Design of Water and Waste Water Facilities	3-0-0	3
CEL897	Membrane Processes for Water and Waste Treatment	3-0-0	3
CEL898	Life Cycle Analysis and Design for Environment	3-0-0	3
CEL899	Environmental Risk Assessment	3-0-0	3
CES890	Independent Study (CEV)	0-3-0	3

M.Tech. in Environmental Engineering and Management   CEV

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	Contact h/week				Credits
									L	T	P	Total	
I	CEP789 Environ, Chemis. & Microbiology (1 - 0- 4) 3	CEL795 Water& Waste Treat Process (3 - 0 - 0) 3	CEL793 Air Pollution and Control (3 - 0 - 2) 4	CEL886 Environmental Systems Analys. (3 - 0 - 2) 4		PE-1 (3 - 0 - 0) 3		4	13	0	8	21	17
II	CEL796 Adv. Wastewater Treatment (3 - 0 - 0) 3	CEP790 Adv. Environ. Engg Lab. (1 - 0 - 6) 4	CEL794 Solid & Hazard. Waste Mgmt. (3 - 0 - 0) 3		PE-2 (3 - 0 - 0) 3	PE-3 (3 - 0 - 0) 3	OE-1 (3 - 0 - 0) 3	5	16	0	6	22	19
Summer	CED891 Major Project Part 1(CEV)							0					
III	CED891 Maj Proj Part 1 (CEV) (0 - 0 - 12) 6					PE-4 (3 - 0 - 0) 3	OE-2 (3 - 0 - 0) 3	2	6	0	12	18	12
IV	CED892 Maj Proj Part 2 (CEV) (0 - 0 - 24) 12							0	0	0	24	24	12

TOTAL = 60

Master of Technology in Transportation Engineering
Department of Civil Engineering

The overall credits structure

Category	PC	PE	OC	Total
Credits	41	12	9	62

Programme Core (PC)

CED881	Major Project Part 1 (CEP)	0-0-12	6
CED882	Major Project Part 2 (CEP)	0-0-24	12
CEL772	Quantitative Methods in Construction Management	2-1-0	3
CEL781	Urban and Regional Transportation Planning	2-0-2	3
CEL782	Pavement Materials and Construction Techniques	2-0-2	3
CEL783	Traffic Engineering	3-0-2	4
CEL784	Design and Maintenance of Pavements	3-0-2	4
CEL785	Advanced Transportation Modelling	2-0-2	3
CEL786	Geometric Design of Streets and Highways	2-0-2	3
	Total PC	***16-1-48***	***41***

Programme Electives (PE)

CEL787	Transportation Safety and Environment	3-0-0	3
CEL788	Public Transportation Systems	3-0-0	3
CEL789	Transportation Systems Management	3-0-0	3
CEL843	Traffic Modelling and Simulation	3-0-0	3
CEL844	Transportation Economics and Finance	3-0-0	3
CEL845	Transportation and Traffic Infrastructure Design	3-0-0	3
CEL729	Advanced Design of Bridges	3-0-0	3
CES880	Independent Study	3-0-0	3

M.Tech. in Transportation Engineering   **CEP**

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	L	T	P	Total	Credits
I	CEL772 Quant Methods Const Mgmt (2 - 1- 0) 3	CEL781 Urban & Region Transpt Planning (2 - 0 - 2) 3	CEL782 Pavement Matl & Const Tech. (2 - 0 - 2) 3	CEL783 Traffic Engineering (3 - 0 - 2) 4		**PE-1** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	6	15	1	6	22	19
II	CEL784 Des & Maint of Pavements (3 - 0 - 2) 4	CEL785 Adv Transptn Modelling (2 - 0 - 2) 3	CEL786 Geomet. Desgn Street Higway (2 - 0 - 2) 3		**PE-2** (3 - 0 - 0) 3	**PE-3** (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3	6	16	0	6	22	19
Summer	CED881 Major Project Part 1(CEP)							0					
III	CED881 Maj Proj Part 1 (CEP) (0 - 0 - 12) 6					**PE-4** (3 - 0 - 0) 3	*OE-3* (3 - 0 - 0) 3	2	6	0	12	18	12
IV	CED882 Maj Proj Part 2 (CEP) (0 - 0 - 24) 12							0	0	0	24	24	12

TOTAL =62

Master of Technology in **Computer Science and Engineering**
Department of Computer Science and Engineering

The overall credits structure

Category	PC	PE	OC	Total
Credits	40	14	6	60

Programme Core (PC)

CSD745	Minor Project (MCS)	0-1-6	4
CSD893	Major Project Part 1 (MCS)	0-0-12	6
CSD894	Major Project Part 2 (MCS)	0-0-24	12
CSL630	Data Structures and Algorithms	3-0-2	4
CSP701	Software Systems Laboratory	0-0-6	3
CSL765	Introduction to Logic & Functional Programming	3-0-2	4
	Total PC	***6-1-52***	***33***

Programme Electives (PE)

CSL632	Introduction to Data Base Systems	3-0-2	4
CSL633	Resource Management in Computer Systems or Operating Systems	3-0-2	4
CSL671	Artificial Intelligence	3-0-2	4
CSL672	Computer Networks	3-0-2	4
CSL718	Architecture of Large Systems	3-0-2	4
CSL719	Synthesis of Digital Systems	3-0-2	4
CSL724	Advanced Computer Networks	3-0-2	4
CSL728	Compiler Design	3-0-3	4.5
CSL730	Modern Parallel Programming	3-0-2	4
CSL740	Software Engineering	3-0-2	4
CSL750	Foundations of Automatic Verification	3-0-2	4
CSL755	Mathematical Foundations of Computer Science	3-0-0	3
CSL758	Advanced Algorithms	3-0-2	4
CSL759	Crptography and Computer Security	3-0-0	3
CSL771	Database Implementation	3-0-2	4
CSL781	Computer Graphics	3-0-3	4.5
CSL783	Digital Image Analysis	3-0-3	4.5
CSL812	System Level Design and Modeling of Dig. Sys.	3-0-0	3
CSL821	Reconfigurable Computing	3-0-0	3
CSL830	Distributed Computing	3-0-0	3
CSL831	Semantics of Programming Languages	3-0-0	3
CSL832	Proofs and Types	3-0-0	3
CSL838	Wireless Networks	3-0-0	3
CSL840	Computer Vision	3-0-2	4
CSL847	Distributed Algorithms	3-0-0	3
CSL851	Algorithmic Graph Theory	3-0-0	3

Programme Electives (PE) (Contd.)

CSL852	Computational Geometry	3-0-2	4
CSL853	Complexity Theory	3-0-0	3
CSL854	Approximation Algorithms	3-0-0	3
CSL855	Mathematical Foundations of Computing	3-0-0	3
CSL856	Mathematical Programming	3-0-2	4
CSL857	Randomized Algorithms	3-0-0	3
CSL859	Computer Graphics 2	3-0-2	4
CSL860	Special Topics in Parallel Computation	3-0-0	3
CSL861	Special Topics in Hardware Systems	3-0-0	3
CSL862	Special Topics in Software Systems	3-0-0	3
CSL863	Special Topics in Theoretical Computer Science	3-0-0	3
CSL864	Special Topics in Artificial intelligence	3-0-0	3
CSL865	Special Topics in Computer Applications	3-0-0	3
CSL866	Special Topics in Algorithms	3-0-0	3
CSL867	Special Topics in High Speed Networks	3-0-0	3
CSL868	Special Topics in Data Base Systems	3-0-0	3
CSL869	Special Topics in Concurrency	3-0-0	3
CSS799	Independent Study (MCS)	0-3-0	3
CSV880	Special Module in Parallel Computation	1-0-0	1
CSV881	Special Module in Hardware Systems	1-0-0	1
CSV882	Special Module in Software Systems	1-0-0	1
CSV883	Special Module in Theoretical Computer Science	1-0-0	1
CSV884	Special Module in Artificial Intelligence	1-0-0	1
CSV885	Special Module in Computer Applications	1-0-0	1
CSV886	Special Module in Algorithms	1-0-0	1
CSV887	Special Module in High Speed Networks	1-0-0	1
CSV888	Special Module in Database Systems	1-0-0	1
CSV889	Special Module in Concurrency	1-0-0	1

A student may opt for a specialization for which the requirements are : (a) project of 18 credits, and (b) 3 to 4 courses in the area of specialization. The areas of specialization are:
i) Computer Graphics, Vision and Multimedia, CSL781, CSL783, CSL840, CSL852, CSL859, CSL864, CSL865, EEL707, SIV864.
ii) Computer Networks and Distributed Systems, CSL724, CSL860, CSL867, CSV887, CSL838, CSL730.
iii) Algorithms and Complexity, CSL758, CSL705, CSL830, CSL847, CSL851, CSL852, CSL853, CSL854, CSL855, CSL856, CSL857, CSL860, CSL863, CSL866.
iv) Formal Methods in Software, CSL728, CSL740, CSL750, CSL830, CSL831, CSL832, CSL847, CSL855, CSL862, CSL863, CSL869, CSV889.
v) Embedded Systems and Architecture, CSL718, CSL719, CSL812, CSL821, CSL861.
vi) Software Systems, CSL740, CSL771, CSL862, CSL865, CSL868, CSL730, CSL728.

M.Tech. in Computer Science and Engineering **MCS**

Sem.	Courses (Number, abbreviated title, L-T-P, credits)						Lecture Courses	Contact h/week				Credits
								L	T	P	Total	
I	CSL765 Intro to Logic & Functional Prog (3 - 0 - 2) 4	CSL630 Data Structures and Algorithms (3 - 0 - 2) 4	CSP701 Software Sys Laboratory (0 - 0 - 6) 3			**PE-1** (3 - 0 - 2) 4	*OE-1* (3 - 0 - 0) 3	*4*	12	0	12	24	**18**
II			CSD745 Minor Project (0 - 1 - 6) 4	**PE-4** (3 - 0 - 2) 4	**PE-2** (3 - 0 - 2) 4	**PE-3** (3 - 0 - 2) 4	*OE-2* (3 - 0 - 0) 3	*4*	12	1	10	23	**18**
Summer	CSD893 Major Project Part 1							*0*					
III	CSD893 Maj Proj Part 1 (0 - 0 - 12) 6					**PE-5** (3 - 0 - 0) 3	**PE-6** (3 - 0 - 0) 3	*2*	6	0	12	18	**12**
IV	CSD894 Maj Proj Part 2 (0 - 0 - 24) 12							*0*	0	0	24	24	**12**

TOTAL = 60

Master of Technology in *Communications Engineering*
Department of Electrical Engineering

The overall credits structure

Category	PC	PE	OC	Total
Credits	40	12	9	61

Programme Core (PC)

EED861	Major Project Part 1 (EEE)	0-0-12	6
EED862	Major Project Part 2 (EEE)	0-0-24	12
EEL711	Signal Theory	3-0-0	3
EEL713	Microwave Theory and Circuits	3-0-0	3
EEL731	Digital Signal Processing 1	3-0-0	3
EEL762	Digital Communications	3-0-0	3
EEL768	Detection and Estimation Theory	3-0-0	3
EEP717	Communication Laboratory 1	0-0-4	2
EEP719	Communication Laboratory 2	0-0-4	2
	Total PC	**15-0-50**	**40**

Programme Electives (PE)

CRL705	Adv. Sensor Array Signal Processing	3-0-0	3
CRL707	Human & Machine Speech Communication	3-0-0	3
CRL712	RF & Microwave Active Circuits	3-0-0	3
CRL715	Radiating Systems for RF Communication	3-0-0	3
CRL722	RF & Microwave Solid State Devices	2-0-2	3
CRL725	Tech. for RF & Microwave Solid State Devices	3-0-0	3
EEL703	Computer Networks	3-0-0	3
EEL710	Coding Theory	3-0-0	3
EEL715	Image Processing	3-0-2	4
EEL716	Telecommunication Switching and Transmission	3-0-0	3

Programme Electives (PE) (Contd.)

EEL718	Statistical Signal Processing	3-0-0	3
EEL760	Antenna Theory and Techniques	3-0-0	3
EEL763	Monolithic Microwave Integrated Circuits and Technology	3-0-0	3
EEL764	Sonar Signal Processing	3-0-0	3
EEL765	Sonar Systems Engineering	3-0-0	3
EEL766	Numerical Techniques in Electromagnetics	3-0-0	3
EEL811	Miscellaneous Under Water Systems	3-0-0	3
EEL812	Millimetre Wave Integrated Circuits	3-0-0	3
EEL861	Selected Topics in Communication Engineering 1	3-0-0	3
EEL862	Selected Topics in Communication Engineering 2	3-0-0	3
EEL863	Selected Topics in Communication Engineering 3	3-0-0	3
EEL864	Modern Antennas and Arrays	3-0-0	3
EEL865	Microwave Propagation and Systems	3-0-0	3
EEL866	Microwave Solid State Devices and Circuits	3-0-0	3
EEL867	Fading Channels	3-0-0	3
EEL869	Optical Data Processing	3-0-0	3
EEV871	Selected Topic in Communication Engineering-IV	1-0-0	1
EEV872	Selected Topic in Communication EngineeringI-V	1-0-0	1
EES810	Independent Study (EEE)	0-3-0	3

M.Tech. in Communications Engineering   EEE

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	Contact h/week				Credits
									L	T	P	Total	
I	EEL711 Signal Theory (3 - 0 - 0) 3	EEL713 μWave Theory & Circuits (3 - 0 - 0) 3	EEP717 Comm Lab - 1 (0 - 0 - 4) 2	EEP719 Comm Lab - 2 (0 - 0 - 4) 2	EEL762 Digital Comm (3 - 0 - 0) 3	EEL731 Digital Signal Proc. (3 - 0 - 0) 3	**PE-1** (3 - 0 - 0) 3	5	15	0	8	23	19
II	EED860 Minor Project (EEE) (0 - 0 - 6) 3	EEL768 Detection & Estimation (3 - 0 - 0) 3		**PE-2** (3 - 0 - 0) 3	**PE-3** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3	5	15	0	6	21	18
Summer	EED861 Major Project Part 1(EEE)							0					
III	EED861 Maj Proj Part 1 (EEE) (0 - 0 - 12) 6				**PE-4** (3 - 0 - 0) 3		*OE-3* (3 - 0 - 0) 3	2	6	0	12	18	12
IV	EED862 Maj Proj Part 2 (EEE) (0 - 0 - 24) 12							0	0	0	24	24	12

TOTAL = 61

Master of Technology in *Computer Technology*
Department of Electrical Engineering

The overall credits structure

Category	PC	PE	OC	Total
Credits	40	14	6	60

Programme Core (PC)

EED701	Minor Project (EET)	0-0-4	2
EED801	Major Project Part 1 (EET)	0-0-12	6
EED802	Major Project Part 2 (EET)	0-0-24	12
EEL601	Computer Architecture	3-0-0	3
EEL602	Operating Systems	3-0-2	4
EEL702	System Software	3-0-2	4
EEL703	Computer Networks	3-0-0	3
EEP701	Digital System Laboratory	0-0-4	2
EEP702	Software Laboratory	0-0-4	2
EEP703	Computer Networks Laboratory	0-0-4	2
	Total PC	***12-0-56***	***40***

Programme Electives (PE)

EEL704	Robotics and Automation	3-0-0	3
EEL705	Embedded Systems and Applications	3-0-0	3
EEL707	Multimedia Systems	3-0-2	4
EEL708	Information Retrieval	3-0-0	3
EEL709	Pattern Recognition	3-0-0	3
EEL715	Image Processing	3-0-2	4
EEL731	Digital Signal Processing 1	3-0-0	3
EEL754	Computer Graphics	3-0-2	4
EEL758	Intelligent and Knowledge Based Systems	3-0-0	3
EEL802	Testing and Fault Tolerance	3-0-0	3
EEL804	Scientific Visualization	3-0-0	3
EEL806	Computer Vision	3-0-2	4
EEL832	Computer Aided VLSI Design	3-0-0	3
EEL851	Special Topics in Computers 1	3-0-0	3
EEL852	Special Topics in Computers 2	3-0-0	3
EEL853	Agent Technology	3-0-0	3
EEL854	Protocol Engineering	3-0-2	4
EEL855	Internet Technologies	3-0-2	3
EEL857	Network Security	3-0-2	4
EEL858	Mobile Computing	3-0-0	3
EEL859	Network Management	3-0-2	4
EES800	Independent Study (EET)	3-0-0	3
CSL719	Synthesis of Digital Systems	3-0-2	4
CSL812	System Level Design and Modeling of Digital Systems	3-0-0	3

M.Tech. in Computer Technology   **EET**

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	Contact h/week				Credits
									L	T	P	Total	
I	EEP701 Digital System Lab (0 - 0 - 4) 2	EEL601 Computer Architecture (3 - 0 - 0) 3	EEL702 System Software (3 - 0 - 2) 4			**PE-1** (3 - 0 - 2) 4/ (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	4	12	0	6/8	18/20	15/16
II	EEP702 Software Lab (0 - 0 - 4) 2	EEL602 Operating Systems (3 - 0 - 2) 4	EEL703 Computer Networks (3 - 0 - 0) 3	EEP703 Computer Networks Lab (0 - 0 - 4) 2	EED701 Minor Project (EET) (0 - 0 - 4) 2	**PE-2** (3 - 0 - 2) 4/ (3 - 0 - 0) 3	**PE-3** (3 - 0 - 2) 4/ (3 - 0 - 0) 3	4	12	0	14/18	26/30	19/21
Summer	EED801 Major Project Part 1(EET)							0					
III	EED801 Maj Proj Part 1 (EET) (0 - 0 - 12) 6				**PE-4** (3 - 0 - 0) 3	**PE-5** (3 - 0 - 2) 4/ (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3	3	9	0	12/14	21/23	15/16
IV	EED802 Maj Proj Part 2 (EET) (0 - 0 - 24) 12							0	0	0	24	24	12

TOTAL =60

Master of Technology in *Control and Automation*
Department of Electrical Engineering

The overall credits structure

Category	PC	PE	OC	Total
Credits	40	12	9	61

Programme Core (PC)

EED875	Major Project Part 1 (EEA)	0-0-12	6
EED876	Major Project Part 2 (EEA)	0-0-24	12
EEL704	Robotics and Automation	3-0-0	3
EEL721	Linear System Theory	3-0-0	3
EEL771	Random Process in Control and Estimation	3-0-0	3
EEL772	Optimal Control Theory	3-0-0	3
EEL774	Parameter Estimation and System Identification	3-0-0	3
EEP725	Control Laboratory	0-0-6	3
EEP874	Project Laboratory (EEA)	0-1-6	4
	Total PC	***15-1-48***	***40***

Programme Electives (PE)

CHL710	Process Dynamics and Control	3-0-0	3
EED820	Minor Project (EEA)	0-0-6	3
EEL602	Operating Systems	3-0-2	4
EEL705	Embedded Systems and Applications	3-0-0	3
EEL723	Microprocessors Based Industrial Control	3-0-0	3
EEL731	Digital Signal Processing 1	3-0-0	3
EEL745	Electrical Drives System	3-0-0	3
EEL758	Intelligent and Knowledge Based Systems	3-0-0	3
EEL796	Power System Control and Instrumentation	3-0-0	3
EEL823	Discrete Time Systems	3-0-0	3
EEL824	Nonlinear Systems	3-0-0	3
EEL829	Selected Topics in Advanced Control and Systems Theory 1	3-0-0	3
EEL878	Artificial Intelligence for Control Applications	3-0-0	3
EEL879	Selected Topics in Advanced Control and Systems Theory 2	3-0-0	3
EEP701	Digital System Laboratory	0-0-4	2
EES720	Independent Study (EEA)	0-3-0	3
IDL711	Instrumentation Transducers	3-0-0	3
MEL783	Automation in Manufacturing	3-0-2	4

M.Tech. in Control and Automation   EEA

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	Contact h/week				Credits
									L	T	P	Total	
I	EEL721 Linear System Theory (3-0-0) 3	EEL771 Rand. Proc. in Control & Est. (3-0-0) 3	EEP725 Control Lab (3-0-2) 4		**PE-1** (3-0-0) 3	**PE-2** (3-0-0) 3	*OE-1* (3-0-0) 3	5	15	0	6	21	18
II	EEL772 Optimal Control Theroy (3-0-0) 3	EEL774 Para. Est. & Sys. Ident. (3-0-0) 3	EEP874 Project Lab (EEA) (0-1-6) 4	EEL704 Robotics & Automation (3-0-0) 3	**PE-3** (3-0-0) 3		*OE-2* (3-0-0) 3	5	15	1	6	22	19
Summer	EED875 Major Project Part 1(EEA)							0					
III	EED875 Maj Proj Part 1 (EEA) (0-0-12) 6				**PE-4** (3-0-0) 3		*OE-3* (3-0-0) 3	2	6	0	12	18	12
IV	EED876 Maj Proj Part 2 (EEA) (0-0-24) 12							0	0	0	24	24	12

TOTAL =61

Master of Technology in *Intergrated Electronics and Circuits*
Department of Electrical Engineering

The overall credits structure

Category	PC	PE	OC	Total
Credits	42	12	6	60

Programme Core (PC)

EED888	Major Project Part 1 (EEN)	0-0-12	6
EED889	Major Project Part 2 (EEN)	0-0-24	12
EEL731	Digital Signal Processing 1	3-0-0	3
EEL732	Microelectronics	3-0-0	3
EEL734	MOS VLSI	3-0-0	3
EEL782	Analog Integrated Circuits	3-0-0	3
EEL784	IC Technology	3-0-0	3
EEL832	Computer Aided VLSI Design	3-0-0	3
EEP735	IEC Laboratory 1	0-0-6	3
EEP785	IEC Laboratory 2	0-0-6	3
	Total PC	*15-1-48*	*40*

Programme Electives (PE)

EED830	Minor Project (EEN)	0-0-6	3
EEL736	Biomedical Electronics	3-0-0	3
EEL781	Neural Networks	3-0-0	3
EEL783	Filter Design	3-0-0	3
EEL786	Mixed Signal Circuit Design	3-0-0	3
EEL787	Memory Design and Testing	3-0-0	3
EEL802	Testing and Fault Tolerance	3-0-0	3
EEL831	Digital Signal Processing 2	3-0-0	3
EEL833	Selected Topics in IEC	3-0-0	3
EEL834	VLSI Design	3-0-0	3
EEL881	Issues in Deep Submicron CMOS IC Design	3-0-0	3
EEP788	IC Processing Laboratory	0-0-6	3
EEP835	Project Laboratory (EEN)	0-0-6	3
EES837	Independent Study (EEN)	0-3-0	3
EEV831	Special Module in Nano Electronics	1-0-0	1
EEV832	Special Module in Analog and Mixed Signal IC Design	1-0-0	1
EEV833	Special Module in Low Power IC Design	1-0-0	1
EEV834	Special Module in VLSI Testing	1-0-0	1
EEV835	Special Module in Machine Learning	1-0-0	1
EEV836	Special Module in Applied Mathematics	1-0-0	1
EEV838	CMOS RF IC Design	3-0-0	3
EEV839	Selected Topics in IC II	3-0-0	3

M.Tech. in Integrated Electronics and Circuits   **EEN**

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	Contact h/week				Credits
									L	T	P	Total	
I	EEL732 Micro Electronics (3 - 0 - 0) 3	EEL734 MOS VLSI (3 - 0 - 0) 3	EEP735 IEC Lab - 1 (0 - 0 - 6) 3			OE-1 (3 - 0 - 0) 3	OE-2 (3 - 0 - 0) 3	*4*	12	0	6	18	**15**
II	EEL731 Digital Singal Processing (3 - 0 - 0) 3	EEL782 Analog Integ. Circuits (3 - 0 - 0) 3	EEL784 IC Technology (3 - 0 - 0) 3	EEP785 IEC Lab - 2 (0 - 0 - 6) 3	EEL832 Comp Aided VLSI Design (3 - 0 - 0) 3	**PE-1** (3 - 0 - 0) 3		*5*	15	0	6	21	**18**
Summer	EED 888 Major Project Part 1 (EEN)							*0*					
III	EED888 Maj Proj Part 1 (EEN) (0 - 0 - 12) 6			PE-2 (3- 0 - 0) 3	**PE-3** (3 - 0 - 0) 3	**PE-4** (0 - 0 - 6) 3		*1*	3	0	24	30	**15**
IV	EED889 Maj Proj Part 2 (EEN) (0 - 0 - 24) 12							*0*	0	0	24	24	**12**

TOTAL =60

Master of Technology in Power Electronics, Electrical Machines and Drives
Department of Electrical Engineering

The overall credits structure

Category	PC	PE	OC	Total
Credits	42	12	6	60

Programme Core (PC)

EED842	Major Project Part 1 (EEP)	0-0-12	6
EED843	Major Project Part 2 (EEP)	0-0-24	12
EEL741	Modelling and Analysis of Electrical Machines	3-0-0	3
EEL742	Physical Phenomenon and Design Concepts in Machines	3-0-0	3
EEL743	Power Electronic Devices and DC Converters	3-0-0	3
EEL744	AC Controllers	3-0-0	3
EEL745	Electrical Drives System	3-0-0	3
EEL841	Solid State Controllers of Drives	3-0-0	3
EEP841	Electrical Machines Laboratory	0-0-3	1.5
EEP842	Power Electronics Laboratory	0-0-3	1.5
EEP843	Electric Drives Laboratory	0-0-3	1.5
EEP844	Microprocessors and DSP Laboratory	0-0-3	1.5
	Total PC	**18-0-48**	**42**

Programme Electives (PE)

EED841	Minor Project (EEP)	0-0-6	3
EEL746	Nonconventional Energy Systems and Energy Converters	3-0-0	3
EEL748	Power Quality & Conditioning	3-0-0	3
EEL749	Special Electromechanical Devices & Systems	3-0-0	3
EEL843	Computer Aided Simulation and Design of Power Electronic Systems	3-0-0	3
EEL844	Advanced or Selected Topics in Power Electronics	3-0-0	3
EEL846	Computer Aided Design of Electrical Machines	3-0-0	3
EEL847	Selected Topics in Machines and Drives	3-0-0	3
EES841	Independent Study (EEP)	0-3-0	3
EET841	Industrial Training and Seminar (EEP)	0-0-6	3

M.Tech. in Power Electronics, Electrical Mechanics and Drives   **EEP**

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	L	T	P	Total	Credits
I	EEL741 Model & Analys of Elect Mach (3 - 0 - 0) 3	EEL742 Phys Phen & Des Conc M/c (3 - 0 - 0) 3	EEL743 Powr Elect Dev & DC Conv (3 - 0 - 0) 3	EEL744 AC controllers (3 - 0 - 0) 3	EEP841 Electrical Machines Lab (0-0-3) 1.5	EEP842 Power Electronics Lab (0-0-3) 1.5	**PE-1***/ *OE-1* (3 - 0 - 0) 3	5	15	0	6	21	18
II	EEL745 Electrical Drive System (3 - 0 - 0) 3	EEP843 Electric Drives Lab (0-0-3) 1.5	EEP844 µProcessors & DSP Lab (0-0-3) 1.5	EEL841 Solid-State Cntrl of Drives (3 - 0 - 0) 3	**PE-2** (3 - 0 - 0) 3	**PE-3**/*OE-2* (3 - 0 - 0) 3	*OE-1* / *#PE-1* (3 - 0 - 0) 3	5	15	0	6	21	18
Summer	EET841* EED842 Major Project Part 1(EEP)							0					
III	EED842 Maj Proj Part 1 (EEP) (0 - 0 - 12) 6				**PE-4** (3 - 0 - 0) 3		*OE-2 / PE-3* 2 (3 - 0 - 0) 3		6	0	12	18	12
IV	EED843 Maj Proj Part 2 (EEP) (0 - 0 - 24) 12							0	0	0	24	24	12

TOTAL = 60

*Ind. Training and seminar (EEP)

#Students opting for OE-1 in **I**ST sem should take PE-1 in IInd sem and vice versa

Master of Technology in *Power Systems*
Department of Electrical Engineering

The overall credits structure

Category	PC	PE	OC	Total
Credits	40	12	9	61

Programme Core (PC)

EED790	Minor Project (EES)	0-0-6	3
EED890	Major Project Part 1 (EES)	0-0-12	6
EED898	Major Project Part 2 (EES)	0-0-24	12
EEL791	Power System Analysis	3-0-0	3
EEL792	Power System Protection	3-0-0	3
EEL796	Power System Control and Instrumentation	3-0-0	3
EEL797	Power System Dynamics	3-0-0	3
EEL894	Flexible AC Transmission System	3-0-0	3
EEP791	Power System Laboratory 1	0-0-4	2
EEP798	Power System Laboratory 2	0-0-4	2
	Total PC	*15-0-50*	*40*

Programme Electives (PE)

EEL793	Power Systems Transients	3-0-0	3
EEL794	High Voltage DC Transmission	3-0-0	3
EEL799	Power System Reliability	3-0-0	3
EEL885	EHV AC Transmission	3-0-0	3
EEL891	Selected Topics in Power System	3-0-0	3
EEL892	Power System Communication	3-0-0	3
EEL896	Power System Optimization	3-0-0	3
EEL897	Load forecasting and Load Management	3-0-0	3
EEL899	Distribution Automation	3-0-0	3
EES893	Independent Study (EES)	0-3-0	3

M.Tech. in Power Systems   EES

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	Contact h/week				Credits
									L	T	P	Total	
I	EEL791 Power System Analysis (3 - 0 - 0) 3	EEL792 Power System Protection (3 - 0 - 0) 3	EEP791 Power System Lab - 1 (0 - 0 - 4) 2		**PE-1** (3 - 0 - 0) 3	**PE-2** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	5	15	0	4	19	17
II	EEL796 Power System Contrl & Instr (3 - 0 - 0) 3	EEL797 Power System Dynmics (3 - 0 - 0) 3	EEL894 Flexible AC Trans System (3 - 0 - 0) 3	EEP798 Power System Lab - 2 (0 - 0 - 4) 2	EED790 Minor Project (EES) (0 - 0 - 6) 3	**PE-3** (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3`	5	15	0	10	25	20
Summer	EED890 Major Project Part 1(EES)							0					
III	EED890 Maj Proj Part 1 (EES) (0 - 0 - 12) 6				**PE-4** (3 - 0 - 0) 3		*OE-3* (3 - 0 - 0) 3	2	6	0	12	18	12
IV	EED898 Maj Proj Part 2 (EES) (0 - 0 - 24) 12							0	0	0	24	24	12

TOTAL = 61

Master of Technology in *Design of Mechanical Equipment*
Department of Mechanical Engineering

The overall credits structure

Category	PC	PE	OC	Total
Credits	42	12	6	60

Programme Core (PC)

MED831	Major Project Part 1 (MED)	0-0-12	6
MED832	Major Project Part 2 (MED)	0-0-24	12
MEL731	Design of Mechanisms and Manipulators	3-0-2	4
MEL733	Vibration Engineering	3-0-2	4
MEL735	Computer Methods in Mechanical Design	3-0-2	4
MEL737	Advanced Mechanical Engineering Design	3-0-2	4
MEL740	Instrumentation and Automatic Control Systems	3-0-2	4
MEL742	Optimum Design of Mechanical Systems	3-0-2	4
	Total PC	***18-0-60***	***45***

Programme Electives (PE)

List A1 : Design Technology Elective

MEL832	Multibody Systems and Vibration Design	3-0-2	4
MEL744	Design for Manufacture and Assembly	3-0-2	4
MEL746	Design for Noise Vibration and Harshness	3-0-2	4
MEL748	Tribological Systems Design	3-0-2	4
MEL749	Mechatronic Product Design	3-0-2	4
MEL844	Designing With New Materials	3-0-2	4

List A2 : Equipment Design Elective

MEL732	Machine Tool Design	3-0-2	4
MEL736	Automotive Design	3-0-2	4
MEL743	Plant Equipment Design	3-0-2	4

List A3 : Specialized Elective

MEL734	Noise Engineering	3-0-2	4
MEL738	Dynamics of Multibody Systems	3-0-2	4
MEL739	Robotics	3-0-2	4
MEL741	Blade and Disc Dynamics	3-0-2	4
MEL842	Advanced Concurrent Engineering	3-0-2	4
MEL831	Advanced Theory of Vibrations	3-0-2	4
MEL835	Special Topics (MED)	3-0-2	4
MEL836	Advanced Lubrication	3-0-2	4
MEL837	Advanced Mechanisms	3-0-2	4
MEL838	Rotor Dynamics	3-0-2	4
MEL839	Precision Engineering	3-0-2	4
MEL840	Experimental Modal Analysis and Dynamic Design	3-0-2	4
MEL841	Advanced Structural Dynamics	3-0-2	4
MES830	Independent Study (MED)	0-4-0	4

M.Tech. in Design of Mechanical Equipment   **MED**

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	Contact h/week				Credits
									L	T	P	Total	
I	MEL731 Des. Mechnms & Manipulators (3 - 0 - 2) 4	MEL733 Vibration Engg (3 - 0 - 2) 4	MEL737 Adv Mechanical Engg Design (3 - 0 - 2) 4	MEL735 Comp. Meth in Mech Design (3 - 0 - 2) 4				*4*	12	0	8	20	**16**
II	MEL740 Instr. & Auto. Cntrl Systems (3 - 0 - 2) 4	MEL742 Opt. Design Mech. Systems (3 - 0 - 2) 4			**PE-1** Des Tech Elect (List A1) (3 - 0 - 2) 4	**PE-2** Eqp Des Elect (List A2) (3 - 0 - 2) 4	*OE-1* (3 - 0 - 0) 3	*5*	15	0	8	23	**19**
Summer	MED831 Major Project Part 1(MED)							*0*					
III	MED831 Maj Proj Part 1 (MED) (0 - 0 - 12) 6				**PE-3** Spec. Elective (List A3) (3 - 0 - 2) 4		*OE-2* (3 - 0 - 0) 3	*2*	6	0	14	20	**13**
IV	MED832 Maj Proj Part 2 (MED) (0 - 0 - 24) 12							*0*	0	0	24	24	**12**

TOTAL = 60

Master of Technology in *Industrial Engineering*
Department of Mechanical Engineering

The overall credits structure

Category	PC	PE	OC	Total
Credits	42	12	6	60

Programme Core (PC)

MED861	Major Project Part 1 (MEE)	0-0-12	6
MED862	Major Project Part 2 (MEE)	0-0-24	12
MEL751	Industrial Engineering and Systems	3-0-2	4
MEL752	Quality Assurance	3-0-2	4
MEL754	Operations Planning and Control	3-0-2	4
MEL756	Supply Chain Management	3-0-2	4
MEL761	Statistics for Decision Making	3-0-2	4
MEL765	Operations Research 1	3-0-2	4
	Total PC	***18-0-48***	***42***

Programme Electives (PE)

MEL661	Materials Management	2-0-2	3
MEL667	Long Range Planning	3-0-0	3
MEL671	Value Engineering	2-0-2	3
MEL674	Principles of Management	3-0-0	3
MEL760	Project Management	2-0-2	3
MEL762	Facilities Planning and Plant Engineering	2-0-2	3
MEL763	Methods Engineering and Ergonomics	2-0-2	3
MEL764	Human Factors Engineering	2-0-2	3
MEL768	Quality Management: A Systems Perspective	2-0-2	3
MEL770	Introduction to Stochastic Modeling and Simulation	3-0-2	4
MEL775	IT in Manufacturing Enterprises	3-0-0	3
MEL783	Automation in Manufacturing	3-0-2	4
MEL786	Metrology	2-0-2	3
MEL794	CAD/CAM	3-0-2	4
MEL850	Network Models and Applications	2-0-2	3
MEL851	Industrial Engineering Challenges in E-Business	3-0-0	3
MEL852	Computers Integrated Manufacturing Systems	2-0-2	3
MEL861	Industrial Applications of Simulation	2-0-2	3
MEL865	Systems Dynamics: Modelling and Industrial Applications	2-0-2	3
MEL866	Maintenance Management	3-0-0	3
MEL868	Operations Research 2	3-0-0	3
MEL870	Knowledge Management	3-0-0	3
MEL871	Financial Engineering	2-1-0	3
MEL875	Operations Research 3	3-0-0	3
MES860	Independent Study (MEE)	0-3-0	3
MEV760	Special Topics in Industrial Engineering (MEE)	2-0-0	2
VEL700	Human Values and Technology	2-1-0	3

M.Tech. in Industrial Engineering   **MEE**

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	Contact h/week				Credits
									L	T	P	Total	
I	MEL751 Industrial Engg & Systems (3 - 0 - 2) 4	MEL761 Statistics for Decision Making (3 - 0 - 2) 4	MEL765 Operations Research - 1 (3 - 0 - 2) 4			**PE-1** (3 - 0 - 0) 3	**PE-2** (3 - 0 - 0) 3	*5*	15	0	6	21	**18**
II	MEL752 Quality Assurance (3 - 0 - 2) 4	MEL754 Operations Plng & Control (3 - 0 - 2) 4	MEL756 Supply Chain Management (3 - 0 - 2) 4		**PE-3** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3			*5*	15	0	6	21	**18**
Summer	MED861 Major Project Part 1(MEE)							*0*					
III	MED861 Maj Proj Part 1 (MEE) (0 - 0 - 12) 6				**PE-4** (3 - 0 - 0) 3		*OE-2* (3 - 0 - 0) 3	*2*	6	0	12	18	**12**
IV	MED862 Maj Proj Part 2 (MEE) (0 - 0 - 24) 12							*0*	0	0	24	24	**12**

TOTAL = 60

Master of Technology in *Production Engineering*
Department of Mechanical Engineering

The overall credits structure

Category	PC	PE	OC	Total
Credits	45	11	6	62

Programme Core (PC)

MED881	Major Project Part 1 (MEP)	0-0-12	6
MED882	Major Project Part 2 (MEP)	0-0-24	12
MEL769	Metal forming Analysis	3-0-2	4
MEL780	Casting Technology	3-0-2	4
MEL781	Machining Processes and Analysis	3-0-2	4
MEL784	CNC Technology and Programming	3-0-2	4
MEL786	Metrology	2-0-2	3
MEL787	Welding and Allied Processes	3-0-2	4
MEL791	Composite Materials and Processing	3-0-2	4
	Total PC	**20-0-50**	**45**

Programme Electives (PE)

MEL674	Principles of Management	3-0-0	3
MEL732	Machine Tool Design	3-0-2	4
MEL749	Mechatronic Product Design	3-0-2	4
MEL751	Industrial Engineering and Systems	3-0-2	4
MEL752	Quality Assurance	3-0-2	4
MEL754	Operations Planning and Control	3-0-2	4
MEL763	Methods Engineering and Ergonomics	2-0-2	3
MEL772	Metal forming Technology	3-0-0	3
MEL775	IT in Manufacturing Enterprises	3-0-0	3
MEL778	Design and Metallurgy of Welded Joints	3-0-2	4
MEL783	Automation in Manufacturing	3-0-2	4
MEL792	Injection Moulding and Mould Design	2-0-2	3
MEL794	CAD/CAM	3-0-2	4
MEL796	Rapid Prototyping and Tooling	3-0-2	4
MEP790	Process Engineering	2-0-4	4
MES880	Independent Study (MEP)	0-3-0	3

M.Tech. in Production Engineering   **MEP**

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	L	T	P	Total	Credits
I	MEL769 Metal Forming Analysis (3 - 0 - 2) 4	MEL781 Machining Proc & Analysis (3 - 0 - 2) 4	MEL787 Welding & Allied Processes (3 - 0 - 2) 4	MEL791 Composite Matl & Processing (3 - 0 - 2) 4			*OE-1* (3 - 0 - 0) 3	*5*	15	0	8	23	**19**
II	MEL780 Casting Technology (3 - 0 - 2) 4	MEL784 CNC Techngy & Programming (3 - 0 - 2) 4	MEL786 Metrology (2 - 0 - 2) 3			**PE-1** (3 - 0 - 2) 3/4	**PE-2** (3 - 0 - 0) 3/4	*5*	14	0	8	22	**17/19**
Summer	MED881 Major Project Part 1(MEP)							*0*					
III	MED881 Maj Proj Part 1 (MEP) (0 - 0 - 12) 6				**PE-3** (2 - 0 - 2) 3/4	**PE-4** (3 - 0 - 0) 3/4	*OE-2* (3 - 0 - 0) 3	*3*	8	0	14	22	**13/15**
IV	MED882 Maj Proj Part 2 (MEP) (0 - 0 - 24) 12							*0*	0	0	24	24	**12**

TOTAL = 62

Master of Technology in *Thermal Engineering*
Department of Mechanical Engineering

The overall credits structure

Category	PC	PE	OC	Total
Credits	40	14	6	60

Programme Core (PC)

MED811	Major Project Part 1 (Thermal Engineering)	0-0-12	6
MED812	Major Project Part 2 (Thermal Engineering)	0-0-24	12
MEL703	Advanced Thermodynamics	3-0-0	3
MEL705	Experimental Methods in Thermal Engineering	2-0-4	4
MEL707	Applied Mathematics for Mechanical Engineers	2-0-2	3
MEL802	Convection Heat and Mass Transfer	3-0-0	3
MEL804	Radiation and Conduction Heat Transfer	3-0-0	3
MEL806	Thermal Systems Simulation and Design	2-0-2	3
AML715	Viscous Fluid Flows	3-0-0	3
	Total PC	***18-0-44***	***40***

Programme Electives (PE)

MEC601	Mechanical Engineering Seminars*	0-1-0	1
MED700	Design Project (Thermal Engineering)	0-1-6	4
MED710	Mini Project (Thermal Engineering)	0-3-0	3
MEL708	Combustion Generated Pollution and Control	3-0-2	4
MEL709	Heat Exchangers	3-0-2	4
MEL710	Air Conditioning	3-0-2	4
MEL711	Refrigeration and Air Conditioning Technologies	3-0-2	4
MEL712	Advanced Power Plant Cycles	2-0-4	4
MEL713	Design of IC Engine Components and Sub-Systems	3-0-2	4
MEL714	Thermal and Nuclear Steam Power Plants	3-0-2	4
MEL715	Gas Dynamics	3-0-2	4
MEL716	Micro-Nano Scale Heat Transfer	3-0-2	4
MEL725	Power Plant Steam Generators	3-0-0	3
MEL801	Fire Dynamics and Engineering	2-0-4	4
MEL807	Computational Heat Transfer	2-0-4	4
MEL808	Refrigeration Systems and Components Design	2-0-4	4
MEL809	Heat Transfer Applications	1-0-4	3
MEL811	Steam and Gas Turbines	3-0-2	4
MEL812	Combustion	3-0-2	4
MEL813	Cascade Theory	3-0-2	4
MEL814	Turbo Compressors	3-0-2	4
MEL815	Applied Combustion	2-0-4	4
MEL816	Analysis of IC Engine Processes	3-0-2	4
MEL818	Multiphase Flows	2-0-4	4
MEP601	Introduction To Computers and Programming*	0-0-4	2
MES810	Independent Study (Thermal Engineering)	0-3-0	3

* These are audit Courses

M.Tech. in Thermal Engineering　　　　　　　　　　　　　　　　　**MET**

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	Contact h/week				Credits
									L	T	P	Total	
I	MEL703 Advanced Thermodynamic (3 - 0 - 0) 3	AML715 Viscous Fluid Flows (3 - 0 - 0) 3	MEL705 Expt Methods Thermal Engg (2 - 0 - 4) 4	MEL707 Applied Math. Mech Engg. (2 - 0 - 2) 3		**PE-1** (3 - 0 - 2) 4		5	13	0	8	21	17
II	MEL802 Conv Heat & Mass Transf (3 - 0 - 0) 3	MEL804 Radiatn & Cond Heat Transfer (3 - 0 - 0) 3	MEL806 Thermal Syst Sim & Design (2 - 0 - 2) 3		**PE-2** (3 - 0 - 2) 3/4	**PE-3** (3 - 0 - 2) 3/ 4	*OE-1/* **PE-4** (3 - 0 - 0) 3/4	6	17	0	6	23	**18/20**
Summer	MED811 Major Project Part 1(MET)							0					
III	MED811 Maj Proj Part 1 (MET) (0 - 0 - 12) 6					**PE-4/** *OE-2* (3 - 0 - 0) 3/4	*OE-2* (3 - 0 - 0) 3/4	2	6	0	12	18	**12/14**
IV	MED812 Maj Proj Part 2 (MET) (0 - 0 - 24) 12							0	0	0	24	24	**12**

TOTAL = 60-62

Master of Technology in *Applied Optics*
Department of Physics

The overall credits structure

Category	PC	PE	OC	Total
Credits	45	9	6	60

Programme Core (PC)

PHD851	Major Project Part 1 (PHA)	0-0-12	6
PHD852	Major Project Part 2 (PHA)	0-0-24	12
PHL751	Optical Sources, Detectors and Photometry	3-0-0	3
PHL752	Laser Systems and Applications	3-0-0	3
PHL753	Optical System Design	3-0-0	3
PHL754	Optical Instruments and Metrology	3-0-0	3
PHL756	Fourier Optics and Optical Information Processing	3-0-0	3
PHL758	Theory and Applications of Holography	3-0-0	3
PHP761	Optics Laboratory 1	0-0-6	3
PHP762	Optics Laboratory 2	0-0-6	3
PHP763	Optical Workshop	0-0-6	3
	Total PC	*18-0-54*	*45*

Programme Electives (PE)

PHL755	Statistical and Quantum Optics	3-0-0	3
PHL757	Optical Materials and Thin Films	3-0-0	3
PHL759	Selected Topics in Applied Optics	3-0-0	3
PHL791	Fiber Optics	3-0-0	3
PHL792	Optical Electronics	3-0-0	3
PHL795	Optics and Lasers	3-0-0	3
PHL891	Guided Wave Optical Components and Devices	3-0-0	3
PHP764	Mechanical Workshop and Engineering Drawing	0-0-6	3
PHP853	Advanced Optical Workshop	0-0-6	3
PHS855	Independent Study (PHA)	0-3-0	3

M.Tech. in Applied Optics   PHA

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	Contact h/week				Credits
									L	T	P	Total	
I	PHL751 Optical Sources, Detector & Phot (3 - 0 - 0) 3	PHL753 Optical System Design (3 - 0 - 0) 3	PHP761 Optics Lab - 1 (0 - 0 - 6) 3	PHP763 Optical Workshop (0 - 0 - 6) 3		**PE-1** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	*4*	12	0	12	24	**18**
II	PHL752 Lasers Systems and Applications (3 - 0 - 0) 3	PHL754 Optical Instrumt and Metrology (3 - 0 - 0) 3	PHL756 Fourier Optics & Opt Info Procs (3 - 0 - 0) 3	PHL758 Theory & Appl & Holography (3 - 0 - 0) 3	PHP762 Optics Lab - 2 (0 - 0 - 6) 3	**PE-2/** *OE-2* (3 - 0 - 0) 3		*5*	15	0	6	21	**18**
Summer	PHD851 Major Project Part 1(PHA)							*0*					
III	PHD851 Maj Proj Part 1 (PHA) (0 - 0 - 12) 6					**PE-3** (3 - 0 - 0) 3	*OE-2/* **PE-2** (3 - 0 - 0) 3	*2*	6	0	12	18	**12**
IV	PHD852 Maj Proj Part 2 (PHA) (0 - 0 - 24) 12							*0*	0	0	24	24	**12**

TOTAL = 60

Master of Technology in *Solid State Materials*
Department of Physics

The overall credits structure

Category	PC	PE	OC	Total
Credits	45	9	6	60

Programme Core (PC)

PHD801	Major Project Part 1 (PHM)	0-0-12	6
PHD802	Major Project Part 2 (PHM)	0-0-24	12
PHL701	Electronic Properties of Materials	3-0-0	3
PHL702	Science and Technology of Thin Films	3-0-0	3
PHL703	Materials Technology	3-0-0	3
PHL704	Semiconductor Device Technology	3-0-0	3
PHL705	Physics of Semiconductor Devices	3-0-0	3
PHL707	Characterization of Materials	3-0-0	3
PHP711	Solid State Materials Laboratory 1	0-0-9	4.5
PHP712	Solid State Materials Laboratory 2	0-0-9	4.5
	Total PC	***18-0-54***	***45***

Programme Electives (PE)

PHL721	Electronic Ceramics	3-0-0	3
PHL722	Analytical Techniques	3-0-0	3
PHL723	Vacuum Science and Cryogenics	3-0-0	3
PHL724	Magnetism and Superconductivity	3-0-0	3
PHL725	Physics of Amorphous Materials	3-0-0	3
PHL726	Nanostructured Materials	3-0-0	3
PHL727	Quantum Heterostructures	3-0-0	3
PHS731	Independent Study (PHM)	0-3-0	3

M.Tech. in Solid State Materials   PHM

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	Contact h/week				Credits
									L	T	P	Total	
I	PHL701 Electronic Prop of Materials (3 - 0 - 0) 3	PHL703 Materials Technology (3 - 0 - 0) 3	PHL705 Phys of Semiconductor Devices (3 - 0 - 0) 3	PHL707 Characterization of Materials (3 - 0 - 0) 3	PHP711 Solid State Materials Lab 1 (0-0-9) 4.5	**PE-1** (3 - 0 - 0) 3		*5*	15	0	9	24	**19.5**
II	PHL702 Science & Tech of Thin Films (3 - 0 - 0) 3	PHL704 Semiconductor Device Technol (3 - 0 - 0) 3	PHP712 Solid State Materials Lab 2 (0 - 0 - 9) 4.5			**PE-2** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	*4*	12	0	9	21	**16.5**
Summer	PHD801 Major Project Part 1(PHM)							*0*					
III	PHD801 Maj Proj Part 1 (PHM) (0 - 0 - 12) 6					**PE-3** (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3	*2*	6	0	12	181	**12**
IV	PHD802 Maj Proj Part 2 (PHM) (0 - 0 - 24) 12							*0*	0	0	24	24	**12**

TOTAL = 60

Master of Technology in *Fiber Science and Technology*
Department of Textile Technology

The overall credits structure

Category	PC	PE	OC	Total
Credits	42	12	6	60

Programme Core (PC)

TTD891	Major Project Part 1 (TTF)	0-0-12	6
TTD892	Major Project Part 2 (TTF)	0-0-24	12
TTL711	Polymer and Fibre Chemistry	3-0-0	3
TTL712	Polymer and Fibre Physics	3-0-0	3
TTL713	Technology of Melt Spun Fibres	3-1-0	4
TTL714	Physical Properties of Fibres	3-0-0	3
TTL715	Technology of Solution Spun Fibres	3-0-0	3
TTL741	Colouration of Textiles	3-0-0	3
TTP711	Polymer and Fibre Chemistry Laboratory	0-0-3	1.5
TTP712	Polymer and Fibre Physics Laboratory	0-0-3	1.5
TTP716	Fibre Production and Post Spinning Operation Laboratory	0-0-4	2
	Total PC	***18-1-46***	***42***

Programme Electives (PE)

TTV700	Special Module in Selected Topics	1-0-0	1
TTL717	Advances in Manufactured Fibres	3-0-0	3
TTL718	High Performance Fibres and Composites	3-0-0	3
TTL724	Textured Yarn Technology	3-0-0	3
TTL740	Science and Applications of Nanotechnology in Textiles	3-0-0	3
TTL742	Theory and Practice of Textile Finishing	2-0-2	3
TTL743	Principles of Colour Measurement and Communication	2-0-2	3
TTL744	Environmental Management in Textile and Allied Industries	3-0-0	3
TTL746	Medical Textiles	3-0-0	3
TTL750	Science of Clothing Comfort	3-0-0	3
TTL752	Functional Textiles Envelopes	2-0-2	3
TTL763	Technical Textile	2-1-0	3
TTL765	Product Development	2-1-0	3
TTL772	Computer Programming and Its Applications	2-0-2	3
TTL773	Design of Experiments and Statistical Techniques	3-0-0	3
TTL782	Nonwoven Science and Engineering	3-0-0	3
TTL830	Modelling and Simulation in Fiberes Assemblies	2-0-2	3
TTL866	Functional and High Performance Textiles	2-1-0	3
TTS890	Independent Study (TTF)	0-3-0	3

M.Tech. in Fiber Science and Technology   TTF

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	Contact h/week				Credits
									L	T	P	Total	
I	TTL711 Polymer & Fibre Chemistry (3 - 0 - 0) 3	TTP711 Polymer & Fibre Chemistry Lab (0 - 0 - 3) 1.5	TTL712 Polymer & Fibre Physics (3 - 0 - 0) 3	TTP712 Polym & Fibre Physics Lab (0 -0- 3) 1.5	TTL713 Technol of Melt Spun Fibres (3 - 1 - 0) 4	TTL741 Coloration of Textiles (3 - 0 - 0) 3	**PE-1** (2 - 0 - 2) 3	5	14	1	8	23	19
II	TTL714 Physical Prop of Fibres (3 - 0 - 0) 3	TTL715 Technol of Soln Spun Fibres (3 - 0 - 0) 3	TTP716 Fib Prod & Post Spng Oper Lab (0 - 0 - 4) 2		**PE-2** (3 - 0 - 0) 3	**PE-3** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	5	15	0	4	19	17
Summer	TTD801 Major Project Part 1(TTF)							0					
III	TTD891 Maj Proj Part 1 (TTF) (0 - 0 - 12) 6					**PE-4** (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3	2	6	0	12	18	12
IV	TTD892 Maj Proj Part 2 (TTF) (0 - 0 - 24) 12							0	0	0	24	24	12

TOTAL = 60

Master of Technology in *Textile Engineering*
Department of Textile Technology

The overall credits structure

Category	PC	PE	OC	Total
Credits	42	12	6	60

Programme Core (PC)

TTD893	Major Project Part 1 (TTE)	0-0-12	6
TTD894	Major Project Part 2 (TTE)	0-0-24	12
TTL721	Theory of Yarn Structure	2-1-0	3
TTL722	Mechanics of Spinning Processes	3-0-0	3
TTL731	Theory of Fabric Structure	2-1-0	3
TTL733	Selected Topics in Fabric Manufacture	2-1-0	3
TTL740	Science and Applications of Nanotechnology in Textiles	3-0-0	3
TTL746	Medical Textiles	3-0-0	3
TTL763	Technical Textiles	2-1-0	3
TTL771	Electronics and Controls for Textile Industry	3-0-2	4
TTL773	Design of Experiments and Statistical Techniques	3-0-0	3
TTP761	Evaluation of Textile Materials 1	0-0-2	1
TTP762	Evaluation of Textile Materials 2	0-0-2	1
	Total PC	***17-4-42***	***42***

Programme Electives (PE)

TTV700	Special Module in Selected Topics	1-0-0	1
TTL714	Physical Properties of Fibres	3-0-0	3
TTL723	Selected Topics in Yarn Manufacture	2-1-0	3
TTL724	Textured Yarn Technology	3-0-0	3
TTL732	Computer Aided Fabric Manufacturing	2-0-2	3
TTL750	Science of Clothing Comfort	3-0-0	3
TTL751	Apparel Engineering and Quality Control	2-0-2	3
TTL752	Functional Textiles Envelope	2-0-2	3
TTL761	Costing, Project formulation and Appraisal	2-1-0	3
TTL762	Management of Textile Production	3-0-0	3
TTL764	Process Control in Spinning and Weaving	2-1-0	3
TTL765	Product Development	2-1-0	3
TTL772	Computer Programming and Its Applications	2-0-2	3
TTL782	Nonwoven Science and Engineering	3-0-0	3
TTL830	Modelling and Simulation in Fiberes Assemblies	2-0-2	3
TTL866	Functional and High Performance Textiles	2-1-0	3
TTS891	Independent Study (TTE)	0-3-0	3

M.Tech. in Textile Engineering   TTE

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	L	T	P	Total	Credits
I	TTL721 Theory of Yarn Structure (2 - 1 - 0) 3	TTL722 Mechanics of Spng Proc (3 - 0 - 0) 3	TTL731 Theory of Fabric Struct. (2 - 1 - 0) 3	TTL771 Electr & Control for Textile Indus. (3 -0- 2) 4	TTP761 Evaluation of Tex Materials 1 (0 - 0 - 2) 1		**PE-1** (3 - 0 - 0) 3	5	13	2	4	19	17
II	TTL733 Selected Topics in Fabric Manuf (2 - 1 - 0) 3	TTL763 Technical Textiles (2 - 1 - 0) 3	TTL773 Des of Exp & Statistical Techn (3 - 0 - 0) 3	TTP762 Evaluation of Tex Materials-2 (0 - 0 - 2) 1	**PE-2** (3 - 0 - 0) 3	**PE-3** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	6	16	2	2	20	19
Summer	TTD893 Major Project Part 1(TTE)							0					
III	TTD893 Maj Proj Part 1 (TTE) (0 - 0 - 12) 6					**PE-4** (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3	2	6	0	12	18	12
IV	TTD894 Maj Proj Part 2 (TTE) (0 - 0 - 24) 12							0	0	0	24	24	12

TOTAL = 60

Master of Technology in *Radio Frequency Design and Technology*
Centre for Applied Research in Electronics

The overall credits structure

Category	PC	PE	OC	Total
Credits	41	15	6	62

Programme Core (PC)

CRD811	Major Project Part 1 (CRF)	0-0-12	6
CRD812	Major Project Part 2 (CRF)	0-0-24	12
CRL702	Architectures and Algorithms for DSP Systems	2-0-4	4
CRL711	CAD of RF and Microwave Devices	3-0-2	4
CRL713	Fundamentals of RF Electronics	2-0-2	3
CRL724	RF and Microwave Measurement System Techniques	3-0-0	3
CRP718	RF and Microwave Measurement Laboratory	0-0-6	3
CRP723	Fabrication Techniques for RF and Microwave Devices	1-0-4	3
EEL762	Digital Communication	3-0-0	3
	Total PC	***14-0-54***	***41***

Programme Electives (PE)

CRD802	Minor Project (CRF)	0-0-6	3
CRL704	Sensor Array Signal Processing	3-0-0	3
CRL705	Advanced Sensor Array Signal Processing	3-0-0	3
CRL707	Human and Machine Speech Communication	3-0-0	3
CRL712	RF and Microwave Active Circuits	3-0-0	3
CRL715	Radiating Systems for RF Communications	3-0-0	3
CRL720	SAW Devices and Applications	3-0-0	3
CRL721	Analog/RF IC Modelling and Design	2-0-2	3
CRL722	RF and Microwave Solid State Devices	3-0-0	3
CRL725	Technology of RF and Microwave Solid State Devices	3-0-0	3
CRL726	RF MEMS Design and Technology	3-0-0	3
CRL728	RF Electronic System Design Techniques	3-0-0	3
CRL731	Selected Topics in RFDT 1	3-0-0	3
CRL732	Selected Topics in RFDT 2	3-0-0	3
CRL733	Selected Topics in RFDT 3	3-0-0	3
CRL737	Selected Topics in Radars and Sonars	3-0-0	3
CRS735	Independent Study (CRF)	0-3-0	3
EEL711	Signal Theory	3-0-0	3
EEL731	Digital Signal Processing-1	3-0-0	3
EEL765	Sonar Systems Engineering	3-0-0	3
EEL768	Detection and Estimation Theory	3-0-0	3
IDL712	Electronic Techniques for Signal Conditioning and Interfacing	3-0-0	3

M.Tech. in Radio Frequency Design and Technology   **CRF**

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	Contact h/week				Credits
									L	T	P	Total	
I	CRL711 CAD of RF & µWave Devics (3 - 0 - 2) 4	CRL713 Fundamentals of RF Electronic (2 - 0 - 2) 3	CRP723 Fab Techniq RF & µWave (1 - 0 - 4) 3	EEL762 Digital Communications (3 -0- 0) 3		**PE-1** (3 - 0 - 0) 3	**PE-2** (3 - 0 - 0) 3	*5*	15	0	10	25	**19**
II	CRL702 Arch & Algoriths for DSP System (2 - 0 - 4) 4	CRP718 RF & µWave Meas Lab (0 - 0 - 6) 3	CRL724 RF & µWave Meas Sys Tech (3 - 0 - 0) 3		**PE-3** (3 - 0 - 0) 3	**PE-4** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	*5*	14	0	10	24	**19**
Summer	CRD811 Major Project Part 1(CRF)							*0*					
III	CRD811 Maj Proj Part 1 (CRF) (0 - 0 - 12) 6					**PE-5** (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3	*2*	6	0	12	18	**12**
IV	CRD812 Maj Proj Part 2 (CRF) (0 - 0 - 24) 12							*0*	0	0	24	24	**12**

TOTAL = 62

Master of Technology in *Atmospheric- Oceanic Science and Technology*
Centre for Atmospheric Science

The overall credits structure

Category	PC	PE	OC	Total
Credits	42	12	6	60

Programme Core (PC)

ASL701	Dynamics of Atmosphere and Ocean	3-0-0	3
ASL703	Physics of Atmosphere and Ocean	3-0-0	3
ASL705	Boundary Layer Meteorology and Air Pollution	3-0-0	3
ASL706	Parameterization of Physical Processes	3-0-0	3
ASP751	Simulation L- I: Weather Analysis & Forecasting	0-0-4	**2**
ASP752	Simulation L- II: Obj. Analysis & Data Assimilation	0-0-6	3
ASP801	Simulation L-III:Ocean-Atmosphere Forecast Methodology	0-1-4	3
ASL808	Atmospheric Chemistry & Aerosols	3-0-0	3
ASD891	Major Project Part – 1	0-0-12	6
ASD892	Major Project Part – 2	0-0-24	12
ASC861	Atmospheric Science Colloquium	0-1-0	1

Programme Electives (PE)

ASL707	Mathematical and Statistical Methods in Atmospheric Sciences	3-0-0	3
ASL712	Air-Sea Interaction	3-0-0	3
ASL715	Science of Climate Change	3-0-2	4
ASL718	Tropical Meteorology	3-0-0	3
ASL720	Satellite Meteorology and Remote Sensing	3-0-0	3
ASL722	Biological Oceanography	3-0-0	3
ASL724	Atmospheric Diffusion and Air Pollution	3-0-0	3
ASL803	Advanced Dynamic Oceanography	3-0-0	3
ASL804	Air Pollution Monitoring and Health Risk Assessment	2-0-2	3
ASL813	Climate Variability	3-0-0	3
ASL814	Modelling of Dynamic Processes of Oceans and Atmosphere	3-0-0	3
ASL815	Marine Pollution and Coastal Zone Management	3-0-0	3
ASL816	Advanced Dynamic Meteorology	3-0-0	3
ASL817	Mesoscale Meteorology	3-0-0	3
ASL819	High Performance Computing in Atmospheric Sciences	2-0-2	3
ASL871	Special Topics on Storm Surges	3-0-0	3
ASL875	Special Topics in Air Pollution	3-0-0	3
ASL877	Special Topics in Marine and Water Pollution	3-0-0	3
ASL879	Special Topics in Remote Sensing	3-0-0	3
ASL881	Special Topics in Objective Analysis	3-0-0	3
ASL883	Special Topics in Clouds and Aerosols	3-0-0	3
ASL885	Special Topics in Lake Circulation Modelling	3-0-0	3
ASL888	Special Topics in Atmospheric Sciences	3-0-0	3
ASV872	Special Module on Storm Surges	1-0-0	1
ASV876	Special Module in Air Pollution	1-0-0	1
ASV878	Special Module in Marine and Water Pollution	1-0-0	1
ASV880	Special Module in Remote Sensing	1-0-0	1
ASV882	Special Module in Objective Analysis	1-0-0	1
ASV884	Special Module in Clouds and Aerosols	1-0-0	1
ASV886	Special Module in Lake Circulation Modelling	1-0-0	1
ASS800	Independent Study	3-0-0	3
AML711	Advanced Fluid Mechanics	3-0-0	3
AML712	Numerical Methods in Fluids	3-0-0	3
AML811	Advanced Computational Fluid Dynamics	3-0-0	3
AML812	Turbulent Shear Flows	3-0-0	3
CHL724	Environmental Engineering and Waste Management	3-1-0	4
CEL735	Hydrological Processes and Modelling	3-0-0	3
CEL 794	Air Pollution and Control	3-0-2	4
CEL797	Environmental Impact Assessment	3-0-0	3
CEL899	Environmental Risk Assessment	3-0-0	3
CSL783	Digital Image Analysis	3-0-3	4.5
CSL718	Architecture of High Performance Computer Systems	3-0-2	4
MEL804	Radiation and Conduction Heat Transfer	3-0-0	3
IDL714	Instrument Design and Simulations	3-0-0	3
IDL734	Laser Based Instrumentation	3-0-0	3

M.Tech. in Atmospheric-Oceanic Science and Technology   AST

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	Contact h/week				Credits
									L	T	P	Total	
I	ASL701 Dynamic...... Ocean (3 - 0 - o) 3	ASL703 Physics.... Ocean (3 - 0 - 0) 3	ASL705 Boundry... Pollution (3 - 0 - 0) 3	ASP751 Simulation Lab-1 (0 -0- 4) 2		**PE-1** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	*4*	15	0	4	19	17
II	ASL706 Parameter...Proc (3 - 0 - 0) 3	ASP752 Simulation Lab-2 (0 - 0 - 6) 3	ASL808 Atmos........ Aerosols (3 - 0 - 0) 3		**PE-2** (3 - 0 - 0) 3	**PE-3** (3 - 0 - 0) 3		*2*	12	0	6	18	15
Summer	ASD891 Major Project Part 1(AST)							*0*					
III	ASD891 Maj Proj Part 1 (0 - 0 - 12) 6	ASC861 Atmos Sci Collm (0 - 1 - 0) 1	ASP801 Simulation Lab-3 (0 - 1 - 4) 3			**PE-4** (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3	*2*	0	0	12	12	16
IV	ASD892 Maj Proj Part 2 (0 - 0 - 24) 12							*0*	0	0	24	24	12

TOTAL = 62

Master of Technology in *Computer Applications*
Interdisciplinary Programme

The overall credits structure

Category	PC	PE	OC	Total
Credits	42	12	6	60

Programme Core (PC)

JCD801	Major Project Part 1 (JCA)	0-0-12	6
JCD802	Major Project Part 2 (JCA)	0-0-24	12

CSL630 OR	Data Structures and Algorithms✶	3-0-2	4
MAL701	Introduction To Programming and Data Structures#		
MAL704 OR	Numerical Optimization#	3-0-2	4
MAL708	Computer Organization and Operating Systems✶		
CSL665	Introduction to Logic and Functional Programming	3-0-2	4
EEL702	System Software	3-0-2	4
MAL705	Discrete Mathematical Structures	3-0-0	3
MAL710	Database Management Systems	3-0-2	4
MAP706	Scientific Software Laboratory	0-0-6	3
MAP707	Programming Languages Laboratory	0-0-4	2
	Total PC	**18-0-56**	**46**

Note : # Courses for non-CS background students.
✶ Courses for CS background students.

Programme Electives(PE)

ASL850	Numerical Modelling of Atmospheric Processes	3-0-0	3
CSL665	Introduction to Logic and Functional Programming	3-0-2	4
CSL671	Artificial Intelligence	3-0-2	4
CSL672	Computer Networks	3-0-2	4
CSL740	Software Engineering	3-0-2	4

Programme Electives(PE)

CSL758	Advanced Algorithms	3-0-0	3
CSL781	Computer Graphics	3-0-3	4.5
CSL783	Digital Image Analysis	3-0-3	4.5
CSL840	Computer Vision	3-0-2	4
CSL862	Special Topics in Software Systems	3-0-0	3
CSL864	Special Topics in Artificial intelligence	3-0-0	3
CSL865	Special Topics in Computer Applications	3-0-0	3
CSL868	Special Topics in Data Base Systems	3-0-0	3
EEL703	Computer Networks	3-0-0	3
EEL706	Computer Vision	3-0-2	4
EEL707	Multimedia Systems	3-0-2	4
EEL708	Information Retrieval	3-0-0	3
EEL709	Pattern Recognition	3-0-0	3
EEL715	Image Processing	3-0-2	4
EEL751	Computer System Software	3-0-2	4
EEL754	Computer Graphics	3-0-2	4
EEL758	Intelligent and Knowledge Based Systems	3-0-0	3
EEL804	Scientific Visualization	3-0-0	3
EEL853	Agent Technology	3-0-0	3
JCD799	Minor Project (JCA)	0-0-6	3
JCS800	Independent Study (JCA)	3-0-0	3
MAL702	Files Systems and Data Management	3-0-0	3
MAL703	Numerical Algorithms for Parallel Computing	3-0-0	3
MAL711	Algorithmic Combinatorics	3-0-0	3
MAL714	Finite Element Techniques and Computer Implementation	3-0-0	3
MAL715	Statistical Computing	3-0-0	3
MAL717	Fuzzy Sets and Applications	3-0-0	3
MAL720	Neuro-Computing and Applications	3-0-0	3
MAL724	Cryptology	3-0-0	3
MAL732	Financial Mathematics	3-1-0	4
MAL733	Stochastics of Finance	3-1-0	4
MAL754	Principles of Computer Graphics	3-0-2	4
MAL803	Pattern Recognition	3-0-0	3
MAL823	Special Topics in Computer Applications	3-0-0	3
SML815	Decision Support and Expert Systems	2-0-2	3

M.Tech. in Computer Applications   JCA

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	L	T	P	Total	Credits
I	MAL701# Intro to Program & Data Stru (3 - 0 - 2) 4	CSL630✶ Data Structures & Algorithms (3 - 0 - 2) 4	MAL705 Discrete Maths Structures (3 - 0 - 0) 3	MAP707 Programming Language Lab (0 -0- 4) 2	EEL702 # System Software (3 - 0 - 2) 4	CSL665✶ Intro to Logic & Funct Progm. (3 - 0 - 2)4	**PE-1** (3 - 0 - 0) 3	*4*	12	0	8	22	**16**
II	MAL710 Data Base Mgmt Systems (3 - 0 - 2) 4	MAL708 # Comp Orgnsn & Oper System (3 - 0 - 2) 4	MAL704✶ Numerical Optimization (3 - 0 - 2)	MAP706 Scientific Software Lab (0 - 0 - 6) 3		**PE-2** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	*4*	12	0	10	22	**17**
Summer	JCD801 Major Project Part 1 (JCA)							*0*					
III	JCD801 Maj Proj Part 1 (JCA) (0 - 0 - 12) 6				**PE-3** (3 - 0 - 0) 3	**PE-4** (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3	*3*	9	0	12	21	**15**
IV	JCD802 Maj Proj Part 2 (JCA) (0 - 0 - 24) 12							*0*	0	0	24	24	**12**

TOTAL = **60**

Master of Technology in *Energy Studies*
Interdisciplinary Programme

The overall credits structure

Category	PC	PE	OC	Total
Credits	42	12	06	60

Programme Core (PC)

ESL710	Energy, Ecology and Environment	3-0-0	3
ESL711	Fuel Technology	3-0-0	3
ESL720	Energy Conservation	3-0-0	3
ESL730	Direct Energy Conversion	3-0-0	3
ESL740	Non-Conventional Sources of Energy	3-0-0	3
ESL750	Economics and Planning of Energy Systems	3-0-0	3
ESL760	Heat Transfer	3-0-0	3
ESP713	Energy Laboratories (JES)	0-0-6	3
JSD801	Major Project Part 1 (JES)	0-0-12	6
JSD802	Major Project Part 2 (JES)	0-0-24	12
	Total PC	***21-0-42***	***42***

Programme Electives (PE)

ESL714	Electrical Power Plant Engineering	3-0-0	3
ESL718	Power Generation, Transmission and Distribution	3-0-0	3
ESL722	Integrated Energy System	3-0-0	3
ESL732	Bioconversion and Processing of Waste	3-0-0	3
ESL768	Wind Energy and Hydro Power Systems	3-0-0	3
ESL770	Solar Energy Utilization	3-0-0	3
ESL774	Quantitative Methods for Energy Management and Planning	3-0-0	3
ESL784	Cogeneration and Energy Efficiency	3-0-0	3
ESL792	Advanced Engergy Systems	3-0-0	3
ESL810	MHD Power Generation	3-0-0	3
ESL840	Solar Architecture	3-0-0	3
ESL850	Solar Refrigeration and Air Conditioning	3-0-0	3
ESL860	Electrical Power Systems Analysis	3-0-0	3
ESL870	Fusion Energy	3-0-0	3
ESL871	Advanced Fusion Energy	3-0-0	3
ESL875	Alternative Fuels for Transportation	3-0-0	3
ESS801	Independent Study (JES)	0-3-0	3
JSD799	Minor Project (JES)	3-0-0	3

M.Tech. in Energy Studies   JES

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	Contact h/week				Credits
									L	T	P	Total	
I	ESL740 Non-convent Sour of Energy (3 - 0 - 0) 3	ESL711 Fuel Technology (3 - 0 - 0) 3	ESL760 Heat Transfer (3 - 0 - 0) 3	ESP713 Energy Laboratories (0 - 0 - 6) 3		**PE-1** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	*5*	15	0	6	21	**18**
II	ESL720 Energy Conservation (3 - 0 - 0) 3	ESL710 Ener, Ecology & Environment (3 - 0 - 0) 3	ESL750 Econ & Plang of Energy Sys (3 - 0 - 0) 3	ESL730 Direct Energy Conversion (3 - 0 - 0) 3		**PE-2** (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3	*6*	18	0	0	18	**18**
Summer	JSD801 Major Project Part 1(JES)							*0*					
III	JSD801 Maj Proj Part 1 (JES) (0 - 0 - 24)12				**PE-3** (3 - 0 - 0) 3	**PE-4** (3 - 0 - 0) 3		*2*	6	0	12	18	**12**
IV	JSD802 Maj Proj Part 2 (JES) (0 - 0 - 24) 12							*0*	0	0	24	24	**12**

TOTAL = 60

Master of Technology in *Energy and Environmental Management*
Interdisciplinary Programme

The overall credits structure

Category	PC	PE	OC	Total
Credits	45	9	6	60

Programme Core (PC)

JND801	Major Project Part 1 (JEN)	0-0-12	6
JND802	Major Project Part 2 (JEN)	0-0-24	12
ESL711	Fuel Technology	3-0-0	3
ESL720	Energy Conservation	3-0-0	3
ESL740	Non-conventional Sources of Energy	3-0-0	3
ESL774	Quantitative Methods for Energy Management and Planning	3-0-0	3
ESL777	Environmental Science and Engineering	3-0-0	3
ESP700	Energy Laboratories	0-0-6	3
Module	A/ B/ C/ D, 3 courses, 3 credits each	9-0-0	9

Compulsory bridge core courses (credits not to be counted for SGPA/ CGPA calculation)

ESN704	Basic Thermal Engineering #		
ESN712	Basic Electrical Engineering∗	1-0-0	1
ESL794	Principles of Chemical Processes and Combustion +		
ESL725	Energy Auditing	1-0-0	1
ESN791	Applied Mathematics and Computational Methods	1-0-0	1
	Total PC	**24-0-42**	**45**

\#   For Non-Mechanical Engineering
∗   For Non-Electrical Engineering
+   For Non-Chemical /Environmental engineering students

Module-wise courses (included in PC)

A student must take all courses from one of the four modules:

Module – A

ESL776	Industrial Energy and Environmental Analysis	3-0-0	3
ESL778	Industrial Waste Management and Recycling	3-0-0	3
ESL784	Cogeneration and Energy Efficiency	3-0-0	3

Programme Electives (PE)

ESL710	Energy, Ecology and Environment	3-0-0	3
ESL722	Intergrated Energy Systems	3-0-0	3
ESL730	Direct Energy Conversion	3-0-0	3
ESL735	Hazardous Waste Management	3-0-0	3
ESL738	Power Systems Planning and Operation	3-0-0	3
ESL745	Environmental Audit and Impact Assessment	3-0-0	3
ESL768	Wind Energy and Hydro Power Systems	3-0-0	3
ESL771	Instrumentation and Control in Energy Systems	3-0-0	3
ESL785	Energy Analysis	3-0-0	3
ESL792	Advanced Energy Systems	3-0-0	3
ESL795	Project Evaluation and Management	3-0-0	3
ESL796	Operation and Control of Electrical Energy Systems	3-0-0	3
ESL870	Fusion Energy	3-0-0	3
ESL875	Alternative Fuels for Transportation	3-0-0	3
JNS800	Independent Study (JEN)	0-3-0	3

Module-wise courses (included in PC)

Module – B

ESL756	Energy Policy and Planning	3-0-0	3
ESL764	Environmental Economics	3-0-0	3
ESL766	Environmental Regulation	3-0-0	3

Module – C

ESL718	Power Generation, Transmission and Distribution	3-0-0	3
ESL860	Electrical Power System Analysis	3-0-0	3
ESL804	Pollution Control in Power Plants	3-0-0	3

Module – D

ESL788	Industrial and Commercial Applications of Renewable Energy Sources	3-0-0	3
ESL736	Power from Renewable and Environmental Impacts	3-0-0	3
ESL742	Economics and Financing of Renewable Energy Systems	3-0-0	3
	Total Credits		

M.Tech. in Energy and Environmental Managemental   JEN

Sem.	Courses (Number, abbreviated title, L-T-P, credits)					Lecture Courses	Contact h/week				Credits
							L	T	P	Total	
I	ESL711 Fuel Technology (3 - 0 - 0) 3	ESL740 Non-conv sour energy (3 - 0 - 0) 3	ESL777 Environ Sc & Engg (3 - 0 - 0) 3	ESL791 App Math Comp Meth (1 - 0 - 0) 0	ESL704/712 Basic Ther/Elec Engg (1 - 0 - 0) 0	5	11	0	0	11	9
II	ESL720 Energy conservation (3 - 0 - 0) 3	ESL774 Qnt Meth E Mgmt Plng (3 - 0 - 0) 3	ESP700 Engergy Laboratories (0 - 0 - 6) 3	ESL725 Energy Auditing (1 - 0 - 0) 0	ESL794 Prin Chem Proc Comt (1 - 0 - 0) 0	2	8	0	6	14	9
Summer											
III			PE-1 (3 - 0 - 0) 3	PE-2 (3 - 0 - 0) 3	PE-3 (3 - 0 - 0) 3	3	9	0	0	9	9
IV	PC-M1 3(3 - 0 - 0) 9	PC-M2 3(3 - 0 - 0) 9	PC-M3 3(3 - 0 - 0) 9	PC-M4 3(3 - 0 - 0) 9		3	9	0	0	9	9
Summer	JND801 Major Project Part 1 (JEN)					0					
III	JND801 Maj Prof Part 1 (JEN) (0 - 0 - 12) 6			OE-1 (3 - 0 - 0) 3	OE-2 (3 - 0 - 0) 3	2	6	0	12	18	12
IV	JND802 Maj Proj Part 2 (JEN) (0 - 0 - 24) 12					0	0	0	24	24	12

PC-M1, PC-M2 and PC-M3 and PC-M4 are four course sets from Module A, B, C or D as part of programme core.   **Total = 60**

Master of Technology in *Industrial Tribology and Maintenance Engineering*
Interdisciplinary Programme

The overall credits structure

Category	PC	PE	OE	Total
Credits	43	12	06	61

Programme Core (PC)

ITL702	Diagnostic Maintenance and Monitoring	3-0-2	4
ITL703	Fundamentals of Tribology	3-0-2	4
ITL705	Material for Tribological Applications	3-0-0	3
ITL709	Maintenance Planning and Control	3-0-0	3
ITL710	Design of Tribological Elements	3-0-2	4
ITL711	Reliability Availability and Maintainability (RAM) Engineering	3-0-0	3
ITL714	Failure Analysis and Repair	3-0-2	4
JID801	Major Project Part 1 (JIT)	0-0-12	6
JID802	Major Project Part 2 (JIT)	0-0-24	12
	Total PC	***21-0-44***	***43***

Programme Electives (PE)

ITL716	Computer Applications in Maintenance Management	2-0-2	3
ITL717	Corrosion and its Control	3-0-0	3
ITL730	Lubricants	2-0-2	3
ITL740	Risk Analysis and Safety	2-1-0	3
ITL752	Bulk Materials Handling	2-0-2	3
ITL760	Noise Monitoring and Control	2-0-2	3
ITL770	Design for Maintenance	2-0-2	3
ITL810	Bearing Lubrication	2-0-2	3
JIS800	Independent Study (JIT)	0-3-0	3

M.Tech. in Industrial Tribology and Maintenance Engineering   **JIT**

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	L	T	P	Total	Credits
I	ITL711 Reliab, Avail & Maint (3 - 0 - 0) 3	ITL703 Fundmentals of Tribology (3 - 0 - 2) 4	ITL705 Materials for Tribological Appl (3 - 0 - 0) 3	ITL709 Maintenance Plang & Control (3 - 0 - 0) 3		**PE-1** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	6	18	0	2	20	19
II	ITL702 Diagnos Maint & Monitoring (3 - 0 - 2) 4	ITL714 Failure Analysis and Repair (3 - 0 - 2) 4	ITL710 Design of Tribolo Elem (3 - 0 - 2) 4		**PE-2** (3 - 0 - 0) 3	**PE-3** (3 - 0 - 0) 3		5	15	0	6	21	18
Summer	JID801 Major Project Part 1(JIT)							0					
III	JID801 Maj Proj Part 1 (JIT) (0 - 0 - 12) 6				**PE-4** (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3		2	6	0	12	18	12
IV	JID802 Maj Proj Part 2 (JIT) (0 - 0 - 24) 12							0	0	0	24	24	12

TOTAL = 61

Master of Technology in **Instrument Technology**
Interdisciplinary Programme

The overall credits structure

Category	PC	PE	OC	Total
Credits	40	12	09	61

Programme Core (PC)

IDP703	Instrument Technology Laboratory 1	0-0-6	3
IDP704	Instrument Technology Laboratory 2	0-0-6	3
IDP705	Advanced Instrument Technology Laboratory	0-0-8	4
IDL711	Instrumentation Transducers	3-0-0	3
IDL712	Electronic Techniques for Signal Conditioning and Interfacing	3-0-0	3
IDL714	Instrument Design and Simulations	2-0-2	3
IDL734	Laser Based Instrumentation	3-0-0	3
JTD801	Major Project Part 1 (JID)	0-0-12	6
JTD802	Major Project Part 2 (JID)	0-0-24	12
	Total PC	**11-0-58**	**40**

Programme Electives (PE)

IDL713	Advanced Electronic Components and Circuits	3-0-0	3
IDL716	Quality Control and Standardization	3-0-0	3
IDL720N	Independent Study	0-3-0	3
IDL721N	Material and Mechanical Design (for non-mechanical students only)	3-0-2	4
IDL722	Precision Measurement Systems	3-0-0	3
IDL724	Advanced Fabrication and Finishing	3-0-0	3
IDL730	Photochemical Machining	2-0-2	3
IDL731	Optical Components and Basic Instruments	3-0-0	3
IDL732	Optical Material and Techniques	3-0-0	3
IDL735	Scientific and Engineering Applications of Moire Patterns	2-0-2	3
IDL741	Instrument Organization and Ergonomics	2-0-2	3
IDL742	Industrial Design Practice	1-0-4	3
IDL811	Selected Topics in Instrumentation	3-0-0	3
IDC812	Term Paper and Seminar (JID)	0-3-0	3
EEL801	Microprocessor Based System Design	3-0-0	3
EEL836	Biomedical Electronics	3-0-0	3
MEL731N	Design of Mechanism and Manipulators	3-0-2	4
MEL786F	Industrial Inspection	3-0-1	3.5
AML880F	Computer Aided Design	3-0-2	4
OE720	Integrated Optics(PH)	3-0-0	3
PHL836	Optical Instrumentation and Metrology	3-0-0	3

M.Tech. in Instrument Technology   **JID**

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	Contact h/week				Credits
									L	T	P	Total	
I	IDP703 Instr. Tech Lab. 1 (0 - 0 - 6) 3	IDL711 Instrum Transducers (3 - 0 - 0) 3			PE-1 (3 - 0 - 0) 3	PE-2 (3 - 0 - 0) 3	OE-1 (3 - 0 - 0) 3	4	12	0	6	18	15
II	IDP704 Instr. Tech Lab. 2 (0 - 0 - 6) 3	IDL712 Elect Tech Sig Cond & Inter. (3 - 0 - 0) 3	IDP714 Instr Design and Simul. (2 - 0 - 2) 3	IDL734 Laser Based Instrum (3 - 0 - 0) 3	PE-3 (3 - 0 - 0) 3	OE-2 (3 - 0 - 0) 3		5	14	0	8	22	18
Summer	JTD801 Major Project Part 1(JID)							0					
III	JTD801 Maj Proj Part 1 (JID) (0 - 0 - 12) 6	IDP705 Adv Instr. Tech. Lab. (0 - 0 - 8) 4			PE-4 (3 - 0 - 0) 3	OE-3 (3 - 0 - 0) 3		2	6	0	20	26	16
IV	JTD802 Maj Proj Part 2 (JID) (0 - 0 - 24) 12							0	0	0	24	24	12

TOTAL = 61

Master of Technology in *Optoelectronics and Optical Communication*
Interdisciplinary Programme

The overall credits structure

Category	PC	PE	OC	Total
Credits	42	9	9	60

Programme Core (PC)

JOD801	Major Project Part 1 (JOP)	0-0-12	6
JOD802	Major Project Part 2 (JOP)	0-0-24	12
JOP791	Fiber Optics and Optical Communications Laboratory 1	0-0-6	3
JOP792	Fiber Optics and Optical Communications Laboratory 2	0-0-6	3
EEL712	Optical Communication Systems	3-0-0	3
EEL769	Digital Communication and Information Systems	3-0-0	3
EEL895	Broadband Communication and Information Systems	3-0-0	3
PHL793	Semiconductor Optoelectronics	3-0-0	3
PHL791	Fiber Optics	3-0-0	3
PHL792	Optical Electronics	3-0-0	3
	Total PC	***18-0-48***	***42***

Programme Electives (PE)

EEL789	Optoelectronic Instrumentation	3-0-0	3
EEL813	Selected Topics 1 (JOP)	3-0-0	3
EEL814	Selected Topics 2 (JOP)	3-0-0	3
EEL890	Photonic Switching and Networking	3-0-0	3
JOS800	Independent Study (JOP)	0-3-0	3
PHL755	Statistical and Quantum Optics	3-0-0	3
PHL790	Integrated Optics	3-0-0	3
PHL795	Optics and Lasers	3-0-0	3
PHL797	Selected Topics 1 (JOP)	3-0-0	3
PHL798	Selected Topics 2 (JOP)	3-0-0	3
PHL891	Guided Wave Optical Components and Devices	3-0-0	3

M.Tech. in Optoelectronics and Optical Communication   JOP

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	Contact h/week				Credits
									L	T	P	Total	
I	PHL791 Fibre Optics (3 - 0 - 0) 3	PHL793 Semiconductor Optoelectronics (3 - 0 - 0) 3	EEL769 Digital Comm & Infor System (3 - 0 - 0) 3	JOP791 Fiber Optics & Opt Com Lab 1 (0 - 0 - 6) 3		**PE-1** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	*5*	15	0	6	21	**18**
II	PHL792 Optical Electronics (3 - 0 - 0) 3	EEL895 Broadband Com & Infor System (3 - 0 - 0) 3	EEL712 Optical Comm Systems (3 - 0 - 0) 3	JOP792 Fiber Optics & Opti Com Lab 2 (0 - 0 - 6) 3	**PE-2** (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3		*5*	15	0	6	21	**18**
Summer	JOD801 Major Project Part 1(JOP)							*0*					
III	JOD801 Maj Proj Part 1 (JOP) (0 - 0 - 12) 6				**PE-3** (3 - 0 - 0) 3	*OE-3* (3 - 0 - 0) 3		*2*	6	0	12	18	**12**
IV	JOD802 Maj Proj Part 2 (JOP) (0 - 0 - 24) 12							*0*	0	0	24	24	**12**

TOTAL = 60

Master of Technology in *Polymer Science and Technology*
Interdisciplinary Programme

The overall credits structure

Category	PC	PE	OC	Total
Credits	42	12	6	60

Programme Core (PC)

JPD801	Major Project Part 1 (JPT)	0-0-12	6
JPD802	Major Project Part 2 (JPT)	0-0-24	12
PTL701	Polymer Chemistry	3-0-0	3
PTL702	Polymer Processing	3-0-0	3
PTL703	Polymer Physics	3-0-0	3
PTL705	Polymer Characterization	2-0-2	3
PTL706	Polymer Testing and Properties	3-0-0	3
PTL707	Polymer Engineering and Rheology	3-0-0	3
PTL709	Polymer Technology	3-0-0	3
PTP710	Polymer Science Laboratory	0-0-4	2
PTP720	Polymer Engineering Laboratory	0-0-2	1
	Total PC	***20-0-44***	***42***

Programme Electives (PE)

JPD799	Minor Project (JPT)	0-0-6	3
JPS800	Independent Study (JPT)	0-3-0	3
PTL711	Engineering Plastics and Specialty Polymers	3-0-0	3
PTL712	Polymer Composites	3-0-0	3
PTL714	Polymer Blends and Alloys	3-0-0	3
PTL716	Rubber Technology	3-0-0	3
PTL718	Polymer Reaction Engineering	2-1-0	3
PTL720	Polymer Product and Mold Design	2-0-2	3
PTL722	Polymer Degradation and Stabilization	3-0-0	3
PTL724	Polymeric Coatings	3-0-0	3
PTL726	Polymeric Nanomaterials and Nanocomposites	3-0-0	3

M.Tech. in Polymer Science and Technology   JPT

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	L	T	P	Total	Credits
I	PTL701 Polymer Chem (3 - 0 - 0) 3	PTL703 Polymer Physics (3 - 0 - 0) 3	PTL705 Polymer Charac (2 - 0 - 2) 3	PTL707 Polymer Engg & Rheo (3 - 0 - 0) 3	PTL709 Polymer Tech (3 - 0 - 0) 3	PTP710 Polymer Sci Lab (0 - 0 - 4) 2		*5*	14	0	6	20	17
II	PTL702 Polymer Processing (3 - 0 - 0) 3	PTL706 Polymer Testing & Prop (3 - 0 - 0) 3	PTP720 Polymer Engg Lab (0 - 0 - 2) 1	**PE-1** (3 - 0 - 0) 3	**PE-2** (3 - 0 - 0) 3	**PE-3** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	*6*	18	0	2	20	19
Summer	JPD801 Major Project Part 1(JPT)							*0*					
III	JPD801 Maj Proj Part 1 (JPT) (0 - 0 - 12) 6					**PE-4** (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3	*2*	6	0	12	18	12
IV	JPD802 Maj Proj Part 2 (JPT) (0 - 0 - 24) 12							*0*	0	0	24	24	12

TOTAL= 60

Master of Technology in *VLSI Design Tools and Technology*

Interdisciplinary Programme

Overall credits structure of the two streams

Category	PC	RC	PE	OC	Total
VLSI Design	**30**	**10**	**14**	**6**	**60**
VLSI Systems	**32**	**10**	**12**	**6**	**60**

Programme Core (PC)

EEL734	MOS VLSI	3-0-0	**3**
CSP745	Digital Systems Design Laboratory	0-0-6	**3**
JVD801	Major Project Part 1 (JVL)	0-0-12	**6**
JVD802	Major Project Part 2 (JVL)	0-0-24	**12**
	Total PC	***3-0-42***	***24***

Restricted Core (RC)

EEL731	Digital Signal Processing 1	3-0-0	**3**
EEL732	Microelectronics	3-0-0	**3**
EEL784	IC Technology	3-0-0	**3**
MAL701/	Data structures	3-0-2	**4**
CSL630	Data structures	3-0-2	**4**

Stream Core (SC)

A. VLSI Design Stream

EEP736	Physical Design Laboratory	0-0-6	**3**
EEL782	Analog Integrated Circuits	3-0-0	**3**

B. VLSI Systems Stream

CSL718	Architecture of High Performance Computers	3-0-2	**4**
CSL719	Synthesis of Digital Systems	3-0-2	**4**

Programme Electives (PE)

EEL602	Operating Systems	3-0-2	**4**
CSL633	Resource Mgmt. in Comp Sys. or Optg. Sys.	3-0-2	**4**
CSL672	Computer Networks	3-0-2	**4**
CRL702	Architectures and Algorithms for DSP Sys.	2-0-4	**4**
EEL703	Computer Networks	3-0-0	**3**
CRL704	Sensor Array Signal Processing	3-0-0	**3**
CRL711	CAD of RF & Microwave Devices	3-0-2	**4**
CRL712	RF & Microwave Active Circuits	3-0-0	**3**
EEL781	Neural Networks	3-0-0	**3**
EEL783	Filter Design	3-0-0	**3**
EEL786	Mixed Signal Circuit Design	3-0-0	**3**
EEL787	Memory Design and Testing	3-0-0	**3**
EEP788	IC Processing Laboratory	0-0-6	**3**
JVD801	Minor Project	0-0-6	**3**
JVS802	Independent Study	0-3-0	**3**
EEL802	Testing and Fault Tolerance	3-0-0	**3**
CSL812	Sys Level Design and Modeling of Dig Sys.	3-0-0	**3**
CSL821	Reconfigurable Computing	3-0-0	**3**
EEV831	Special Module in Nano Electronics	1-0-0	**1**
EEL831	Digital Signal Processing 2	3-0-0	**3**
EEV832	Special Module in Analog & Mixed Signal IC Design	1-0-0	**1**
EEL832	Computer Aided VLSI Design	3-0-0	**3**
EEL833	Selected Topics in IEC	3-0-0	**3**
EEV833	Special Module in Low Power IC Design	1-0-0	**1**
EEV834	Special Module in VLSI Testing	1-0-0	**1**
EEL834	VLSI Design	3-0-0	**3**
EEV838	CMOS RF IC Design	3-0-0	**3**
CSL858	Advanced Computer Networks	3-0-2	**4**
EEL881	Issues in Deep Submicron CMOS IC Design	3-0-0	**3**

VLSI Design Stream

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	L	T	P	Total	Credits
I	EEL734 MOS VLSI (3 - 0 -0) 3	CSP745 Digital Sys Des Lab (0 - 0 - 6)3	**RC-1** (3 - 0 - 0) 3			**PE-1** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	4	12	0	6	18	**15**
II	EEL782 Analog Int Circuit (3 - 0 - 0) 3	**RC-2** (3 - 0 - 0) 3	EEP736 Physical Des Lab (0 - 0 - 6) 3		**PE-2** (3 - 0 - 0) 3	**PE-3** (3 - 0 - 0) 3		4	12	0	6	18	**15**
Summer	JVD801 Major Project Part 1(JVL)							0					
III	JVD801 Minor Project (0 - 0 - 12) 6	**RC-3** (3 - 0 - 0) 3			**PE-4** (3 - 0 - 0) 3	**PE-5** (3 - 0 - 0) 3	*OE-2*	3	9	0	18	27	**18**
IV	JVD802 Independent Study (0 - 0 - 24) 12							0	0	0	24	24	**12**

VLSI Systems Stream

Sem.	Courses (Number, abbreviated title, L-T-P, credits)							Lecture Courses	L	T	P	Total	Credits
I	EEL734 MOS VLSI (3 - 0 -0) 3	CSP745 Digital Sys Des Lab (0 - 0 - 6)3	CSL719 Synthesis of Dig Sys (3 - 0 - 2) 4			**PE-1** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3	4	12	0	8	20	**16**
II	CSL718 Archit of HP Comp (3 - 0 - 2) 4	**RC-1** (3 - 0 - 0) 3	**RC-2** (3 - 0 - 0) 3		**PE-2** (3 - 0 - 0) 3	**PE-3** (3 - 0 - 0) 3		5	15	0	2	17	**16**
Summer	JVD801 Major Project Part 1(JVL)							0					
III	JVD801 Minor Project (0 - 0 - 12) 6	**RC-3** (3 - 0 - 0) 3			**PE-4** (3 - 0 - 0) 3	**PE-5** (3 - 0 - 0) 3	*OE-2*	3	9	0	18	27	**18**
IV	JVD802 Independent Study (0 - 0 - 24) 12							0	0	0	24	24	**12**

Master of Technology in *Power Generation Technology*
Interdisciplinary Programe

The overall credits structure

Category	PC	PE	OC	*Total*
Credits	41*/40#	15	06	*60*/61#*

Programme Core (PC)   * for C&I # for EE and ME

Core courses for all students

JGD801	Major Project Part 1(JPG)	0-0-12	6
JGD802	Major Project Part 2(JPG)	0-0-24	12
ITL702	Diagnostic Maintenance and Monitoring	3-0-2	4
JGL720	Power Plant Performance	3-0-0	3

Core courses for C&I students

MEL626	Mathematical Equipment in Power Plants	3-0-0	3
EEL721	Linear System Theory	3-0-0	3
EEL771	Random processes in Control and Estimation	3-0-0	3
EEL772	Optimal Control Theory	3-0-0	3
EEP874	Project Laboratory	0-1-6	4

Core courses for EE students

MEL626	Mathematical Equipment in Power Plants	3-0-0	3
EEL744	A.C.Controllers	3-0-0	3
EEL791	Power System Analysis	3-0-0	3
EEP792	Power System Protection	3-0-0	3
EEP790	Advanced Electrical Laboratory	0-1-4	3

Core courses for ME students

EEL641	Electrical Equipment in Power Plants	3-0-0	3
AML715	Viscous Fluid Flow	3-0-0	3
MEL725	Power Plant Steam Generators	3-0-0	3
MEL727	Power Plant Turbomachinery	3-0-0	3
MEP720	Advanced Mechanical Laboratory	0-1-4	3
	Total PC	**(C&I)**	**18-01-44 41**
		(EE)	**18-01-42 40**
		(ME)	**18-01-42 40**

Programe Electives (PE)

ITL760	Noise Monitoring and Control	2-0-2	3
ITL714	Failure Mechanism Analysis and Repair	3-0-2	4
ITL717	Corrosion and its Control	3-0-0	3
ITL752	Bulk Materials Handling	2-0-2	3
MEL708	Combustion Generated Pollution and Control	3-0-2	4
MEL709	Heat Exchangers	3-0-2	4

Programe Electives(PE) (Contd.)

MEL712	Advanced Power Plant Cycles	2-0-4	4
MEL730	Hydroelectric Power Plants	3-0-0	3
MEL733	Vibration Engineering	3-0-2	4
MEL740	Instrumentation and Automatic Control Systems	3-0-2	4
MEL741	Blade and Disc Dynamics	3-0-2	4
MEL760	Project Management	2-0-2	3
MEL802	Convection Heat and Mass Transfer	3-0-0	3
MEL804	Radiation and Conduction Heat Transfer	3-0-0	3
MEL806	Thermal Systems Simulation and Design	2-0-2	3
MEL807	Computational Heat Transfer	2-0-4	4
MEL811	Steam and Gas Turbines	3-0-2	4
MEL812	Combustion	3-0-2	4
MEL838	Rotor Dynamics	3-0-2	4
ESL711	Fuel Technology	3-0-0	3
EEL743	Power Electronic Devices and D.C. Converters	3-0-0	3
EEL745	Electrical Drives Systems	3-0-0	3
EEL746	Non-conventional Energy Systems and Energy Conservation	3-0-0	3
EEL758	Intelligent and Knowledge Based Systems	3-0-0	3
EEL774	Parameter Estimation and System Identification	3-0-0	3
EEL796	Power Systems Control and Instrumentation	3-0-0	3
EEL797	Power Systems Dynamics	3-0-0	3
EEL799	Power Systems Reliability	3-0-0	3
EEL823	Discrete Time Systems	3-0-0	3
EEL824	Non-linear Systems	3-0-0	3
EEL841	Solid State Controllers of Drives	3-0-0	3
EEL894	Flexible AC Transmission Systems (FACTS)	3-0-0	3
IDL811	Selected Topics in Instrumentation	3-0-0	3
JGL712	Power Plant Control and Instrumentation	3-0-0	3
JGS800	Independent Study	0-3-0	3

M.Tech. in Power Generation Technology   JPG

Sem.	Courses (Number, abbreviated title, L-T-P, credits)						Lecture Courses	Contact h/week				Credits
								L	T	P	Total	
I	ITL702	MAL626# * EEL641+	EEL721# EEL791* MEL725+	EEL771# EEL792* AML715+	**PE-1**# EEL744* MEL727+		5	15	0	2	17	
	Diag Maint Monitor (3 - 0 - 2) 4	Core Course (3 - 0 - 0) 3	Core Course (3 - 0 - 0) 3	Core Course (3 - 0 - 0) 3	Core Course/PE (3 - 0 - 0) 3							16
II	JGL720	EEP874# EEP790* MEP720+	EEL772# **PE-1***+	**PE-2**	**PE-3**	OE-1	5	15	1	4	20	
	P P Perform (3 - 0 - 0) 3	Core course (0 - 1 - 4) 4	Core course/PE (3 - 0 - 0) 3	(3 - 0 - 0) 3	(3 - 0 - 0) 3	(3 - 0 - 0) 3						18
Summer	JGD801 Major Project Part 1(JPG)											
III	JGD801 Maj Proj P 1(JPG) (0 - 0 - 12) 6			**PE-4** (3 - 0 - 0) 3	**PE-5** (3 - 0 - 0) 3	OE-2 (3 - 0 - 0) 3	3	9	0	12	21	15
IV	JGD802 Maj Proj P 2(JPG) (0 - 0 - 24) 12						0	0	0	24	24	12

Note: # for C&I; * for EE; + for ME   TOTAL = **61**

Master of Technology in *Telecommunication Technology and Management*
Interdisciplinary Programme

The overall credits structure

Category	PC	PE	OE	Total
Credits	42	12	6	60

Programme Core (PC)

EEL711	Signal Theory	3-0-0	3
EEL762	Digital Communications	3-0-0	3
EEL767	Telecommunication Systems	3-0-0	3
EEL818	Telecommunication Technologies	3-0-0	3
EEP773	Telecommunication Software Laboratory	0-1-4	3
EEP775	Telecommunication Networks Laboratory 1	0-1-4	3
EEP776	Wireless Communication Laboratory	0-1-4	3
JMD801	Major Project Part 1 (JTM)	0-0-12	6
JMD802	Major Project Part 2 (JTM)	0-0-24	12
SMD792	Minor Project (SMF, SMN, SMT, JTM)	0-0-6	3
SML723	Telecommunication Systems Management	3-0-0	3
	Total PC	***18-2-50***	***42***

Programme Electives (PE)

EEL703	Computer Networks	3-0-0	3
EEL707	Multimedia Systems	3-0-2	4
EEL716	Telecommunication Switching & Transmission	3-0-0	3
EEL731	Digital Signal Processing	3-0-0	3
EEL817	Access Networks	3-0-0	3
EEL854	Protocol Engineering	3-0-2	4
EEL855	Internet Technologies	3-0-0	3
EEL857	Network Security	3-0-2	4
EEL858	Mobile Computing	3-0-0	3
EEL859	Network Management	3-0-2	4
EEL860	Wireless Communication Networks	3-0-2	4
EEL861	Selected Topics in Communication Engineering 1	3-0-0	3
EEL862	Selected Topics in Communication Engg. 2	3-0-0	3
EEL863	Selected Topics in Communication Engg. 3	3-0-0	3
EEL871	Selected Topics in Communication Engg. 4	1-0-0	1
EEL872	Selected Topics in Communication Engg. 5	1-0-0	1
EEL882	Introduction To Telecommunication Systems (Audit/Bridge)	3-0-0	3
EEP757	Embedded Telecommunication Systems Laboratory	0-1-4	3
EEP858	Telecommunication Networks Laboratory 2	0-1-4	3
EEP881	Network Software Laboratory	0-1-4	3
JMS800	Independent Study (JTM)	3-0-0	3
SML726	Telecommunication Systems Analysis, Planning and Design	3-0-0	3
SML728	International Telecommunication Management	3-0-0	3

M.Tech. in Telecommunication Technology and Management   **JTM**

Sem.	Courses (Number, abbreviated title, L-T-P, credits)						Lecture Courses	L	T	P	Total	Credits
I	EEL711 Signal Theory (3 - 0 - 0) 3	EEL762 Digital Communication (3 - 0 - 0) 3	EEL767 Telecom Systems (3 - 0 - 0) 3	EEP773 Telecom Software Lab (0 - 1 - 4) 3	EEP776 Wireless Comm Lab (0 - 1 - 4) 3	SML723 Telecom Sys Mgmt (3 - 0 - 0) 3	*4*	12	2	8	22	**18**
II	EEL818 Telecom Technologies (3 - 0 - 0) 3	EEP775 Telecom Networks Lab 1 (0 - 1 - 4) 3	SMD792 Minor Project (JTM) (0 - 0 - 6) 3		**PE-1** (3 - 0 - 0) 3	**PE-2** (3 - 0 - 0) 3	*OE-1* (3 - 0 - 0) 3 *4*	12	4	4	20	**18**
Summer	JMD801 Major Project Part 1(JTM)						*0*					
III	JMD801 Maj Proj Part 1 (JTM) (0 - 0 - 12) 6				**PE-3** (3 - 0 - 0) 3	*OE-2* (3 - 0 - 0) 3	*2*	9	0	18	27	**12**
IV	JMD802 Maj Proj Part 2 (JTM) (0 - 0 - 24) 12						*0*	0	0	24	24	**12**

TOTAL = 60

10. COURSE DESCRIPTIONS

The details about every course are given in this section. Information about each course includes course number, credits, L-T-P structure, pre-requisites, overlapped courses and course contents.

For some 700 and 800 level courses, the pre-requisites have been explicitly indicated. Where there are not mentioned, the default pre-requisites shall be applicable for UG students (see sections 2.6 and 3.12).

For additional information see the website or contact the concerned course coordinator or head of the department/centre/school/programme coordinator.

Department of Applied Mechanics

AML110 Engineering Mechanics
4 credits (3-0-2)
Laws of mechanics, equivalent force systems and equations of equilibrium, Internal forces in structures and beams, friction and its applications, Kinematics of point mass and rigid body, Center of mass, System of particles, Inertia tensor, Dynamics of rigid bodies, Euler's equations of motion, Impulse-momentum, Work-energy methods with applications, Principle of virtual work and stability.

AML120 Materials Science
4 credits (3-0-2)
Structures of materials – crystal structure, substructure, microstructure, etc. Phase diagram and phase transformation. Diffusion phenomenon. Mechanical behavior – strength, hardness, deformation, creep, fatigue, etc. Mechanisms of strengthening and toughening of materials. Metallic alloys, Ceramics, Polymeric and Composite materials. Conductors, semiconductors and magnetic materials.

AML130 Experimental Methods and Analysis
5 credits (3-1-2)
(a) Experimental Analysis: measurements and errors, internal and external estimates of errors, statistical analysis, accuracy and precision, best estimate, accuracy of the mean, significant digits, methods of least squares, curve fitting, linear regression, comparison and combination of measurements, extensions least square method. Theory of errors, Gaussian distribution, confidence limits, significance test, and goodness of fit.

(b) Instrumentation: Principle of measurements, Basic elements of measurement device, various types of measurement systems, standards and calibration, Dynamic characteristics of first and second order instruments, Transducers.

(c) Experimental Devices: displacement measurement dial gauge, optical method pneumatic transducer, variable resistance, inductance and capacitance transducer, Seismic devices for motion measurement. Principle of planimeter, Strain and stress measurements, Force and torque measurements, various types of load cells and their applications.

AML140 Mechanics of Solids
4 credits (3-1-0)
Overlaps with: AML150, AML180
Introduction, Definition of stress, Equations of equilibrium, Principal stress, Maximum shear stress, Plane stress, Concept of strain, Strain displacement relations, Principal strains, Plane strain, Constitutive relations, Uniaxial tension test, Idealized stress-strain diagram, Isotropic linear elastic, viscoelastic and plastic materials, Uniaxial deformations, Thermal stresses, Torsion of shafts, Bending and shear of beams, Energy methods, Fracture, Deflection, Stability.

AML150 Mechanics of Solids and Fluids
5 credits (3-1-2)
Overlaps with: AML140, AML160, AML170, AML180, CHL231, CHL204, AMP262
Introduction, fundamental concepts, mathematical preliminaries.

Analysis of strain deformation, strain displacement relations, Normal and shear strains, Transformation, Principal strains and Maximum shear strains, Volumetric strain, Compatibility equations, Plane strain, Stain rosettes, Velocity field and strain rates.

Constitutive relations; Hookean elastic solids, Yield criteria and plasticity, Viscoelasticity, Non-viscous fluid, Newtonian fluid.

Solid mechanics applications – Axisymmetric thin shells, Uniaxial deformation. Torsion, bending, buckling, etc.

Fluid mechanics applications – Fluid statics, fluid motion; Material and spatial description. Integral and differential flow analysis, ideal fluid flow, simple viscous flow, Dimensional analysis.

AML160 Mechanics of Fluids
4 credits (3-1-0)
Overlaps with: AML150, AML170, CHL231, CHL204
Introduction. Definitions. Fluid properties: classification of fluids and flow regimes. Fluid statics: Stationary fluids and liquids subjected to

constant linear acceleration and to constant rotation. Fluid kinematics: Lagrangian and Eulerian descriptions, pathlines, streaklines and streamlines, acceleration. Integral flow analysis: Reynolds transport theorem, conservation of mass/continuity equation and conservation of linear and angular momentum for a control volume in inertial and accelerating reference frames, energy equation, Bernoulli's equation, engineering applications. Differential analysis of flow: Continuity and Navier-Stokes equations. Dimensional analysis and Similitude theory. Inviscid flows: Irrotational flow, circulation, velocity potential and applications. Viscous flows in pipes and ducts. External viscous flows: concept of boundary layer, momentum integral equation, drag and lift, separation. Fluid machinery: Introduction and classification of machines, types of hydraulic turbines and pumps and their performance characteristics, turbomachinery analysis and velocity triangles, cavitation, NPSH concept, similarity rules, applications.

AML170 Fluid Mechanics
5 credits (3-1-2)
Overlaps with: AML150, AML160, CHL231, CHL204, AMP262
Introduction, fluid properties, classification, fluid statics, rigid body motions, kinematics of fluid motions, Reynolds transport theorem, mass, momentum and energy laws with applications, governing equations for Newtonian fluids, exact solutions, laminar and turbulent pipe flow. Introduction to boundary layer theory, Dimensional analysis and modeling, open channel flow.

AML180 Solid Mechanics
5 credits (3-1-2)
Overlaps with: AML140,AML150, AMP262
Introduction, Definition of stress, Equations of equilibrium, Principal stress, Maximum shear stress, Plane stress, Concept of strain, Strain displacement relations, Principal strains, Plane strain, Constitutive relations, Uniaxial tension test, Idealized stress-strain diagram, Isotropic linear elastic, viscoelastic and plastic materials, Uniaxial deformations, Thermal stresses, Torsion of shafts, Bending and shear of beams, Energy methods, Fracture, Deflection, Stability.

AML190 Design Engineering
5 credits (3-1-2)
Introduction To Design: History of Design, Industrial Design, Engineering Design, Craft Design. Design Process: Recognition of need, Conceptualization and Creativity, Feasibility Assessment, Preliminary Design, Detailed Design, Prototype Testing. IMportant Design Considerations: Design Materials, Manufacturing Processes, Human Factors, Applied Ergonomics, Reliability, Safety and Environmental Protection, Optimization, Engineering Economics, Engineering Ethics. Advanced Technology For Design: Concurrent/Simultaneous Design, CAD and CAM, Rapid Prototyping, CIM.

AMP262 Fluids and Solids Laboratory
1.5 credits (0-0-3)
Pre-requisites: AML140 & AML160
Overlaps with: AML150 / AML170 / AML180
Experiments will build-up on knowledge of Mechanics of Solids and Mechanics of Fluids. Applications of uncertainty analyses. A professional report is to be prepared for each experiment. Students work in a group of two.

AML300 Constitutive Modelling and Application of New Materials
3 credits (3-0-0)
Pre-requisites: AML140 / AML150 / AML180 and EC 60
Overview of new developments in materials. Composites, fiber and matrix. Mechanical property of lamina. Failure of lamina. Micro-mechanics. Laminates and their applications. Visco elasticity – spring/dashpot models. 3-D constitutive relation. Creep, age / strain hard. Applications to beams and torsion. Fracture mechanics. Introduction to 1-D FEM and simple applications.

AMD310 Mini Project (AM)
3 credits (0-0-6)
Pre-requisites: EC 80
A project will be specified by the concerned teacher and it is expected that under his/her guidance the students will carry out all the activities related to the project.

AML310 Computational Mechanics
4 credits (3-0-2)
Pre-requisites: AML140 / AML150 / AML160 / AML170 / AML180 / CHL231 / CHL204 and EC 60
Concept of a continuum. Introduction to stress, strain and rate-of-strain tensors. Principal stresses and strains. Equations of equilibrium/motion in solid and fluid mechanics constitutive equations. Role of computational methods in Mechanics. Error analysis. Determination of constitutive curves interpolation techniques. Application of numerical integration and differentiation to axial loading of bars and beams; integration of the boundary layer equations. Integration of ODEs. Application to axial and transverse loading of beams. Application to I-D fluid flow. Boundary value and initial value problems. Simultaneous linear and non-linear equations. How they arise in Mechanics. Direct and indirect methods of solution. PDEs classification. Applications to transientbeam bending, axial stretching, boundary-layer equations. Emphasis will be on finite difference type methods.

AML340 Chaos in Engineering Systems
3 credits (3-0-0)
Pre-requisites: AML110 and EC 60
Introduction to chaos. Various examples of chaos in engineering systems, electrical systems (Van Der Pol oscillator); electrical systems (Van Der Pol oscillator); Fluid mechanical systems (Lorenzequations, Aeroelastic flutter), Vibration (Duffing sequation), Chemical reactions (Belousov-Zhabotinski reaction) etc. Basic concepts in the mathematical treatment of non linear systems. Note: The emphasis in this course will be on developing a physical understanding of chaotic systems. The laboratory sessions will be partly experimental demonstrations and partly computer simulations (performed by the students).

AML350 Corrosion and Prevention
3 credits (3-0-0)
Pre-requisites: EC 60
Aqueous corrosion, theory and mechanism, corrosion kinetics, corrosion behaviour of specific metals and alloys, effects of stress, strain temperature and environment, corrosion fatigue, stress corrosion cracking, corrosion testing methods, Prevention of corrosion in practice (cathodic and anodic protection, corrosion inhibitors, protective coating etc., case studies.

AML360 Engineering Fluid Flows
4 credits (3-1-0)
Pre-requisites: AML150 / AML160 / AML170 / CHL231 / CHL204 and EC 60
Overlaps with: AML711 / AML713 / AML715
Fundamentals. Governing equations: Equation of motion; Stress at a point; Relative motion near a point; Constitutive laws for Newtonian fluid; Navier-Stokes equations; Boundary conditions; Energy equation. Exact Solutions: Solutions involving one and two variables; Conversion of PDEs to ODEs. Non-dimensionalization: Non-dimensionalization of the N.S. equations; Order of magnitude analysis; Thin layer approximation. Low Reynolds number flows: Stokes and Oseen approximations; Hydrodynamic lubrication. Inviscid Flows: Vorticity equation; Irrotational flows. Flow at High Reynolds number: Prandtl's boundary layer equations; Blasius solution; Falkner-Skan solution; Momentum Integral equation; Jets and Wakes. Hydrodynamic Stability: Experimental results; Fundamentals of stability theory; Orr-Sommerfield equation. Turbulence: Fundamentals; Reynolds averaging; Closure problem; Turbulence Models. CFD: Finite difference and finite volume methods.

AML370 Pipeline Engineering
3 credits (3-0-0)
Pre-requisites: AML150 / AML160 / AML170 / CHL231 / CHL204 and EC 60
Overlaps with: CHL390
Flow through pipes, Designing of pipelines for non Newtonias and Newtonian Liquids, Laminar and Turbulent Flows, Friction Factor, Time independent and Visco Elastic Fluid Flow through pipelines, Multiphase pipelines, slumy pipeline transportation. Flow of gas-solid and liquid-liquid mixture, Hydro and pneumo capsule pipelines, corrosion-errors in pipelines and its control, Transient flow in pipelines and pipeline networks.

AML380 Biomechanics
4 credits (3-0-2)
Pre-requisites: AML110 and EC 60
Revision of mechanics. Kinematics and dynamics. Introduction to physiology of various life forms. Structural aspects. Locomotion principles. Properties of tissue. Analysis of motion and forces. Mehanics of injuries. Ageing effects. Design and use of implants. Materials of construction and maufacture of orthopaedic inserts.

AML410 Computational Methods in Fluid Dynamics
4 credits (3-0-2)
Pre-requisites: AML310
Conservation laws, boundary layer theory and similarity solutions, finite difference and finite volume methods, primitive and secondary variable formulations, explicit, implicit and semi-implicit methods, panel methods for inviscid flows, turbulence modeling, application to laminar and turbulent flows, introduction to finite element methods, grid generation.

AML430 Advanced Computational Methods
4 credits (3-1-0)
Pre-requisites: AML310
Overlaps with: AML806
Advanced topics in Computational Solid/Fluid mechanics to suit specific student needs and topics chosen from the following: (i) finite element analysis of plates and shells, (ii) finite elements in fluids, (iii) reduced integration patch test, (iv) dynamic FE analysis, (v) geometrically nonlinear problems. (vi) material nonlinearity. (vii) automated mesh generation. (viii) pre and post processing. (ix) solid fluid interaction problems. (x) efficient solution technique-PCG, domain decomposition. (xi) point source method. (xii) boundary element method. (xiii) aero elastic flutter. (xiv) other special topics.

AML440 Parallel Processing in Computational Mechanics
4 credits (3-0-2)
Pre-requisites: AML310
Advanced topics in computational solid/fluid mechanics to suit specific student needs and topics chosen from the following: Finite element analysis of plates and shells, Finite elements in fluids, Reduced integration patch test, Dynamic FE analysis, Geometrically nonlinear problems, Material nonlinearity, Automated mesh generation, Pre and Post processing, Solid fluid interaction problems, Efficient solution technique-PCG, domain decomposition, Point source method, Boundary element method, Aero elastic flutter, Other Special Topics.

AML700 Experimental Methods for Solids and Fluids
4 credits (3-0-2)
Basic principles of experimental analysis, strain gauges and strain gauge circuits. Rosettes. Photoelasticity. Brittle coating method. Moire fringe methods, holography, etc.

Flow visualization techniques. Measurement of pressure, velocity, discharge in fluid flow. Hot wire anemometry. Hot film anemometry, laser Doppler anemometer. Instrumentation in two-phase flows. Recent developments.

AML701 Engineering Mathematics & Mechanics
3 credits (3-0-0)
Partial differential equations. Fourier Series and transforms. Calculus of variations. Newtonian and Lagrangian mechanics. Variational and Hamiltonian mechanics.

AML702 Applied Computational Methods
4 credits (3-0-2)
Algorithms. Methods of undetermined coefficients. Numerical differentiation and integration. Solution of ordinary differential equations. Solution of linear and non-linear algebraic equations. Boundary value problems and initial value problems. Numerical solution of partial differential equations. Eigenvalue problems.

AM704 Flow of Non-Newtonian Fluids and Complex Mixtures
3 credits (3-0-0)
Classification and properties of non-Newtonian fluids. Rheological parameters and flow properties. Governing equations. Flow of non-Newtonian fluids through pipes. Turbulent flows. Complex mixtures. Phase separation and setting behaviour. Fundamental concepts for flow of mixtures. Flow of mixtures through pipes. Typical flow patterns. Applications.

AML705 Finite Element Methods
4 credits (3-0-2)
Pre-requisites: AML140 / AML150 / AML160 / AML170 / AML180 / CHL231 / CHL204
Overlaps with: MAL381
Method of weighted residuals and variational approach for solving differential equations. Galerkin and Rayleigh-Ritz methods. Finite element method and implementation. Convergence criterion. Finite element formulation for linear elastic continuum and extended Laplace equation including inertia and dissipative terms. Substructuring. Co-elements including isoparametric elements. Plate bending and 'C' elements. Non-conforming elements and patch test. Dynamic and non-linear problems. Finite Element formulation-problems involving initial stress and initial strain. Axisymmetric problems-classical solution. Finite Element solution of free vibration problems. Principles of transient dynamic analysis. Laboratory work for the solution of solid mechanics problems using FE packages.

AML706 Finite Element Methods and its Applications to Marine Structures
3 credits (3-0-0)
Introduction to FEM. Variational methods. Element types and properties. Boundary conditions. Stress-strain determination. Solution techniques. Mesh refinement. Convergence criterion. Frames, beams and axial element. Plane stress. Plane strain. Axisymmetric problems. Plate bending. Fluid mechanics and heat transfer. Modules modelling and elastic analysis. Super elements. Structural instability of frames and beams.

AML710 Computer Aided Design
4 credits (3-0-2)
Pre-requisites: EC 60
Overlaps with: MEL414
Principles of computer aided design. Computer configuration for CAD applications. Computer peripherals for CAD. Computer graphics fundamentals. Points and lines. Three-dimensional transformations and projections. Plane curves. Space curves. Surface description and generation. Hidden line algorithms for wireframe modelling. Surface modelling. Solid modelling, Representation of 3-D objects.

B-rep solid modellers and constructive solid geometry-CAD system utilization and application-Hidden surface algorithms and shading. Finite element systems. Computer aided drafting system.

Modelling using Solid Modeler (I-Deas) : Introduction - Part Modelling - Creating Geometry - Operations - Modifying parts - Constraints and construct Networks - Surface Modelling - Assembly - Part and Instance - Concurrent Engineering and Data Management - Drafting - Part Design.

Programming Exercises: 3-D Transformations and Projections - Curves - Surfaces - composite surfaces - CSG Modelling Tools - B-Rep Modelling Tools - Hidden Line Removal and Hidden Surface Removal.

AML711 Advanced Fluid Mechanics
4 credits (3-1-0)
Review of basic laws of fluid flow in integral and differential form, kinematics.Ideal fluid flow. Newtonian fluid flow and applications. Creeping flow. Boundary layer theory. Transition and turbulance. Turbulant boundary layer. Fundamentals of compressible flows. Modelling and dimensional analysis.

AML712 Numerical Methods in Fluid Flows
3 credits (3-0-0)
Review of numerical methods. Application of finite difference methods to different fluid flows such as inviscid flow, boundary layer development flow through fluid machines etc. Introduction of finite element methods, different approaches for deriving element equation. Application to different fluid flow situations..

AML713 Applied Fluid Mechanics
4 credits (3-1-0)
Basic equations of fluid motion, Dynamics of ideal fluid motion, Generalised Bernoulli equation and special cases, Governing equations for viscous fluid flows, creeping fluid flows, Boundary layer approximation, Transition to turbulence, Fundamentals of turbulent flow, turbulent boundary layer over a flat plate.

AML714 Fluid Flow Analysis and Applications to Power Plants
3 credits (3-0-0)
Introduction to flow types, fluid statics, relative equilibrium and kinematics. Fluid flow equations for mass, momentum, angular momentum, energy and their applications. Inviscid flows. Flow through pipes and Reynolds number effects. Navier-Stokes equations and applications. Models of turbulence. Boundary layer flows. Thermal boundary layers. Boundary layers in power plant flows (case study). Pipe networks. Turbulent flows in power plant flows (case study). Plane and axi-symmetric jets and wakes and their applications in power plants (case study). Compressible flows and applications in power plants (case study). Transportation of material by fluid flows. Types of complex mixtures. Two phase flows. Phase separation and settling behaviour. Slurry pipeline transportation and applications in power plants (case study). Review of numerical methods in fluid flows. Basic principles of experimental analysis. Flow visualization techniques. Flow metering and other fluid devices for measurement of pressure, velocity, discharge, etc. and their applications in power plants (case study).

AML715 Viscous Fluid Flow
3 credits (3-0-0)
Governing equations in differential form. Navier-Stokes' equations and applications. Review of boundary layer prediction methods. Transition and turbulence. Turbulent boundary layers. Drag on bodies. Free turbulent flows. Turbulent boundary layer prediction methods.

AML730 Reliability Engineering for Power Plants
3 credits (3-0-0)
Introduction to reliability & failures, Different sub systems of power plants and understanding of their contribution in reliable operation of over all plant Reliability effectiveness criteria, Stochastic and Markove processes. Different types of failures, normal exponential, Weibull and other failure distributions. Flow graphs and reliability. Reliability models of maintained and non-maintained systems, series, parallel, stand-by and mixed configuration. Allocation of redundancy. Reliabilitic designs using existing quality components, weight, volume and other constraints, Allocation of failure and repair rates. Availability, Instantaneous, average uptime and steady state availability. Maintainability concepts. Good as new and bad as old concepts.

AML731 Applied Elasticity
4 credits (3-1-0)
Cartesian tensors, axioms, motion, stress, equations of motion, Piol, Kirchoff stress, finite strain measures, strain energy, small strains, linear elastic constitutive equations. Basic problems. General theorems of uniqueness. Superposition and reciprocity. St. Venant's problem. Plane problems. Principle of virtual work. Potential energy. Complementary energy. Reissner's variational principles. Approximate analytical and numerical methods of solution.

AML732 Solid Mechanics
3 credits (3-0-0)
Elementary theory of elasticity and plasticity. Theory of plates. Instability of rectangular plates. Stiffened plates. Anisotropic plates.

AML733 Dynamics
3 credits (3-0-0)
Single degree freedom system. Multidegree freedom system. Numerical methods. Holzer-type problem geared and branched systems. Euler's equation for beams. Torsional vibrations. Continuous systems. Lagrange's equations. Balancing of shaft. Self excited vibration.

AML734 Advanced Dynamics
4 credits (3-1-0)
Axioms, Hamilton's principles. Principle of virtual work. Lagrange's equations. Single degree of freedom systems. Multi-degree of freedom systems. Distributed parameter systems.

AML750 Modern Engineering Materials
3 credits (3-0-0)
Introduction, Structure- Property correlation: role of crystal structure, substructure and microstructure on properties.

High performance structural metallic alloys – Alloy steels, Selected Cu, Al, Ti, & Mg alloys and their applications. Advanced composite materials – Important reinforcements and matrix materials (metal, ceramics, polymer), micro mechanics of composites, role of interface, mechanical & thermal behavior, load transfer from matrix to fiber, nano structural composites.

Processing & characterization of composites - Forming and fabrication methods, testing and evaluation, strength, fracture and fatigue of composites.

Surface engineering of materials & their applications – Techniques for modification of surfaces for wear, corrosion and high temperature applications, typical structural applications.

Structure, property and processing of some new engineering materials, nanocrystalline materials, metallic foams, functionally graded materials, smart materials, shape memory materials.

Applications of materials to automobile and transport vehicles, Aerospace applications, materials for power generation, etc.

Materials for armament applications, marine environment and ocean structures, materials for other specialized applications.

AML751 Materials for Marine Vehicles
3 credits (3-0-0)
Corrosion. Selection of materials. Brittle fracture techniques. Intro-duction of fracture mechanics. Fatigue. Non-destructive testing.

AML771 Decision Theory and Design Optimization
3 credits (3-0-0)
Introduction to decision processes. Deter-ministic models. Probabilistic models. Decision-making undercertainty. Risk and certainty. Techniques of design optimization.

AMP772 Feasibility Study
3 credits (1-0-4)
This is a short project to be completed in one semester wherein a student will carry out a feasibility study for the manufacture of a given product.

AML773 Modelling & Analysis-I
3 credits (3-0-0)
Modelling and analysis in the context of design morphology, CAD and concurrent Engineering Analysis of stress, fluid flow and heat transfer.

Approximate, analytical and numerical methods for strength design: techniques of experimental stress analysis. Plastic behaviour, Limit design. Stress analysis of products made from composites.

Basic equations of fluid flow. Laminar flow through pipes. Transition and turbulence. Concept of boundary layer. Approximate methods. Similitude and modelling. Applications in product design.

AML774 Modelling & Analysis-II
3 credits (3-0-0)
Design of products subjected to vibration, Balancing, self excited vibrations. Modelling and analysis of heat transfer in products, thermal stresses, case studies.

Analysis of flow over bodies. Computation of forces. Flow through turbomachines. Design of flow metering and other fluid devices. Solid-fluid interaction problems in product design. Wind tunnel studies and applications to design.

AML775 Design Methods
3 credits (3-0-0)
Design problem and design process. Place of design activity in the production- consumption cycle. Design cycle including need analysis. Feasibility study, preliminary design, detailed design and planning for complete production-consumption cycle.

AMP776 Product Design Project I
3 credits (1-0-4)

AMP777 Product Design Project II
2 credits (0-0-4)
The above two courses would be run in successive semesters. The combined project work would comprise the following:

Application of systematic design procedure for the design of a chosen industrial product. Students are expected to carry out all the three phases of the design cycle including fabrication and testing. Lectures will deal with ergonomical factors in product design.

AML791 Ship Resistance & Propulsion
3 credits (3-0-0)
Similarity considerations and Model testing, Wave making resistance, Viscous resistance, Estimation of ship resistance, Appendage resistance, Presentation of resistance data and use of methodical series, Resistance of high speed and advanced marine vehicles.

Hull propeller interaction, Cavitation, Wave-wake interference, Thrust computations, Scale effect, Propeller design, Various propulsion devices, Ship standardisation trials.

AML792 Structural Design of Ships
3 credits (3-0-0)
Introduction, Ship as beam, long term loading of ship structure, periodic wave loading, longitudinal response & dynamic behaviour, Criteria of failure, Analysis of plates and grillages, Buckling of plates and panels, Recent advances in load definition, transverse strength, torsional strength, bulkhead design, design of special structures, structural design of unconvential crafts like hydrofoils, hovercrafts, SES, SWATH, Catamarans, trimarans etc., design of submarine structures, pressure hull, design of cylindrical shells, cones, bulkheads etc., Applications of computers to ship structures and structural optimization.

AML793 Ship Dynamics
3 credits (3-0-0)
Dynamics of oceans. Wave characteristics. Probabilistic theory of waves. Ship motions. Sea loads and bending moments. Limiting criteria stability and control of ships. Stabilization systems. Tests and trials.

AML794 Warship Design
3 credits (3-0-0)
Salient features of warships, merchantships, naval auxiliaries and yard-craft Principles and morphology of engineering design. Design spiralFeasibility studies. Preliminary design. Detailed design Warship design and production procedures. Staff requirements. Design activities. Drawing and specifications. Ship productionTests and trials. General arrangement drawings—Weapon layout. Mass and space analysis. Stability aspects, Resistance, propulsion. Seakeeping and manoeuvering considerations in design. Structural considerations. Survivability Cost aspects. Special types of hull forms. Computer aided ship design.

AML795 Submarine Design
3 credits (3-0-0)
Flotation and trim. Hydrostatics. Survivability. Surface unsinkability. Stability. Design of pressure proof structures. Design of school mounts of equipments. Resistance. Methods of drag reduction. Selection propulsion system. Endurance and indiscretion rates. Sea motions. Manoeuverability in vertical and horizontal planes and control surface design. Habitability. Ergonomics. Stealth systems. Submarine design procedures. System approach of submarine design and military economic analysis. Use of computers in submarine design. Outer hull lines development. Simulation of submarine in vertical plane.

AMS801 Independent Study
3 credits (0-3-0)

AMS802 Independent Study
3 credits (0-3-0)

AML803 Continuum Mechanics
3 credits (3-0-0)
Fundamental concepts. Thermo-dynamics of homogeneous processes. Equipresence. Kinematics. Field laws. Constitutive equations of simple materials. The isotropy group. Representative applications of solids, fluids and materials with fading memory.

AML805 Advanced Finite Element Methods
3 credits (3-0-0)
Automatic mesh generation techniques. Post-processing. Stress smoothing. Error analysis. P and H version. Adaptivity. Hierarchical formulations. Transition elements. Mixed formulations. FEM analysis of plates and shells. Parallel computing in FEM. Material and geometric non-linearity. Mode superposition and direct integration techniques for dynamic problems.

AMD811 Major Project Part-I
6 credits (0-0-12)

AML811 Advanced Computational Fluid Dynamics
3 credits (3-0-0)
Transport equation in rotating reference frame, finite volume methods including higher order upwinding, grid generation, Galerkin & upwind finiteelement methods, considerations in discretization of turbulence models, rotating reference frame, hybrid methods grindinless methods, multigrid method, special topics chosen from phase change problem, two-phase flow, compressible flow and numerical simulation.

AMD812 Major Project Part-II
12 credits (0-0-24)

AML812 Turbulent Shear Flows
3 credits (3-0-0)
Origin of turbulence. Review of pheno-menological theories. Structure of wall-turbulence and free-turbulence. Turbulent boundary layers. Plane and axisymmetric jets and wakes.

AMD813 Major Project Part-I
6 credits (0-0-12)

AML813 Impeller Pumps
3 credits (3-0-0)
Fundamental notations and classification of impeller pumps. Flow through impeller. Euler's equation, pressure and velocity distribution in impeller passages. Influence of finite number of blades, impulse and reaction types of impellers. Dynamic similarity. Impeller shapes. Blades with single curvature and double curvature.

Centrifugal pumps, single and multistage. Mixed flow pumps, helical and diagonal pumps. Propeller pumps, circular cascades. Inlet and outlet systems. Cavitation and net-positive suction head considerations.

AMD814 Major Project Part-II
12 credits (0-0-24)

AML814 Fluid Transportation Systems
3 credits (3-0-0)
Mechanism of transportation of materials by fluid flow. Rheology and classification of complex mixtures. Fundamentals of two-phase flow. Phase separation and settling behaviour. Slurry pipeline transportation. Design methods. Terminal facilities. Pipe protection. Pneumatic conveying, pneumocapsule and hydrocapsule pipelines. Metrology associated with pipelines.

AML815 Hydrodynamic Stability
3 credits (3-0-0)
Formulation of hydrodynamic stability problems in various situations of flows, and particularly for parallel flows. Waves and allied experimental studies. Study of laminar to turbulent transition. Non- linear stability theories.

AML816 Compressible Fluid Flow and Gas Dynamics
3 credits (3-0-0)
Review of one-dimensional flows. Two-dimensional flows. Shocks and interactions. Small perturbation theory. Method of characteristics. Stock-boundary layer interaction. Viscous effects. Introduction to flows with chemical reactions. Dynamics of radiating gases. Hypersonic flows.

AML820 Advances in Fluid Engi-neering
3 credits (3-0-0)
A course on any advanced topic in the area of Fluid Engineering may be floated under this number.

AML821 Flow Induced Vibrations
3 credits (3-0-0)
General governing equations for solid-fluid interaction problems. De-coupling approximations. Acoustically applied forces. Steady-state scatter, transient scatter and transient shock response. Hydrodynamically applied forces Flow induced noise, dynamic divergence of compliant surfaces, flutter, stability of boundary layer on compliant surfaces, propeller induced forces. Aeroelastic flutter of plates, linear and non-linear response. Flow induced vibrations of pipes and tube arrays etc.

AML831 Theory of Plates and Shells
3 credits (3-0-0)
Small deflections of transversely loaded plates. Plate equations, boundary conditions. Rectangular and circular plates with different support conditions. General equations of elastic shells in invariant form. Membrane theory. Moment theory. Rotationally symmetric shells. Shallow shell theory. Examples.

AML832 Applications of Theory of Plates and Shells
2 credits (2-0-0)
Introduction. Recapitulation of classical plate theory. Orthotropic plate bending. Simplified 4th order theory. Panels and grillages. Navier's and Levy's solutions. Stability. Bending of circular cylindrical shells. Stability of semi-infinite and finite cylinders. Donnel equations. Shells of revolution. Applications.

AML833 Applied Plasticity
3 credits (3-0-0)
Fundamentals of plasticity theory. Solution of elastoplastic problems. Theory and application of slip-line field. Bound theorems. Plastic anisotropy. Large deformations. Dynamic plasticity.

AML834 Structural Stability
3 credits (3-0-0)
Types of instability, static, dynamic and energy criterion of buckling. Imperfection sensitive structures. Applications to columns, beams, plates and shells. Follower forces, non-conservative loads.

AML835 Mechanics of Composite Materials
3 credits (3-0-0)
Composites, various reinforcement and matrix materials. Strength and stiffness properties. Effective moduli: spherical inclusions, cylindrical and lamellar systems. Laminates: Laminated plates. Analysis, strength and design with composites. Fibre reinforced pressure vessels. Dynamic, inelastic and non-linear effects. Technological applications.

AML836 Non-linear Vibration and Chaos
3 credits (3-0-0)
Prerequisite: AML701/AML734/CEL719/MEL733
Non-linear system. Analytical and graphical solutions. Solution stability and bifurcation. Fourier transforms. Poincare section. Temporal chaos in dissipative systems. Simple and strange attractors. Fractal dimension and geomatric characterization. Hopf bifurcation and limit cycle. Sub-harmonic instability and periodic doubling.

AML837 Structural Mechanics
3 credits (3-0-0)
Matrix analysis of structures. Displacement methods. Substructuring grillages. Finite element methods for a structural continuum. Element behaviour. Element families. Computational aspects of finite element methods.

AML838 Non-linear Mechanics
3 credits (3-0-0)
Singular points of non-linear systems. Phase plane and limit cycles. Non-linear conservative systems. Variational techniques for solving autonomous, resonant and non-resonant systems and asymptotic methods. Application to beams, plates and shells.

AML840 Advances in Solid Mechanics
3 credits (3-0-0)
An advanced course on any specialized topic in the area of Solid Mechanics may be given under this number. The course content will be announced by the teacher.

AML841 Advanced Theory of Elasticity
3 credits (3-0-0)
Two-dimensional problems in elasticity using complex variable techniques and conformal mapping. Three-dimensional problems. General representation theorems. Stability theory. Dynamics elasticity. Theory of rods.

AML851 Fracture Mechanics
3 credits (3-0-0)
Linear elastic fracture mechanics—Energy approach and stress intensity factor approach. General yielding fracture mechanics. Concept of crack opening displacement and J integral fracture criteria. Evaluation of fracture mechanics parameters. Fracture safe designing of structures and machine components. Service failure analysis.

AML852 Engineering Failure Analysis and Prevention
3 credits (3-0-0)
Common causes of failure. Principles of failure analysis. Fracture mechanics approach to failure problems. Techniques of failure analysis. Service failure mechanisms—ductile and brittle fracture, fatigue fracture, wear failures, fretting failures, environment induced failures, high temp. failure. Faulty heat treatment and design failures, processing failures (forging, casting, machining etc.), failure problems in joints and weldments. Case studies for ferrous and non-ferrous metallic parts and parts made from polymers and ceramic.

AML854 Advances in Physical Metallurgy
3 credits (3-0-0)
Recent developments in phase transformations. Phase equilibrium in ternary alloys. Fracture resistant design.

AML855 Solid State Phase Transformations
3 credits (3-0-0)
Classification of solid state phase transformations. Nucleation and growth concepts. Spinodal decomposition. Specific transformations such as martensitic, polymorphic, re-crystallization, particle coarsening, etc. Crystallographic aspects of phase transformations.

AML856 Electron Metallography and Electron Diffraction
3 credits (3-0-0)
Interaction of electrons with matter electron optical systems. Term: Principles of electron diffraction, double diffraction. Fine structure of diffraction patterns. Theory of contrasts and applications to the study of imperfections and phase transformation. Techniques of specimen preparation.

Analysis of micrographs and diffraction patterns. SEM contrast in SEM and applications to the study of material problems. High voltage electron microscopy. TEM & STEM base methods of microdiffraction.

AML857 Quantitative Metallography
3 credits (3-0-0)
Introduction to probability theory. Geometric probabilities. Determination of volume, surface area, length, average size and number in volume. Particle size distribution. Coarsening of particles. Dislocation densities and strain measurements. Various applications of materials science and engineering.

AML871 Product Reliability and Maintenance
3 credits (3-0-0)
Definition of reliability, product pathology, reliability evaluation criteria, Stochastic and Markovian processes, product failure theories, reliability of parallel, standby and series products, reliability of non-maintained and maintained products. Use of signal flow graph theory for evaluating reliability. Reliability and reward. Making of more reliable products using less reliable components: "Good as New" and "Bad as Old" concepts. Maintenance policies. Information theoretic approach to reliability. Examples.

AML872 Optimization Techniques
3 credits (3-0-0)
Classical optimization techniques for unconstrained optimization. Kutur Tucker conditions. Sensitivity analysis for linear programming problems. Non-linear programming. Penalty function methods. Sequential linear programming. Feasible direction methods. Quadratic programming. Geometric programming. Integer programming. Application in engineering design.

AML873 Design for Production
3 credits (3-0-0)
Basic concepts and goals of design for production. Processes, machines and tools for the manufacture of parts made from metals, ceramics and polymers. Significance of form in case of manufacture. Attainable tolerances. Industrial finishes like painting, polishing, anodising nickel and chrome painting, surface texturizing. Value analysis. Group technology. Assembly strategies. Design for quality.

AML874 Critical Product Evaluation
3 credits (3-0-0)
Value analysis. Quality standards in electronic, optical, mechanical and other products. Critically examining product literature, raising questions, filling gaps in information and discovering hidden details from product literature. Identifying areas of design action by identifying limitations in existing products and gaps in market segment. Examining an existing product for appreciation and detailing.

AML883 Properties and Selection of Engineering Materials
3 credits (3-0-0)
Properties and uses of ferrous and non-ferrous metals, ceramics and polymers in product design.

AMD895 Major Project (M.S. Research)
40 credits (0-0-80)

AMD897 Minor Project
4 credits (0-0-8)

AMD899 Design Project
10 credits (0-0-20)

Department of Biochemical Engineering and Biotechnology

BEL101 Biochemistry
5.5 credits (3-1-3)
Course contents (about 100 words): Introduction-aims and scope; Non-covalent interactions in biological systems, Carbohydrates-structure and function; Proteins-structure and function; Nucleic acids-structure and function; Protein purification techniques; Introduction to enzymes; Vitamins and coenzymes; Lipids and biological membranes; Transport across cell membrane; Design of metabolism; Metabolic pathways for breakdown of carbohydrates-glycolysis, pentose phosphate pathway, citric acid cycle, electron transport chain, Photo-phosphorylation; Oxidation of fatty acids; Gluconeogenesis and control of glycogen metabolism, Signal transduction.

Laboratory : Estimation of proteins and nucleic acids; Extraction of lipids; Separation of lipids using thin layer chromatography, Gel filtration and ion exchange chromatography; Gel electrophoresis, Determination of enzymatic activities and determination of K_m, V_{max}; Identification of intermediates of EMP pathway.

BEL102 Bioprocess Calculations
4 credits (3-1-0)
Overlaps with: CHL231, CHL251
Units and dimensions, Fundamentals of material balance, Balance on unit processes and reactive systems, Behaviour of ideal and real gases, vapour pressure, humidity and saturation. Energy balance, Heat capacity of gases, liquid and solids, Latent heat, Heat of reaction, formation and combustion, Solution and dilution, Energy balance of reactive and non-reactive processes. Stoichiometric relations and yield concepts, Maintenance coefficient, Mass balance based on available electron concept. Unsteady state material and energy balance in bioprocess.

BEL103 General Microbiology
4.5 credits (3-0-3)
Lectures: Introduction-aims and scope. Role of microbes in agriculture, public health, medicine and industry. Organization of prokaryotic and eukaryotic cells: Structure and function of cell organelles and surface structure and cellular reserve materials; Distinguishing features of various groups of microorganisms: actinomycetes, bacteria, molds, yeasts and algae and their broad classification. Characteristics of selected groups of microorganisms including microorganisms of extreme environment. Microbial nutrition and growth-principles of nutrition, growth measurement techniques, effect of environmental and culture parameters on growth, assimilation of nitrogen and sulphur. Isolation and preservation of cultures. Energy transduction in microbial systems: fermentation, aerobic and anaerobic respiration. Phototrophic microorganisms, Phosphoketolase, Entner-Doudoroff and glyoxalate pathways. Control of microbial growth – effect of heat, disinfectants and therapeutic agents. Microbial pathogenicity, Bioassays.

Laboratory: Preparation and sterilization of media, examination of possible sources of contamination; microscopic examination of different groups of microorganisms; aseptic technique; simple and differential staining; isolation of a pure culture - use of enrichment media; growth and enumeration of microorganisms; effect of physical and chemical environment on growth; selected biochemical tests; isolation of auxotropic mutants; microbiological assay of antibiotics.

BEL110 Molecular Cell Biology
3 credits (3-0-0)
Overlaps with: BEL101, BEL103
Biology-technology interface; Cell structure and function; Noncovalent interactions in living cells; Molecules in cell; Enzymes: Structure, Catalysis, Industrial applications; Membrane transport; Bioenergetics; Introduction to metabolism; Information storage and processing in cells; Cell signaling; Nerve cells and electrical properties; Techniques in cell and molecular biology; Cell evolution: biochemical capacities.

BEN150 Introduction to Biochemical Engineering and Biotechnology
2 credits (0-0-4)
Demonstration, audio-visual presentations, and/or hands-on experiments about micro-organisms and their applications; heredity and genetics; bioinformatics; infrastructural and analytical tools required for biotechnology operations and engineering aspects of biochemical and biotechnology products.

BEL204 Molecular Biology and Genetics
4.5 credits (3-0-3)
Pre-requisites: BEL101 & BEL103
Historical development and essentials of Mendelian genetics. Chromosomal theory of inheritance. Evolution and development of molecular biology. DNA model and classes. Organization of eukaryotic chromosome – the chromatin structure. Genetic Information and its perpetuation – DNA replication and repair. Transcription, translation. Molecular biology of bacteriophage lamda. Gene exchange in bacteria. Gene regulation in prokaryotes. The operon model – lac, ara, trp operons and gene regulation.

Laboratory : Isolation of DNA, Denaturation of DNA, isolation of chromatin, lambda DNA, transformation, conjugation. Gene induction.

BEL301 Bioprocess Engineering
3 credits (3-0-0)
Pre-requisites: BEL101 & BEL103 and EC 60
Overlaps with: CHL291
Microbial growth, substrate utilisation and product formation kinetics; simple structured models; air sterilization; media sterilization; batch, fed-batch and continuous processes; aeration and agitation; rheology of fermentation fluids; scale-up concepts; design of fermentation media; aseptic transfer; various types of microbial and enzyme reactors; instrumentation in bioreactors.

BEL302 Fluid Solid Systems
3 credits (3-0-0)
Pre-requisites: CHL203
Overlaps with: CHL331
Size reduction; crushing and grinding; equipment for size reduction; screening; design procedure;Flow of fluids past a stationary particle for low, medium and high Reynolds numbers; sedimentation and sedimentation theory; thickeners and classifiers; flow through packed beds; flow distribution, packings and pressure drop calculations; fluidization; filtration theory and its application in plate and frame and rotary vacuum filters; solid-liquid separation using centrifugation; 'S' concept in centrifugation for scale-up; different types of centrifuges and their design; application for biological suspensions.

BEP303 Design of Bioprocesses
2.5 credits (0-1-3)
Pre-requisites: BEL101 & BEL103 and EC 60
Design and execution of simple laboratory scale experiments on the following topics: Estimation of cell mass; different phases of microbial growth; Mass and energy balance in a typical bioconversion process; Concept of limiting nutrient and its effect on cell growth; growth inhibition kinetics; product formation kinetics in a fermentation process; aerobic and anaerobic bioconversion process; power consumption in a fermentation process and its correlation with rheology of the fermentation fluid; different agitator types; mixing time in a bioreactor; quantification of KLa in a fermentation process; Heat balance across a batch sterilization process; Assembly and characterization of pH/DO electrodes.s

BEL311 Physical and Chemical Properties of Biomolecules
3 credits (2-1-0)
Pre-requisites: BEL101 and EC 60
Introduction: characteristic features of biological systems, structure-functions relationships in biomolecules; Characterization of macromolecules: molecular shape and size; molecular weight; Transport properties of solution- Applications in deducing conformation of biomolecules: viscosity, Diffusion, Ultra centrifugation, electrophoresis; Optical properties of biomacromolecules; Spectroscopic methods: IR, NMR, optical rotary and circular dichroism.

BEL312 Carbohydrates and Lipids in Biotechnology
3 credits (2-1-0)
Pre-requisites: BEL101 and EC 60
Introduction, Molecular Structure of polysaccharides; Enzymes degrading polysaccharides; Physical properties of polysaccharides; Production of microbial polysaccharides; Food usage of exopolysaccharides; Industrial Usage of exopolysaccharide; Medical applications of exopolysaccharides. Molecular structure of lipids; Physical properties of lipids; oleaginous microorganisms and their principal lipids; Production of microbial lipids; Modification of lipids for commercial application; Extracellular microbial lipids and biosurfactants; Micelles and Reverse micelles in biology, Liposomes in drug delivery.

BEV330 Special Module in Biochemical Engineering and Biotechnology
1 credit (1-0-0)
Pre-requisites: EC 60
Special module that focusses on state of the art and research problems of importance in biochemical engineering and biotechnology.

BED350 Mini Project (BB)
3 credits (0-0-6)
Pre-requisites: EC 80
No fixed course content. Study to concentrate on a selected topic under the supervision of a faculty member of the department.

BER350 Professional Practices (BB)
2 credits (0-1-2)
Pre-requisites: EC 60
No fixed course content. Activities to include visits to industry, interactive meetings with personnel from industry and R&D organizations.

BES350 Independent Study (BB)
3 credits (0-3-0)
Pre-requisites: EC 80
No fixed course content. Study to concentrate on a selected topic under the supervision of a faculty member of the department.

BEL401 Bioprocess Technology
2 credits (2-0-0)
Pre-requisites: BEL301
Bioprocessing vs. chemical processing. Substrates for bioconversion processes. Inoculum development. Process technology for production of primary metabolites, such as baker's yeast, ethanol, citric acid, amino acids, polysaccharides and plastics. Microbial production of industrial enzymes- glucose isomerase, cellulase, amylase, protease etc.. Production of secondary metabolites- penicillins and cephalosporins.

BEL403 Enzyme Engineering and Technology
4 credits (3-0-2)
Pre-requisites: BEL401
Introduction and Scope; Chemical and Functional nature of enzymes; Application of enzymes in process industries and health care; Microbial production and purification of industrial enzymes, Kinetics of enzyme catalyzed reactions; Immobilization of enzymes; Stabilization of enzymes.
Bioreactors for soluble and immobilized enzymes, Mass transfer and catalysis in immobilized enzyme reactors.
Enzyme based biosensors; Enzyme catalyzed processes with cofactor regeneration; Enzymatic reactions in micro-aqueous medium and non-conventional media.
Laboratory: assay of enzyme activity and specific activity; Kinetic analysis of an enzyme catalyzed reaction; Immobilization of enzymes by adsorption and covalent binding; Salt precipitation of an enzyme; Immobilization of microbial cells by entrapment; Effect of water activity and solvent on the lipase catalyzed esterification reaction.

BEL411 Food Science and Engineering
3 credits (3-0-0)
Pre-requisites: BEL301
Chemical constituents of foods, their properties and functions; Characteristic features of natural and processed foods; Chemical/ biochemical reactions in storage/handling of foods; Units operations in food processing – size reduction, evaporation, filtration etc.; Methods for food preservation; Rheology of food products; Flavour, aroma and other additives in processed foods; Case studies of a few specific food processing sectors, cereals, protein foods, meat, fish and poultry, vegetable and fruit, milk products; legislation, safety and quality control.

BEL412 Immunology
4 credits (3-0-2)
Pre-requisites: BEL204 and EC 90
Immune system. Molecules of immune system – immunoglobulins, MHCs, Cytokines, T cell receptors. Generation of antibody and T cell receptor diversity. Complement system. Humoral and Cell mediated immunity. Immune regulation. Vaccines. Hybridoma. Immunodeficiencies and AIDS. Transplantation immunity and cancer.

BEL413 Modelling and Simulation of Bioprocesses
4 credits (3-0-2)
Pre-requisites: BEL301
Types of kinetic models, Data smoothing and analysis, Mathematical representation of Bioprocesses, Parameter estimation, Numerical Integration techniques, Parameter Sensitivity analysis, Statistical validity, Discrimination between two models.

Physiological state markers and its use in the formulation of a structured model, Development of compartment and metabolic pathway models (Software Probe) for intracellular state estimation.

Dynamic Simulation of batch, fed-batch steady and transient culture metabolism, Numerical Optimization of Bioprocesses using Mathematical models.

BEL414 Thermodynamics of Biological Systems
3 credits (3-0-0)
Pre-requisites: CHL101 and EC 90
Biological systems as open, non-equilibrium systems, failure of classical thermodynamics in describing biological processes, concepts of thermodynamic flux and force, concept of entropy production, constitutive equations, Onsager reciprocal relations, Prigogine's principle, coupling in biological processes, thermodynamics of coupled biochemical reactions, thermodynamic analysis of oxidative phosphorylation, Nath's principle for coupling in bioenergetic processes, active transport.

BEL415 Advanced Bioprocess Control
3 credits (3-0-0)
Pre-requisites: CHL202 and EC 90
The course begins with a detailed analysis of the stability of bioreactors and gradually brings in the general concept of Lyapunov stability. The contrast between classical control and modern control is illustrated through state space techniques and concepts of reachability (Controllability) and reconstructability (Observability). Then several techniques of differential are brought and the power of the method demonstrated through various techniques such as the input-output linearization. In the final phase of the course several case studies are undertaken and future trends in the field of research presented.

BEL416 Membrane Applications in Bioprocessing
3 credits (3-0-0)
Pre-requisites: BEL301
Introduction; Organic/inorganic membranes and its manufacture; transport theories for MF/UF/NF membranes; Laboratory/ commercial modules of membranes: Applications of membranes: Milk/ cheese processing, Fruit/ sugarcane juice processing, Pharmaceuticals/ Therapeutic drugs processing and membrane-coupled separation of biomolecules; Membrane based bioreactor for cell/enzyme recycle; Mammalian/ plant cell culture; Case studies.

BEL417 Biophysics
3 credits (3-0-0)
Pre-requisites: PHL110 and EC 90
Spectroscopic methods in biophysics, conformational changes in biological processes, transport across biomembranes, the biophysics of motility, the biophysics of the nerve impulse.

BEL418 Bioinformatics
3 credits (2-0-2)
Pre-requisites: CSL110 / CSL120 and EC 90
Introduction to Bioinformatics and its Application, Molecular Biology for bioinformatics (Central Dogma), Biological data bases (primary, secondary hybrid etc), and its Annotation, Protein and Nucleotide (DNA) sequencing techniques, Pairwise and multiple sequence alignment algorithm, Phylogentic Analysis, Hidden Markov Model (HMM) and its Application, Microbial Genomics, Metabolic Flux Analysis.

BEL419 Enzyme Catalyzed Organic Synthesis
3 credits (2-0-2)
Pre-requisites: BEL101 and EC 90
Enzyme as biocatalysts, Enzyme catalyzed reactions in organic solvents, Structure of enzyme in organic solvents, pH memory and molecular imprinting, Biocatalyst design and challenges, cofactor recycling, enzyme stability and stabilization. Biocatalytic applications in organic synthesis-hydrolytic reactions, oxidation reduction reactions, formation of C-C bond, addition and elimination reactions, glycosyl transfer reactions, isomerization, halogenation/ dehalogenation reactions.

Laboratory: Use of lipases to demonstrate esterification and interesterification reactions. Effect of solvents on lipase catalyzed reactions, Use of proteases for synthetic reactions. Cofactor recycling. Immobilized biocatalysts for bioconversion.

BEL420 Analytical Methods in Biotechnology
3 credits (2-0-2)
Pre-requisites: BEL101 and EC 90
Nature and properties of biochemical metabolites, Radioactivity and use of isotopes in biological systems, Principles and applications of chromatography, Hydrodynamic methods : Sedimentation and ultracentrifugation, Spectrophotometry, Fluorescence methods, Circular dichroism, Mass spectrometry, Gas chromatography.

BEL421 Metabolic Regulation and Engineering
3 credits (3-0-0)
Pre-requisites: BEL204 & BEL301
Regulatory mechanisms for control of enzyme synthesis – an overview. Control of enzyme activity-proteolysis, covalent modification and ligand binding. Metabolic control theory and metabolic flux analysis, and their applications. Metabolic regulation of a few major metabolic pathways especially those relevant to bioprocess industries. Metabolic pathway synthesis. Application of gene cloning in redirecting cellular metabolism for over-production of a few industrial products. Strategies to overcome regulatory mechanisms for hyper production of primary and secondary metabolites such as enzymes, amino acids, alcohols, anti-oxidants, organic acids and antibiotics.

BEL422 Solid State Cultivation
3 credits (3-0-0)
Pre-requisites: BEL301
Definition, Microbial basis of processes, Substrate for processes, Quantification of biomass, Environmental parameters, Growth patterns, Growth kinetics and the modeling of growth in SSC, General principles of reactor design and operation for SSC, Overall process concepts in fungal biomass production, product leaching and downstream processing.

BEC450 Colloquium (BB)
3 credits (0-3-0)
Pre-requisites: registered for BET450
Each student is to make a minimum of three presentations of about 30 minutes duration. Topics for these presentations could be drawn from the practical training experience or other scientific documents/ publications.

BET450 Practical Training (BB)
Non credit
Pre-requisites: EC 90 at the end of 5th sem.
Observation of processes, operating procedures, construction techniques, management procedures, amongst others, and executing a project related 5to the industry.

BEL701 Biotechnology Resource Planning and IPR Issues
2 credits (2-0-0)
Pre-requisites: BEL401 & BEL403
Economic, social and product benefits of modern biotechnology; Resource base for process biotechnology; Typical stages in commercialization of process/ product; Commercial and financial aspects of bioprocessing ; Financial appraisal of bioprocessing projects.

TRIPS agreement; IPR issues in relation to biotech products/ processes; Architecture of Patent application.

Alternative models of technology transfer and licensing; Good manufacturing practices; Funding mechanisms of commercial projects.

Biosafety Principles - environment and health risk assessment; biosafety regulatory guidelines and controlling agencies, Environmental law for hazardous microorganisms and GMOs; Biotechnology Related Issues of Public Concern - Bioethics.

BEL702 Bioprocess Plant Design
5 credits (3-0-4)
Pre-requisites: AML110 & MEL110 & CHL203 & CHL204 & BEL401 and EC 90
Introduction; General design information; Mass and energy balance; Flow sheeting; Piping and instrumentation; Materials of construction for bioprocess plants; Mechanical design of process equipment; Vessels for biotechnology applications; Design of fermenters; Design considerations for maintaining sterility of process streams and processing equipment; Selection and specification of equipment for handling fluids and solids; Selection, specification and design of heat and mass transfer equipment used in bioprocess industries; Design of facilities for cleaning of process equipment used in biochemical industries; Utilities for biotechnology production plants; Process economics; Bioprocess validation; Safety considerations; Case studies.

Laboratory: Design of the complete process plant for an identified product or service. Each student to choose a separate product/industry.

BEL703 Downstream Processing in Biotechnology
5 credits (3-0-4)
Pre-requisites: BEL301 & BEL401
Characteristics of bio product, flocculation and conditioning of fermented medium, Revision of mechanical separation (filtration, Centrifugation etc.), cell disruption, Protein precipitation and its separation, Extraction, Adsorption-Desorption processes, Chromatographic methods based on size, charge, shape, biological affinity etc., Membrane separations-ultrafiltration and electrodialysis, Electrophoresis, Crystalization, Drying.

Laboratory: Conventional filtration, centrifufation in batch and continuous centrifuge, Cell disruption, Ion-exchange chromatography, Membrane based filtration- ultrafiltration in cross flow modules and microfiltration.

BEL711 Recombinant DNA Technology
4 credits (2-0-4)
Pre-requisites: BEL204
Restriction and modification phenomena, Other enzymes used in rDNA research, Plasmid, l phage, M13 biology, Vectors – plasmid, phage, phagemid, Cosmid, Expression vectors, Construction of libraries, DNA Sequencing, PCR, Genome mapping, Stability of recombinant cells in the production of biochemicals.

BEL712 Plant Cell Technology
3 credits (2-0-2)
Pre-requisites: BEL301
Lectures: Special features and organization of plant cells. Totipotency, regeneration of plants. Plant products of industrial importance. Biochemistry of major metabolic pathways and products. Autotrophic and heterotrophic growth. Plant growth regulators and elicitors; Cell suspension culture development: methodology, kinetics of growth and production formation, nutrient optimisation. Production of secondary metabolites by suspension cultures with a few case studies. Biological

and technological barriers- hydrodynamic shear and its quantification, mixing and impeller design aspects. Plant cell reactors: comparison of reactor performances. Immobilized plant cell and cell-retention reactors. Hairy root cultures and their cultivation.

Laboratory : Development of callus and suspension cultures of plant cells; shear sensitivity; growth and product formation kinetics in suspension cultures; production of secondary metabolites in bioreactors using suspension cultures / immobilized cells; development of hairy root cultures.

BEL713 Microbial Engineering
3 credits (3-0-0)
Pre-requisites: BEL403
Non-ideality and RTD in bioreactors; stability analysis; analysis of multiple interacting microbial populations; stability of recombinant cells; physiology of immobilised cells; special reactors for animal and plant cells; integrated systems of bioreaction and bioseparation; biosensors.

BEL714 Protein Science and Engineering
3 credits (3-0-0)
Pre-requisites: BEL204
Introduction-Definition, Aims; Basic structural principles of proteins-amino acids, Motifs of protein structure and their packing: alpha domain, alpha/Beta domain, Antiparallel b structures; Protein folding and assembly – protein folding pathways in prokaryotes and eucaryotes; Folding of BPTI, Recovery of active proteins from inclusion bodies; Structure prediction-structural classes, secondary and tertiary protein structure prediction; Sequence homology searches, Strategies for protein engineering – random, site-directed, case studies; X-ray and NMR analysis of proteins-basic principles; Drug-protein interactions and design, Rational protein design.

BEL715 Biological Waste Treatment
4 credits (3-0-2)
Pre-requisites: BEL301
Qualitative and quantitative characterization of wastes; Waste disposal norms and regulations; Indian regulations; Principles of biological treatment; Aerobic and anaerobic biological wastewater treatment systems; Suspended and attached cell biological wastewater treatment systems; Biological nutrient removal; Treatment plant design calculations; Treatment and disposal of sludges; biological means for stabilization and disposal of solid wastes; Treatment of hazardous and toxic wastes; Degradation of xenobiotic compounds; bioremediation.

Laboratory: Characterization of wastes; Design calculations for various types of wastes using various types of biological processes.

BEL716 High Resolution Methods in Biotechnology
3 credits (2-0-2)
Pre-requisites: BEL301
Need for high resolution separation for biologicals; Difficulties with traditional methodologies; Affinity precipitation and partitioning; MF/UF/NF for high resolution separation; chromatography techniques; Affinity chromatography and electrophoresis, Separation by gene amplification (PCR), Molecular imprinting.

BEL717 Animal Cell Technology
4 credits (3-0-2)
Characteristic of animal cell, metabolism, regulation and nutritional requirements; Kinetics of cell growth and product formation and effect of shear force; Product and substrate transport; Perfusion bioreactors, hollow fiber bioreactor, operational strategies and integrated approach; Micro and macro carrier culture; Hybridoma technology; Genetic engineering in animal cell culture; Scale-up and large scale operation; Case studies.

Laboratory: Cell culture in static phase (T-flask), quantification of cell growth, monolayer culture, determination of critical shear stress, micro carrier and perfusion culture, product formation.

BEL718 Combinatorial Biotechnology
3 credits (3-0-0)
Pre-requisites: BEL204
Introduction, solid phase synthesis, solution phase synthesis. Strategies for library construction. Solid phase synthesis of peptides and oligonucleotides. Strategies for identification of potent molecules. Indexed combinatorial library. Combinatorial libraries of various biomolecules. Instrumentation and analytical methods.

BEL719 Current Topics in Biochemical Engineering and Biotechnology
3 credits (3-0-0)
Pre-requisites: BEL403
Topics of current interest in various areas of Biochemical Engineering and Biotechnology will be covered. The faculty offering the course will specify the contents at the time of offering.

BEL720 Biotechnology in Food Processing
3 credits (3-0-0)
Pre-requisites: BEL301
Microbial role in food process operations and production; new protein foods-SCP, mushroom, food yeasts, algal proteins; fermentation as a method of preparing and preserving foods. Food additives like colouring, flavours and vitamins. Organisms and their use in pickling, producing colours and flavours, alcoholic beverages and other products. Mechanism of enzyme functions and reactions in process techniques-starch and sugar conversion processes, baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill-proofing cheese making by proteases and various other enzyme catalytic actions in food processing. Process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products, Genetically Modified Food.

BEL721 Bionanotechnology
3 credits (3-0-0)
Pre-requisites: BEL101 and EC 60
Introduction; Scanning probe microscopy (SPM), Self-assembly of biomolecules in nanotechnology; Tailoring nanometer scale objects to mimic and interact with natural materials; Biological nanostructures and biomimetic machinery; Molecular motors: natural molecular motors like kinesin, dynein, flagella, RNA and DNA helicases, topoisomerases; Ion channels as molecular switches; patch clamp technique; Photoreceptors as single photon optical detector; Manipulating redox systems application in nanotechnology; Microfabricated devices in biotechnology e.g. micro reactors; Protein array technology; Exploiting enzymes in bionanotechnology; Nanoscale devices for biosensors, Biodegradeable nanoparticles for drug and gene delivery to cells and tissues.

BEL722 Genomics and Proteomics
3 credits (3-0-0)
Pre-requisites: BEL204
Genomics and proteomics- introduction, DNA sequencing, DNA fingerprinting, ESTs and SNPs, Application in pharmagenomics, Structural and functional genomics, DNA microarrays and expression profiling, protein isolation and purification, protein expression – methodologies, proteome analysis – various techniques, 2D gel elctrophoresis, FPLC, MALDI-TOF etc., Protein structure determination.

BEL723 Data Analysis for DNA Microarrays
4 credits (3-0-2)
Pre-requisites: BEL204
Microarray technology, Basic digital imaging and image processing, Probabilities, common distributions, Bayes' theorem, Analyzing microarray data with classical hypothesis testing, Analysis of variance, Experimental Design, Analysis and visualization tools: Box plots, Scatter plots, Histograms, Cluster Analysis: one-way, two-way, Graphic, Methods for selection of differentially regulated genes, Hypothesis- driven experiments using focused microarrays, Biological interpretation, Commercial software available.

BEL724 Advanced Biochemistry
3 credits (3-0-0)
Pre-requisites: BEL204
Overview of carbohydrate and fatty acid metabolism and linkage to Bioenergetics, Biosynthesis of Amino acids, Protein Synthesis and Targeting, Protein Degradation and turnover, Enzymatic reaction

mechanism and role of transition metal ions, Allosteric transitions and cellular controls, Signal Transduction, Peptide synthesis and peptide sequencing, Protein folding and stabilization, Molecular chaperones and neurodegenerative disorders, and Biosynthesis of Lipids and nucleotides.

BEC750 Seminar (BB)
1 credit (1-0-0)
Pre-requisites: EC 165
Literature study on a selected topic. Report writing. Seminar presentations.

BED800 Major Project
40 credits (0-0-80)
This involves research component of the M.S degree requirement.

An R&D project covering literature, experimental and analytical work over two/three semesters.

BEL810 Enzyme and Microbial Technology
3 credits (3-0-0)
Isolation, development and preservation of industrial microorganisms; Substrates for industrial microbial processes; Regulatory mechanisms of metabolic pathways in industrial strains; Analysis of various microbial processes used in production of biomass, primary and secondary metabolites; Microbial leaching of minerals; Microorganisms in degradation of xenobiotics and removal of heavy metals; Biotrans-formations.

Enzymes as industrial biocatalysts; production; isolation; purification and application of industrial enzymes; immobilized enzymes; stabilization of enzymes; enzyme catalyzed organic synthesis; multienzyme systems.

BEL820 Downstream Processing
3 credits (3-0-0)
Characteristics of biological materials; Pretreatment;, Microbial separation: Centrifugation and filtration, Cell disruption methods, Protein precipitation, Extraction, Adsorption, Electrophoresis, Chromato-graphy, Ultrafiltration, Reverse osmosis, Isoelectric focussing, Affinity based separations, Case Studies.

BEL830 Microbial Biochemisry
3 credits (3-0-0)
Structure and function of biomolecules aminoacids, proteins, lipids, nucleotides and nucleic acids: Enzymes-structure and kinetics, Vitamins and coenzymes, Metabolic pathways: Carbohydrate metabolism: glycolysis, pentose phosphate pathway, citric acid cycle; Bioenergetics oxidative phosphorylation and photo-synthesis: Fatty acid metabolism; Amino acid metabolism; Regulatory mechanisms-feed back inhibition, induction, catabolite repression; Nucleic acid and protein biosynthesis.

BEP840 Laboratory Techniques in Microbial Biochemistry
2 credits (0-0-4)
Estimation of carbohydrates/proteins/nucleic acids; separation of phospho-lipids by thin layer chromatography; chromatographic separation of proteins; identification and estimation of intermediates of glycolytic pathway; oxidative phosporylation; cell fractionation; aseptic techniques; microscopic examination of bacteria & fungi; selected biochemical tests; plasmid DNA preparation; expression of cloned DNA in bacteria; isolation of auxotrophic mutants.

BEL850 Advanced Biochemical Engineering
5 credits (3-0-4)
Kinetics of cell growth; Mathematical models for substrate uptake and product formation; Plasmid stability in recombinant cell cultures; Kinetics of enzyme-catalyzed reactions; Media and air sterilization; Cell cultivation strategies; Novel bioreactor designs; Developments in aeration & agitation in bioractors; immobilized whole cell and immobilized enzyme reactors; RTD and mixing in bioreactors; Dynamics of mixed cultures; Scale-up and scale down of bioreactors.

Laboratory Microbial growth and product formation kinetics; enzyme kinetics; Effects of inhibitor on microbial growth; enzyme immobilization techniques; Bioconversion using immobilized enzyme preparation; Bioconversion in batch, fedbatch and continuous bioreactors; Oxygen

transfer studies in fermentation; Mixing and agitation in fermenters; RTD studies; Mass transfer in immobilized cell/enzyme reactors.

BED851 Major Project Part 1 (BB)
6 credits (0-0-12)
Pre-requisites: EC 165
Overlaps with: BED853
Initial phase of the major project chosen by the student under a pre-designated supervisor. Projects are to be individual and should be an in-depth intensive effort.

BED852 Major Project Part 2 (BB)
14 credits (0-0-28)
Pre-requisites: BED851
Overlaps with: BED854
Continuation and completion of the work started in Major Project Part 1.

BED853 Major Project Part 1 (BB)
4 credits (0-0-8)
Pre-requisites: EC 165
Overlaps with: BED851
Initial phase of the major project chosen by the student under pre-designated supervisor. Porjects are to be individual and should be an in-depth intensive effort.

BED854 Major Project Part 2 (BB)
16 credits (0-0-32)
Pre-requisites: BED853
Overlaps with: BED852
Continuation and completion of the work started in Major Project Part 1.

BEL860 Bioprocess Analysis and Reactor Design
3 credits (3-0-0)
Thermodynamic and stoichiometric aspects of microbial processes; Engineering analysis of metabolic pathways; Optimization of fermentation media; Kinetic modelling of enzyme/microbial processes; Mass transfer in biochemical processes; Scale up concepts. Batch, fed batch and continuous microbial reactors; Immobilized enzyme/cell reactors; Non-ideal effects; sensors for monitoring bioprocess parameters; Bioprocess control and computer coupled bioreactors; Growth and product formation by recombinant cells.

BEL880 Advanced Biochemistry
4.5 credits (3-0-3)
Protein conformation; Conformational mobility in globular proteins; Protein purification methods; Enzyme catalysis, kinetics and inhibition: Mechanism of Enzyme Action : Regulatory enzymes : Overview of metabolism: Biological membranes; Glycolysis, TCA cycle and oxidative phosphorylation, pentose phosphate pathway and Gluconeogenesis : Metabolism of fatty acids : Regulation of metabolic pathways : Biosynthesis of lipids, Amino acids, Nucleotides and their regulation: Regulatory process control and over-production of primary and secondary metabolites. Regulation of protein synthesis and secretion.

BEV880 Special Module in Anaerobic Digestion
1 credits (1-0-0)
The anaerobic trophic food web (digester, animal, soil and sediment example) Microbes involve in the different type of anaerobic process (phycrophile, mesophile, termophile) : classical approaches.

Microbes involves in the different type of anaerobic process (psychrophil, mesophile, thermophile) : molecular approaches.

The ecological features : richness, diversity, stability, resilience and production AD of industrials waste waters : Technologies, Performances, New applications, Industrial examples.

The Anaerobic Digestion of solid wastes : Pre treatment, technologies, Performances, Post treatment, VFA production coupled with WW treatment plant, Sizing of digesters, Examples of full scales applications.

Landfilling, Biogas utilization, Example of full scale applications in Europe Digester technologies in rural zones, Example of full scale applications.

BEL890 General Microbiology

4.5 credits (3-0-3)

Morphological, structural and biochemical characteristics of procaryotes and eucaryotes, Bacterial taxonomy, viruses, Methods in micro- biology, microbial growth and control of micro-organisms, transport of nutrients across cell membrane; Energy transduction mechanisms in microbial cell fermentation, aerobic and anaerobic respiration, microbial photosynthesis, Reproduction in Bacteria-vegetative and sexual (transduction, transformation, conjugation, transfection, sexduction), microbial interactions. Introduction to industrial, agricultural and medical microbiology, viruses.

BED895 Major Project (M.S. Research)

40 credits (0-0-80)

BEL895 Selected Topics

3 credits (3-0-0)

The course will aim at introducing students to some of the areas of current research interests in biochemical engineering and biotechnology while the exact content might vary. Some of the representative topics likely to be covered include : Animal and plant cell culture. Biosensors, bioprocess control and bioreactor designs. Modern microbial biotechnology. Regulation of microbial metabolism, Molecular biology.

Department of Chemical Engineering

CHL101 Introduction to Chemical Engineering Thermodynamics
3 credits (2-1-0)
Overlaps with: CHL121
Simplified mechanical structure of solids, liquids and gases; Origin of intermolecular forces and non-ideal behaviour of gases; C_p, C_v and equations of state; Generalized properties; First law and energy balances as applied to thermochemistry and fluid flow. Work in compression and expansion of fluid flow; Second law, concept of irreversibility; Introduction to phase and chemical equilibria; partial molar properties.

CHL103 Chemical Reactor Analysis and Design
4 credits (3-1-0)
Overlaps with: CHL122
Basic introduction to reaction engineering; Introduction to rate equations, stoichiometry and rate laws for biochemical reactions; Design of batch, plug flow, well mixed and semi-batch biochemical reactors; Introduction to pseudo steady state hypothesis and transition state theory; Michaelis – Menten equation and identification of its parameters; Multiple enzyme and substrate systems; Design equations for bio-reactors; Inhibitors and Propagators for biochemical reactions; Residence time Distribution; Diffusion with chemical reaction in catalyst particles, effectiveness factors; Scale up of bioreactors; Treatment of unsteady state and non-isothermal conditions for catalysed/uncatalysed biochemical reactions.

CHL110 Transport Phenomena
4 credits (3-1-0)
Definition of transport properties, their measurement and estimation. Shell balance approach for developing equations for momentum, heat and mass transport. Solution of problems involving transport in one dimension. Introduction to turbulent flows and expressions for turbulent fluxes. Concept of transfer coefficients. Similarity of momentum, heat and mass transport and various analogies. Application of these concepts to various disciplines in engineering and science.

CHN110 Introduction to Chemical Engineering
2 credits (0-0-4)
Presentations, discussions, demonstrations, literature survey and industrial visit related to different aspects of chemical engineering and its applications in energy, security, food, textiles, habitat, health and hygiene, body care and cosmetics, information and entertainment technology and environmental care.

CHL111 Material and Energy Balance
4 credits (2-2-0)
Mathematical and engineering calculations, Dimensional groups and constants, , Behaviour of ideal gases, gaseous mixtures, Vapour pressure, Clausius Clapeyron equation, Cox chart, During's plot, Raoult's law, Humidity and saturation, humid heat, humid volume, dew point, humidity chart and its use, Crystallisation, dissolution, Material balance; solving material balance problems with and without simultaneous equations; recycle, bypass and purge calculations, Aid of computer in solving material balance problems, Energy balance: heat capacity, calculation of enthalpy changes; energy balances with chemical reaction, Heat of vaporization, heat of formation, laws of thermochemistry, heat of combination, heat of reaction, Solution of sets of equations, Case studies.

CHL112 Chemical Process Technology
4 credits (3-1-0)
The course covers the concept of combination of unit processes and unit operations along with the basic raw materials. Synthesis of steady state flow sheets for the chemical plant. Processing of water for various end uses. Industrial gases and different techniques for air separation systems. Manufacture of Fertilizers including sulfuric acid; ammonia and its allied products like, Urea, Nitric acid and other products. Food processing and agro based products like paper, sugar, oils and soap etc. including the manufacture of ethyl alcohol. Electrochemicals and chloralkali industries. Safety and Hazard in chemical process plant design and environmental constraints. Concept of green technologies.

CHL121 Chemical Engineering Thermodynamics
4 credits (3-1-0)
Overlaps with: CHL101
Basic concepts – force, energy, heat, work etc.; closed and open systems; First law for closed and open (flow) systems; Heat effects; Second law and entropy; Second law for flow systems and lost work. Thermodynamic relations – fundamental property relations and Mazwell's relations; PVT behaviour of pure substances; Equations of state generalized correlations, acentric factor; Calculation of thermodynamic properties using these; Heat engine, Carnot and other cycles; Refrigeration cycles; General Vapor Liquid Equilibrium (VLE) behaviour, equilibrium criterion and Raoult's law; Partial molar quantities, excess properties, chemical potential, fugacity and activity coefficients; VLE calculations – Bubble point, Dew point and Flash calculations. Chemical reaction equilibrium and equilibrium constants; single and multi-reaction equilibria.

CHL122 Chemical Reaction Engineering – I
4 credits (3-1-0)
Overlaps with: CHL103
Introduction to reaction engineering; Concepts of rate equations, stoichiometry and rate laws; Material balance for CSTR and PFR, their use for kinetic interpretation and design; Comparison of batch reactor, CSTR and PFR; Evaluation of performance properties of the reactors; Analysis of rate data for batch/continuous flow reactors and development of rate equation; Introduction to the concept of yield and selectivity for multiple reactions; Unsteady state reactor design; Concepts of adiabatic and non-isothermal operations (energy balance).

CHL133 Powder Processing and Technology
4 credits (3-1-0)
Powder characterization for size, size distribution, surface area and flowability. Size distribution and material handling equipment performance, powder strength and flowability. Shape characterization. Instruments for measurement of powder characteristics. Powder storage in silos. Flow properties of powders. Air induced segregation, segregation during heap formation and flow through chutes. Measurement of flow factor and silo design. Analysis methods for flow through chutes, cyclones, etc. Retrofitting. Comminution. Grinding process and circuit analysis. Gas solid separation and equipment like cyclone collectors and bag house scrubbers. Application of cyclone in waste heat recovery. Energy saving through pollution control.

CHL202 Process Systems Analysis and Control
4 credits (3-1-0)
Pre-requisites: MAL110
Overlaps with: CHL261
Revision of Laplace transform; Dynamic behaviour of first order and second order systems: response of first order systems, response of first order systems in series, second order systems and transportation lag, block diagrams and transfer functions; Feedback Control: P, PI, PID controllers, transient response of control systems: Stability: general concepts, Routh stability criterion, direct substitution method; Frequency response: Bode diagrams, Nyquist diagrams, control system design by frequency response, tuning and troubleshooting; feedforward control, ratio control, cascade control; Introduction to modern control theory.

CHL203 Transport Processes - I
4 credits (3-1-0)
Pre-requisites: CHL110
Overlaps with: CHL231, AML160, AML150, AML170
Revision of momentum transfer principles; flow of incompressible fluids in conduits; fittings and valves; network of pipelines; economic pipe diameter; flow through open channels; compressible fluid flow; transportation and metering of fluids; pumps, fans, blowers and compressors; flow measuring devices; agitation and mixing of fluids; Revision of heat transfer principles; boiling and condensation; heat exchangers; overall heat transfer coefficients; LMTD; analysis of heat exchangers; jacketed vessels; heat exchanger coils; condensors and evaporators; multiple effect evaporation; surface area determination.

CHL204 Transport Processes - II
4 credits (3-1-0)
Pre-requisites: CHL110
Overlaps with: CHL251
Empirical correlations based on analogy between momentum, heat and mass transfer; Mass balance in co-current and counter-current continuous contact equipment; operating line concept; ideal stage and stage efficiency; design of continuous contact equipment; HTU and NTU concept; batch and continuous distillation; absorption; adsorption: applications to chromatography; extraction and leaching operations; equipments and equilibrium diagrams; design procedures and calculations; humidification operations; design of cooling towers; drying of solids; design of batch and continuous dryers.

CHL221 Chemical Reaction Engineering – II
4 credits (3-1-0)
Pre-requisites: CHL122
Introduction to Catalysis, classification, preparations, properties; Physical and chemical adsorption, Different types of adsorption isotherms; Kinetics of solid catalyzed gas phase reaction; Laboratory reactors for catalytic gas-solid reactions; Diffusion and chemical reaction in catalysts; Effects of external mass transfer and heat transfer; Effectiveness factors; Fixed bed catalytic reactors; Fixed bed reactor models; Psendo-Homogeneous and 2-dimensional models concept of heterogeneous models Non-catalytic gas-solid reactions different models reactors; Gas-liquid reaction; Film and penetration theories; Enhancement factor in G-L reactions; Reactor systems for G-L reactions. Laboratory/design activities could also be included.

CHL231 Fluid Mechanics for Chemical Engineers
4 credits (3-1-0)
Pre-requisites: CHL110
Overlaps with: AML160, AML150, AML170, CHL203
Properties of fluids, classification of fluids, forces on fluids, normal forces and shear stresses on fluids, pressure-depth relation for fluids, forces on submerged bodies, rigid body motion, pressure and velocity measurement, kinematics of flow, mass. energy and momentum balances (macroscopic), Fluid friction in pipes, flow in chemical engineering equipment, differential equations of fluid mechanics, solution of viscous flow problems, Laplace's equation for irrotational flow, stream function, potential flow, description of fluid fields, boundary layer, other unidirectional flow, turbulent flow .

CHL251 Heat and Mass Transfer
4 credits (3-1-0)
Pre-requisites: CHL110
Overlaps with: CHL204
Diffusion in gases, liquids, and solids. Steady and unsteady Mass/Heat conduction in solids Mass transfer operations. Heat exchange equipment Mass balance in simple situations with and without chemical reaction. Theories of mass transfer. Individual and overall mass and heat transfer coefficients. Simultaneous heat and mass transfer. Mass, heat, and momemtum transfer analogies. Convective mass transfer. Convection – diffusion problems. Mole and energy balance in co-current and countercurrent continuous contact equipments. Empirical correlations for mass/heat transfer coefficients in various situations. Dimensionless numbers and their significance. Concept of operating line. Multistage countercurrent operations. Concept of ideal stage. Stage efficiencies. Design of continuous contact equipments. HTU and NTU concepts. Gas absorption. Heat effects. Design of a packed-bed gas absorber.

Laboratory/design activities could also be included.

CHL260 Applications of Programming in Chemical Engineering
4 credits (3-0-2)
Pre-requisites: CSL101/CSL102 and CHL110
Solving of linear, non-linear algebraic equations, interpolating polynomials, different ion, integration, ordinary differentiation equations and their applications to Chemical Engineering Design problems. Application of Matlab, various toolboxes, features of symbolic math toolbox.

Use of MATLAB functions for performing integration and differentiation and solving algebraic equations, ordinary and partial differential equations with initial and boundary conditions.

Introduction to ANSI C, character set, keywords, constants, data types, variables, expressions, simple input/output programs, pointers, conversion characters, escape sequence, relational and logical expression and control statements, bit manipulations, introduction to functions with examples, classes of variables, arrays and pointers, Preprocessor and recursive functions, structures, union, field type definition, input/output files.

CHL261 Instrumentation and Process Control
4 credits (3-1-0)
Pre-requisites: MAL110 and CHL122
Overlaps with: MEL312, EEL301, CHL202
Introduction to instrumentation and process control. Measuring instruments for: Temperature, pressure, level, flow, composition, pH. Basic concepts of feedback control: Control loop and its elements. Dynamic behaviour of first, second and higher order physical systems. Linearization of non-linear systems. Controller hardware, sensors, transmitters and control valves. Stability of control loop using Routh's test. Introduction to root locus method. Frequency response analysis: Bode stability criteria. Introduction to advanced control systems: feed forward, cascade, ratio control. Design of single loop feedback control systems and tuning of feedback controllers. Control schemes with applications to distillation systems, chemical reactors, heat exchangers, boilers etc. State space representation of physical system. Transfer function matrix and multivariable control.

CHL275 Safety and Hazards in the Process Industries
4 credits (3-1-0)
Pre-requisites: CHL112
Identification, classification and assessment of various types of hazards, Hazards due to fire, explosion, toxicity and radiation, Protective and preventive measures in hazards control, Industrial hygiene, Reliability and risk analysis, HAZOP and HAZAN, Consequence analysis (vapour cloud modelling), Event probability and failure frequency analysis, Safety Training, Emergency planning and disaster management, Case studies.

CHL277 Materials of Construction
3 credits (3-0-0)
Pre-requisites: CHL112
Types and mechanism of corrosion, factors influencing corrosion, combating corrosion, corrosion testing methods, Metallic materials, Non-metals, High and low temperature materials, Selection of materials of construction for handling different chemicals, Industrial applications and case studies.

CHL291 Introduction to Biochemical Engineering
4 credits (3-1-0)
Pre-requisites: CHL111
Overlaps with: BEL301
Basics of microbiology and biochemistry. Mass and energy balance in microbial processes. Microbial growth, substrate utilization and product formatio kinetics. Medium and air sterilization. Enzyme kinetics and immobilized enzyme systems. Design of batch, continuous and fed-batch bioreactors. Mass Transfer in biological reactors. Scale-up principles, Instrumentation and control of bioprocesses, Bioseparation.

CHL296 Nano Engineering of Soft Materials
3 credits (3-0-0)
Pre-requisites: CHL110
The course can be subdivided in three subheadings viz., Soft materials, Intermolecular forces, Surface Instabilities in soft materials

Soft materials: soft materials and their properties, ways to control and measure the properties of soft materials.

Intermolecular forces: van der Waals, Acid-Base, Double layer and other forces, their decay behavior and measurement

Surface instabilities: Conditions for onset of surface instability; Morphological changes during evolution of instability. Ways to tune this evolution to result in desired morphology.

CHP301 Fluid Mechanics and Heat Transfer Laboratory
1.5 credits (0-0-3)
Pre-requisites: CHL110 + EC60
Overlaps with: CHP304
Selected experiments in fluid mechanics (e.g. Flow Visualisation, Flow through a converging-diverging duct, Free jets through nozzles and orifices, Flow over a notch or weir, Fully developed flow through pipes, Performance characteristics of a centrifugal pump) and heat transfer (e.g. Shell and tube heat exchanger, Double pipe heat exchanger, Thermal conductivity of metal bar, Heat transfer through forced convection and natural convection).

CHP302 Mass Transfer and Fluid Particle Mechanics Laboratory
1.5 credits (0-0-3)
Pre-requisites: CHL110 + EC60
Overlaps with: CHP304, CHP305
Selected experiments in (a) mass transfer - batch distillation, diffusion efects, batch drier, absorber, cooling tower performance; and (b) particle mechanics - fluidization, packed bed, particle drag, mill operations, cyclone performance, grinding operations.

CHP303 Chemical Reaction Engineering and Process Control Laboratory
1.5 credits (0-0-3)
Pre-requisites: CHL122 & CHL261
Overlaps with: CHP305
Practicals in reaction engineering and process control and instrumentation.

CHP304 Chemical Engineering Laboratory - I
1.5 credits (0-0-3)
Pre-requisites: CHL203
Overlaps with: CHP301, CHP302
Experiments in fluid mechanics, fluid-particle mechanics and heat transfer.

CHP305 Chemical Engineering Laboratory - II
1.5 credits (0-0-3)
Pre-requisites: CHL103 & CHL204
Overlaps with: CHP302, CHP303
Experiments in mass transfer, thermodynamics and reaction engineering.

CHD310 Mini Project (CH)
3 credits (0-0-6)
Pre-requisites: EC 60
Design/fabrication work under the guidance of a faculty member. Prior to registration, a detailed plan of work should be submitted by the student to the Head of Department for approval.

CHR310 Professional Practices (CH)
2 credits (0-1-2)
Pre-requisites: EC 60
Lectures on recent developments in chemical engineering by faculty and executives from industry. Visits to industry to observe and study various chemical operations.

CHS310 Independent Study (CH)
3 credits (0-3-0)
Pre-requisites: EC 60
Research oriented activities or study of subjects outside regular course offerings under the guidance of a faculty member. Prior to the registration, a detailed plan of work should be submitted by the student to the Head of Department for approval.

CHP311 Design and Laboratory Practices
2 credits (0-0-4)
Pre-requisites: CHL110 + EC60
Preparation of fabrication drawings and testing of fabricated laboratory equipment. Piping connections. Study and use of various valves and fittings.

CHL331 Fluid-particle Mechanics
4 credits (3-1-0)
Pre-requisites: CHL231
Overlaps with: CHL204
Size and size distribution: size distribution equations and their uses. Shape characterization, fractals and fourier analysis. Method of measurements, image processing. Instrumental method for measurement of powder size and distribution, microscope, sieve analysis. Settling of single particle and multiple particles, application for size analysis of particles and design of settling tank. Pressure, vacuum and ultra filtrations. Flow through packed and fluidized beds. Application of Kozney Carman equation for development of surface area meter and evaluate bag filter performance. Powder storage in Silos. Flow properties of powders. Jensen equation Funnel and mass flow. Retrofitting with inserts and bin serts. Comminution. The selection of Comminution equipment. Grinding circuit analysis. Various methods of production of particles, nano particles and their importance. Gas solid separation: Settling chambers, cyclone collectors. bag house scrubbers, Electrostatic separators, scrubbers and other filtration techniques. Laboratory design activities could be also included.

CHL332 Fluidization Engineering
4 credits (3-1-0)
Pre-requisites: CHL331
Fluidization, Classification of particles, regimes of fluidization, minimum fluidization velocity, Particulate and aggregative fluidization, bubbling fluidization, bubbling bed models for catalytic reactions, turbulent and fast fluidization, dilute and dens phase transport, cyclones, stand pipes, circulating fluidized beds, spouted beds, three phase fluidization, performance modeling of multiphase systems.

Laboratory/design acivities could also be included.

CHL351 Mass Transfer Operations
4 credits (3-1-0)
Pre-requisites: CHL251
Overlaps with: CHL203
Distillation: Raoult's law, ideal solutions, x-y and H-x-y diagrams, flash vaporization and condensation, Differential distillation, steam distillation, Binary distillation: McCabe-Thicle and Ponchon-Savarit Method, Total reflux, minimum and optimum reflux ratios, Design of distillation column with open steam, multiple feeds, side streams and partial condensers, Approximate and plate to plate calculations for multicomponent distillation, Liquid-liquid extraction, Extraction equipment Design, Equilibrium diagram, Choice of solvent, Single stage and multistage counter current extraction with/without reflux, Continuous contact extractors, Leaching equipment and equilibrium, Single stage and multistage cross current and counter-current leaching, Adsorption: adsorption equilibria, adsorption column sizing.

CHL353 Modern Separation Processes
4 credits (3-1-0)
Pre-requisites: CHL251
Membrane separation processes, Pressure swing adsorption, Foam separation, Chromatographic techniques: Column chromatography, Gas-liquid chromatography, Ion-exchange chromatography, Separation by thermal diffusion, Electrophoresis, Crystallization. Laboratory/design activities could also be included.

CHL390 Process Utilities and Pipeline Design
4 credits (3-0-2)
Pre-requisites: CHL231&CHL251
Steam systems: sizing and pressure drop, water hammer, steam trap, flash tank design, lagging, scale formation. Water treatment. Air

systems: vessels, air cleaning and dehumidification, air filters, compressors, blowers and piping. Refrigeration and air conditioning basics. Instrumentation and feed back control systems. Energy auditing for steam and air systems. Solar energy applications for utilities.

CHL392 Polymer Science and Engineering
4 credits (3-1-0)
Pre-requisites: CHL122 and CHL231
Overlaps with: CYL230
Classification of pol.d application. Polymer based industries.

CHC410 Colloquium (CH)
3 credits (0-3-0)
Pre-requisites: registered for CHT410 and EC 90
One hour lecture by each student on his practical training. Circulation of a ten page notes on his lecture. Some special assignment on his training.

CHT410 Practical Training (CH)
Non credit
Pre-requisites: EC 90 at the end of 5th sem.
Observation of operating chemical plants. Noting down operating procedures, construction details, management procedures. Doing a Project related to the selected industry.

CHD411 Major Project Part 1 (CH)
4 credits (0-0-8)
Pre-requisites: EC 120
Formulation of the problem; Literature search; Design of the experimental setup and study of experimental techniques in the case of experimental projects; Formulation of design equations, development of solution techniques and familiarization with relevant software in the case of design or theoretical projects.

CHD412 Major Project Part 2 (CH)
6 credits (0-0-12)
Pre-requisites: CHD411
Theoretical or design projects: To arrive at a complete design of a chemical plant in particular give complete design detail of major process equipment or to develop computer simulation models for industrial processes at macro or micro level.

Experimental Projects: Collect and interact data and model the experimental system.

CHL471 Process Equipment Design and Economics
4.5 credits (3-0-3)
Pre-requisites: CHL351
Heat Exchange Equipment: rating of an existing unit and design of a new system of shell and tube heat exchangers; design of multiple-effect evaporator.

Mass Exchange Equipment: design of a sieve-tray tower for distillation; design of a packed tower for gas absorption.

Plant Economics: estimation of various costs to install and run a plant; interest costs and present/future worth of cash flows; straight-line and combination methods for depreciation; discounted cost flow/net present worth methods for profitability analysis.

CHL603 Advanced Transport Phenomena
3 credits (3-0-0)
Development of mass, momentum and energy balance equations. Equation of change for isothermal systems. Velocity distribution in flow systems. Interphase transport. Microscopic and macroscopic balances. Multicomponent systems and their transport characteristics. Energy transport in non-isothermal systems. Energy transport by radiation.

CHL604 Fluid Solid Reaction Engineering
4 credits (3-0-2)
Elements of reaction kinetics. Kinetics of heterogeneous catalytic reactions. Transport process with fluid-solid heterogeneous reactions. Non-catalytic fluid, solid reactions. Catalyst deactivation. Gas-Liquid reactions. Regression and other statistical methods for Kinetic Parameter

Estimation. Determination of transport and reaction parameters by experimental methods.

CHL626 Multi Phase Contactors
3 credits (3-0-0)
Shell balance for momentum transfer. Velocity profiles. Residence time distribution Measurement techniques. RTD for single phase flow in tubes, coils, packed beds, stirred vessels. Multiphase flow. Stratified and dispersed flows. Interaction between phases Measurement techniques. Modelling and correlations of RTD in different contactors; Trickle beds, packed beds, bubble columns, spray columns, plate columns, fluidised beds etc. Prediction of Pressure drop; Friction factor, drag coefficient, single phase flow, multiphase flow. Lockhart Martinelli approach. Drift flow concept, Rheology.

CHL634 Management of R&D in Chemical Industries
3 credits (3-0-0)
Introduction. Nature of planning. Choice and objectives of technological forecasting. Proposal preparation and motivative effort to initiate the research and developmental programme. Concept of creativity, group approach to idea generation. Conditions for successful growth of creative ideas to realisation. Quality of research personnel and staff selection. Organisation and special problems of research and development. Conducting a research and development project. Scheduling, monitoring, and decision-making for cost effectiveness. Accountability and responsibility.

CHL653 Application of Programming in Chemical Engineering
4 credits (3-0-2)
Basic concept of OOP using C++, elements of C++ language, variables and constants, data types, operators, control statements, functions, reference variables and arguments, classes and objects, constructors and destructors, operator overloading, data and type conversions, derived classes and inheritance, pointers, virtual functions, streams, templates.

Elements of visual C++, dialogs and controls, Messages and commands, documents and views, reading and writing file, working with menus, bars and toolbars, common controls, multitasking with windows threads, building an ActiveX control, creating an ODBC Database access.

CHL701 Process Engineering
4 credits (3-0-2)
Pre-requisites: CHL112 & CHL351
Process Synthesis; Hierarchical conceptual design of process; Batch vs. continuous; input-output structure of flowsheet; choice of reactor; choice of separation system; Distillation column sequencing; Heat exchanger network design; Pinch technology; Utility selection; Steam and cooling water circuits.

Process economics: Cost estimation; annuities; perpetuities and present value; Tax and depreciation; Profitability measures; comparison of equipments and projects; NPV and DCFROR, Risk management.

Introductory Optimization: Linear programming and its use in process industry; transportation problems; integer programming (branch and bound method); use of commercial softwares LINDO, CPLEX.

Second Law Analysis: Estimate of inefficiency in equipment/process by finding lost work' modification of operating conditions/process to improve efficiency.

CHL702 Plant Design
4 credits (3-0-2)
Pre-requisites: CHL471
Plant layout, auxiliaries, materials handling, offsite facilities, selection and detailed design of equipments, e.g., mixers, conveyers, heat exchangers, separation equipments, pumps, compressors, etc.

CHL704 Polymer Composite Process Modelling
4 credits (3-1-0)
Introduction to Chemical Engineering principles involved in polymer matrix composite processes and their applications; A brief review of numerical methods and their application to various manufacturing processes of PMCs. Modelling and simulation of the physicochemical reactions, fluid solid reactions involved in these manufacturing processes and parametric optimization applicable to these manufacturing processes. Modelling and simulation of the flow processes involved in

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the manufacturing processes like resin transfer molding, vacuum assisted resin transfer molding.

CHL705 Electrokinetic Transport Phenomena
4 credits (3-0-2)
Pre-requisites: CHL331
Definition of colloidal state and implications, intermolecular and surface forces, electrostatics, transport equations in electrolytic solution, electrokinetic phenomena, electrophoresis, sedimentation potential, coagulation of particles, particle deposition and aggregation, electrochemistry and electrochemical engineering, electrode and redox potential, over voltages electro analytical techniques – cyclic voltammetry, chrono amperommetry, chrono coulometry, applications of these concepts in fuel cell technology, fuel cell modeling.

CHL707 Adsorption Separation Processes
3 credits (3-0-0)
Pre-requisites: EC90 and CHL251
Microporous adsorbents, Physical adsorption and characterization of porous adsorbents, Adsorption equilibria, Diffusion in porous media, kinetics of adsorption in batch systems, Column processes, Chromatographic separation processes, Pressure swing adsorption, Structure and properties of ion exchange resins, Ion-exchange equilibrium, Ion-exchange kinetics, Ion-exchange columns, Behaviour of ion-exchangers in non-aqueous and mixed solvents.

CHL710 Process Dynamics and Control
5 credits (3-1-2)
Pre-requisites: CHL261
Lumped parameter systems—classical and multivariable control theory, Distributed parameter systems, Measurement of process variables such as temperature, pressure, composition, flow rate, level, density, etc. Dynamics of process instruments and loops, Analogue and digital signals, process actuators and control equipment.

CHL711 Numerical Methods in Chemical Engineering
4 credits (3-0-2)
Pre-requisites: (CSL101/CSL102) & MAL110 and EC 90 and CHL110
Efficient and recent numerical techniques applied to problems of chemical engineering interests, Solution of linear and non-linear simultaneous algebraic equations, Interpolation, extrapolation and finite difference, Numerical integration and differentiation, coupled ordinary differential and partial differential equations, curve fitting, spline, regression analyses, molecular simulations.

CHP711 Process Development Laboratory
3 credits (0-0-6)
Pre-requisites: CHL221 & CHL351
Selection of a problem. Definition of the problem. Literature Search. Design of an experimental program. Fabrication of necessary equipment. Operation of the equipment. Interpretation of data, report writing and oral defence. Measurements, and interpretation of data.

CHL712 Computer Aided Design in Chemical Engineering
3 credits (2-0-2)
Pre-requisites: CHL351 and MAL110 and CSL101/CSL102
Software development for design of various chemical equipments. Design of minimum energy heat exchanger network, sequencing and energy integration in distillation column simulation of process flow sheets using software package, Aspen Plus.

CHL714 Advanced Heat Transfer
3 credits (3-0-0)
Pre-requisites: CHL251 & MAL260
Formulation and solution of transient and steady-state conduction, heat transfer in fixed beds, fluidized beds, magneto fluid dynamic systems, transpiration cooling in non-Newtonian fluids, heat pipes, solar collectors.

CHL717 Mechanical Design of Process Equipment
4 credits (3-0-2)
Pre-requisites: CHL471
Specification and design of simple structural members, Design of spherical/ cylindrical shells and heads/ closures for cylindrical shells under internal and external pressure, Design of a self- supporting tall vertical cylindrical vessel under wind/ seismic loading, Design of RCC foundation for a tall vessel; Compensation for openings in cylindrical shells, Design of special flanges, Design of storage tanks for liquids.

Laboratory/ design activities could also be included.

CHL721 Advanced Chemical Engineering Thermodynamics
4 credits (3-1-0)
Pre-requisites: CHL121 & 90 credits
This course provides a thorough understanding of chemical engineering thermodynamics, with emphasis in the following areas - Vapor - Liquid equilibria, Liquid-Liquid Equilibria, Statistical Thermodynamics, Chemical Reaction Equilibria in multi-component systems, encountered in most chemical systems. We expect that students use their fundamental understanding of thermodynamic principles and learn to solve several complex problems in the above-mentioned areas.

CHL722 Fundamentals of Fuel Cell Technology
4 credits (3-0-2)
Pre-requisites: UG/Dual- EC 120
Overview of fuels cells: Low and high temperature fuel cells: Fuel cell thermodynamics – heat, work potentials, prediction of reversible voltage, fuel cell efficiency; Fuel cell reaction kinetics – electrode kinetics, overvoltages, Tafel equation, charge transfer reaction, exchange currents, electrocatalyses – design, activation kinetics, Fuel cell charge and mass transport – flow field, transport in electrode and electrolyte; Fuel cell characterization: - in-situ and ex-situ characterization techniques, i-V curve, frequency response analyses; Fuel cell modeling and system integration: - 1D model – analytical solution and CFD models, Balance of plant; Hydrogen production and storage; safety issues, cost expectation and life cycle analysis of fuel cells.

CHL723 Chemical Reaction and Reactor Engineering
3 credits (3-0-0)
Pre-requisites: CHL251 & CHL221
Theory of mass transfer with chemical reaction, irreversible reaction, enhancement factor for single irreversible and reversible reactions, enhancement factor for reversible and other complex reaction schemes, modeling of solid catalyses gas-liquid reactors, stability and control of chemical reactors, modeling of solid catalyses gas-liquid reactors.

CHL724 Environmental Engineering and Waste Management
4 credits (3-1-0)
Pre-requisites: CHL251
Ecology and Environment, Sources of air, water and solid Wastes, Air Pollution: Micromet-eorology and dispersion of pollutants in environment, Fate of pollutants, Air pollution control technologies: centrifugal collectors, electrostatic precipitator, bag filter and wet scrubbers, Design and efficiencies, Combustion generated pollution, vehicles emission control, Case studies, Water Pollution: Water quality modelling for streams. Characterisation of effluents, effluent standards, Treatment methods, Primary methods: settling, pH control, chemical treatment. Secondary method: Biological treatment, Tertial treatments like ozonisation, disinfection, etc. Solid waste collection, treatment and disposal, Waste recovery system

CHL727 Heterogeneous Catalysis and Catalytic Processes
4 credits (3-0-2)
Pre-requisites: CHL221
Basic concepts in heterogeneous catalysis, catalyst preparation and characterization, poisoning and regeneration, Industrially important catalysts and processes such as oxidation, processing of petroleum and hydrocarbons, synthesis gas and related processes, commercial reactors (adiabatic, fluidized bed, trickle-bed, slurry, etc.), Heat and mass transfer and its role in heterogeneous catalysis, Calculations of effective diffusivity and thermal conductivity of porous catalysts, Reactor modeling, Emphasizes the chemistry and engineering aspects of catalytic processes along with problems arising in industry, Catalyst deactivation kinetics and modeling.

CHL731 Introduction to Soft Matter
3 credits (3-0-0)
Soft matter an overview, forces, energies and timescales in soft matter, phase transitions in soft matter, spinodal decomposition, nucleation, colloidal dispersions, polymers, gelation, liquid crystals, polymer crystals, self assembly in soft materials, soft materials in nature.

CHL735 Design of Separation Processes
4 credits (3-0-2)
Pre-requisites: CHL351 and CHL121
Separation processes based on micro-emulsion, micelles, micro-gas bubble, electrical charges, design of such processes with special emphases on separation technology in petroleum refinery and petro-chemicals, multicomponent distillation, extraction, adsorption-short-cut method, rigorous calculations, design of tray and packed columns, economic analyses of columns, crystallization, membrane separation, challenges in new technologies.

CH740 Selected Topics in Chemical Engineering
3 credits (3-0-0)
Various advanced topics in chemical engineering of interest to research and/or of industrial importance.

CHL743 Petrochemical Technology
3 credits (3-0-0)
Pre-requisites: CHL221
Introduction: Composition of petroleum, laboratory tests, refinery products, characterization of crude oil, Indian Petrochemical Industries, A review, Feed stocks for petrochemical Industries and their sources, A brief introduction to Catalytic cracking, Catalytic reforming, Delayed coking Hydrogenation and Hydro cracking, Isomerization, Alkylation and Polymerization, Purification of gases, Separation of aromatics by various Techniques, Petrochemicals from Methane, Petrochemicals from Ethane – Ethylene – Acetylene. Petrochemicals from C3, C4 and higher Hydrocarbons. Synthetic Gas Chemicals, Polymers from Olefins, Petroleum Aromatics, Synthetic Fibers, Rubber, Plastics and Synthetic Detergents, Energy conservation in petrochemical Industries, Pollution control in Petrochemical Industries, New Trends in petrochemical Industry.

CHC750 Seminar (CC)
1 credit (0-0-2)
Pre-requisites: EC 142
Literature study on a selected topic. Report writing. Seminar presentations.

CHL751 Multi-component Mass Transfer
3 credits (3-0-0)
Pre-requisites: CHL351
Diffusion: Maxwell-Stefan's, Fick's and Irreversible Thermodynamics approaches to multicomponent diffusion,Estimation of multicomponent Diffusion Coefficients, Effect of nonideality of fluids, Linearized theory for multicomponent diffusion problems, Interphase mass transfer, mass transfer coefficients, bootstrap matrix, Film Theory, Surface renewal models, mass transfer in turbulent flows.

Laboratory/design activities could also be included.

CHP754 Applications of Simulation Software
2 credits (1-0-2)
Pre-requisites: CHL351 & CHL121 & CHL111
Introduction to simulation software packagesa) - PROII, Aspen Plus, HEXTRAN, Data reconciliation. Techniques of solving recycle flow problems. Techniques Dynamic simulation. Practice sessions with 'Simsci' and Aspen Plus software for steady state simulation of chemical plants.

CHD760 Minor Project (CHD)
3 credits (0-0-6)

CHC760 Seminar (CP)
1 credit (0-0-2)
Pre-requisites: EC 142
Literature study on a selected topic. Report writing. Seminar presentations.

CHL761 Chemical Engineering Mathematics
3 credits (3-0-0)
Pre-requisites: MAL110 and EC 90 and CHL110
Data Analysis: Classification, estimation and propagation of errors, Presentation of data, Statistical methods, sample and population distributions, testing of hypothesis, analysis of variance.

Solution of equations: Vector spaces, basis, matrices and differential operators, Eigen values, vectors and functions, Solvability conditions for linear equations, Sturm-Louiville Theory, Separation of variables and Fourier transform, Frobenius method for ordinary differential equations, Greens Function and its application.

CHL762 Modeling, Simulation and Control
4 credits (3-0-2)
Pre-requisites: CHL351&CHL221&CHL261
Development of conservation and constitutive equations for a variety of chemical engineering unit operations and processes under steady state and unsteady state conditions, their analysis and solution. Concept of lumped and distributed parameter models. Introduction to steady state and dynamic simulation software. Study of plant wide control schemes.

CHL763 Computer Process Control
3 credits (3-0-0)
Pre-requisites: MEL432
16 bit microprocessor architecture, overview of IBM PC to Pentium Computer, Computer- Process Interface equipment, DDC, Distributed Process Control, Supervisory Control, PLC, Fuzzy Logic and Neural Networks, Applications in Control of Chemical Processes.

CHL766 Interfacial Engineering
3 credits (3-0-0)
Pre-requisites: CHL351&CHL110&CHL121
Concept and definition of interface, Physical surfaces, Surface chemistry and physics of colloids, thin films, dispersions, emulsions, foams, polyaphrons, Interfacial processes such as crystallization, epitaxy, froth flotation, adsorption, adsorptive bubble separation, catalysis, reaction-injection moulding, microencapsulation, Industrial aspects of interfacial engineering.

CHL768 Fundamentals of Computational Fluid Dynamics
3 credits (2-0-2)
Pre-requisites: CHL110 and CSL101/CSL102 and EC90
Overlaps with: AML811
Review of basic fluid mechanics and the governing (Navier-Stokes) equations, Techniques for solution of PDEs – finite difference method, finite element method and finite volume method, Finite volume (FV) method in one-dimension, Differencing schemes, Steady and unsteady calculations, Boundary conditions, FV discretizationin two and three dimensions, SIMPLE algorithm and flow field calculations,variants of SIMPLE, Turbulence and turbulence modeling, illustrative flow computations, Commercial softwares FLUENT and CFX – grid generation, flow prediction and post-processing.

CHD770 Major Project Part- 1(CHD)
6 credits (0-0-12)
Formulation of the problem, literature search, design of the experimental setup and study of experimental techniques in the case of experimental projects, formulation of design equations in development of solution techniques and familiarization with relevant software in the case of design or theoretical projects.

CHL771 Process Operations Scheduling
4 credits (3-0-2)
Course Contents
(i) Classification of scheduling formulations; various storage policies, objective functions, network representations, time representations.

(ii) Short-term scheduling of batch processes: discrete-time and continous-time based models.

(iii) Cyclic and short-term scheduling of continues processes.

(iv) Optimization: Introduction to Linear Programming (LP) and Mixed-Integer Linear Programming(MILP).

(v) Solution of resulting models using GAMS modeling language.

CHL773 Planning of Experiments and Analysis of Engineering Data
4 credits (3-0-2)
Graphical method of model selection from experimental data,Two variable equations, Linear and logarithmic plots, modified Logarithmic and semi-logarithmic plots, Reciprocal plots, Equations for bumped data. Elongated "S" curve, Sigmoid curves……Three variable empirical equations, Multivariable empirical equation…. Dimensionless numbers. Nomography, Introduction, modulus and scale and principle of construction, Application of logarithmic charts, Equations of the form $F_1(x) + F_2(X) = F_3(X)$, Selection of empirical equation for fitting experimental data Testing of hyposthesis, Testing of means and variances, Planning of experiments as per factorial design to estimated significant variables which affect the process,Fractional factorial design to use significant variables to estimates the relationship between the significant variables and independent variable Response surface analysis by reducing the equations developed to canonic order with interaction factor, Case studies on application to research and industrial data analysis.

CHL774 Process Optimization
4 credits (3-0-2)
Pre-requisites: CHL221&CHL471
Overlaps with: MAL210, MAL704, MAL726
Formulation of an optimization problem, Convexity Analysis, Linear Programming, Nonlinear Programming, Optimality Conditions, Dynamic Optimization, Dynamic Programming, Introduction to Mixed Integer Programming. Laboratory/design activities could also be included.

CHD780 Major Project Part-2 (CHD)
12 credits (0-0-24)
Theoretical or design projects: to arrive at a complete design of a chemical plant in particular give complete design detail of major process equipment or to develop computer simulation models for industrial processes at macro or micro level.

Experimental Projects: Collect and data and model the experimental work.

CHS780 Independent Study
3 credits (0-3-0)

CHL793 Membrane Science and Engineering
3 credits (3-0-0)
Pre-requisites: CHL110&CHL351
Introduction to membrane separation processes, their classification, and applications. General transport theories including theory of irreversible thermodynamics for multicomponent systems.

Membrane preparation techniques. Design and analysis and industrial application of various membrane processes such as reverse osmosis, ultrafiltration electrodialysis, dialysis, liquid membrane separation, gas permeation and pervaporation.

CHL794 Petroleum Refinery Engineering
4 credits (3-0-2)
Pre-requisites: CHL351 and CHL122
Introduction : Composition of petroleum, laboratory tests, refinery products, characterization of crude oil. Design of crude oil distillation column. Catalytic cracking. Catalytic reforming. Delayed coking. Furnace design. Hydrogenation and Hydrocracking. Isomerization, Alkylation and Polymerization. Lube oil manufacturig. Energy conservation in petroleum refineries. New Trends in petroleum refinery operations. Pyrolysis of Naphtha and light hydrocarbons: modeling (time permitting).

CHL795 Agro Process Technology
3 credits (3-0-0)
Pre-requisites: CHL351
Post Harvest Technology of Cereals, Pulses and Oilseeds.Processing of oil seeds, solvent extraction, utilization of rice bran .Storage of food grains.Food chemistry.
Development of food chemistry .Edible oils and fats: physical and chemical properties, Carbohydrates, Proteins, Flavours and aroma of food. Food preservation and processing: Nutritive aspects of food, food additives,Food adulteration and simple detection techniques, Soilage of food, food poisoning, micro-organisms in foods, Sanitation and cleaning requirements for food processing plants Quality control and quality assurance.

Food preservation : principles and methods, Fruits and fruit products, Vegetables and vegetable products.

By-product utilization, Waste utilization. Packaging and packaging materials.

Case studies: Biomass utilization, solvent extraction of neem oil and by products from neem seeds, solvent extraction of jojoba oil, Solvent extraction of hops.

CHL807 Population Balance Modeling
3 credits (3-0-0)
Pre-requisites: MAL120 and CHL221 and CHL331 and CHL351 & EC120
Particle size distribution, Crystal size distribution, Comminution processes and other particulate processes, Representation of distribution, Properties of distributions, Particle phase space, Population fluxes distributions, Particle phase space, Population fluxes-convections, Birth and death, Particle number continuity equation, Population balance over a macroscopic external coordinate region, Moment transformation of population balance over a macroscopic external coordinate region, Macro-moment equations, Recovery of particle size distribution function, Steady state MSMPR crystalliser, Significance of distribution representation, Exponential distribution, Mass Balance, Dynamic population balance, CSD transients, Transient moment equations, Transient size distribution by method of characteristics, Stability of CSD, Crystallisation kinetics, Nucleation, Crystal growth, Comminuton Processes, Microbial population, Residence-time distribution, Dispersed-phase mixing.

CHL813 Thermodynamics and Process Design
3 credits (2-0-2)
Pre-requisites: CHL121 and EC120
Thermophysical properties of pure fluids, Equilibrium properties such as vapour pressure, latent heats, critical constants and PVT behaviour, Transport properties such as viscosity, thermal conductivity and diffusivity, estimation and correlation methods, Properties of multicomponent systems, V-L-E using equations of state and group contribution methods, L-L-E correlation and prediction, Homogeneous and heterogeneous chemical equilibria with competing chemical reactions.

CHL830 Advanced Computational Techniques in Chemical Engineering
3 credits (2-0-2)
Pre-requisites: CHL711
Introduction, Review of fundamental conservation equations for momentum, heat and mass transport. Formulation of problems in steady state. Weighted residual methods: orthogonal collocation, Galerkin finite element, Fourier collocation. Application to reaction-diffusion in porous catalysts pellets. The non-isothermal situation. Calculation of effectiveness factor. Application in micro-fluid mechanics-particle capture efficiency in suspension flows. Moving boundary problems. Transient problems leading to PDEs. Examples in heat and mass transfer and their numerical solution. The MonteCarlo method and its diverse applications. Computational laboratory exercises.

CHD851 Major Project Part 1 (CC)
6 credits (0-0-12)
Pre-requisites: EC 165
Overlaps with: CHD853
Formulation of the problem; Literature search; Design of the experimental setup and study of experimental techniques in the case of experimental projects; Formulation of design equations in development of solution techniques and familiarization with relevant software in the case of design or theoretical projects.

CHD852 Major Project Part 2 (CC)
14 credits (0-0-28)
Pre-requisites: CHD851
Overlaps with: CHD854
Theoretical or design projects: To arrive at a complete design of a chemical plant in particular give complete design detail of major process equipment or to develop computer simulation models for industrial processes at macro or micro level.

Experimental Projects: Collect and data and model the experimental work.

CHD853 Major Project Part 1 (CC)
4 credits (0-0-8)
Pre-requisites: EC 165
Overlaps with: CHD851
Formulation of the problem Literature search; Design of the experimental setup and study of experimental techniques in the case of experimental projects; Formulation of design equations in development of solution techniques and familiarization with relevant software in the case of design or theoretical projects.

CHD854 Major Project Part 2 (CC)
16 credits (0-0-32)
Pre-requisites: CHD853
Overlaps with: CHD852
Theoretical or design projects: To arrive at a complete design of a chemical plant in particular give complete design detail of major process equipment or to develop computer simulation models for industrial processes at macro or micro level.

Experimental Projects: Collect and data and model the experimental work.

CHD861 Major Project Part 1 (CP)
6 credits (0-0-12)
Pre-requisites: EC 165
Overlaps with: CHD863
Formulation of the problem; Literature search; Design of the experimental setup and study of experimental techniques in the case of experimental projects; Formulation of design equations in development of solution techniques and familiarization with relevant software in the case of design or theoretical projects.

CHD862 Major Project Part 2 (CP)
14 credits (0-0-28)
Pre-requisites: CHD861
Overlaps with: CHD864
Theoretical or design projects: To arrive at a complete design of a chemical plant in particular give complete design detail of major process equipment or to develop computer simulation models for industrial processes at macro or micro level.

Experimental Projects: Collect and data and model the experimental work.

CHD863 Major Project Part 1 (CP)
4 credits (0-0-8)
Pre-requisites: EC 165
Overlaps with: CHD861
Formulation of the problem; Literature search; Design of the experimental setup and study of experimental techniques in the case of experimental projects; Formulation of design equations in development of solution techniques and familiarization with relevant software in the case of design or theoretical projects.

CHD864 Major Project Part 2 (CP)
16 credits (0-0-32)
Pre-requisites: CHD863
Overlaps with: CHD862
Theoretical or design projects: To arrive at a complete design of a chemical plant in particular give complete design detail of major process equipment or to develop computer simulation models for industrial processes at macro or micro level.

Experimental Projects: Collect and data and model the experimental work.

CHL864 Applications of AI and ANN in Chemical Engineering
4 credits (3-0-2)
Pre-requisites: EEL758
AI and Chemical Engineering, Expert System and Chemical Engineering-CONPHYDE and OPS5, KBS for Process Synthesis and Design, Design problem solving (Exsep), Product design methodologies – polymeric composites, molecules, developing design support environment, Process plant diagnosis and safety analysis (Falcon), Expert system tools and shells for Chemical Engineering – critical evaluation of KBES tools such as KEE, ART, INSIGHT2 +, NEXPERT, etc. from the perspective of Chemical Engineers.

CHL869 Applications of Computational Fluid Dynamics
3 credits (2-0-2)
Pre-requisites: CHL768
Brief review of CFD for single phase flows; Solution of scalar equations – heat and mass transfer; Application to heat exchanger and stirred tank flows; CFD for multiphase systems – Lagrange-Euler and Euler – Euler approaches; Multiphase models – granular kinetic theory; Reaction modeling; Volume of Fluid (VOF) method for two-phase flow with interfaces; Current status of multiphase flow simulation in various chemical process equipment—bubble column, phase separator, packed bed, fluidized bed, polymerization reactor, cyclones etc.

CHD895 Major Project (M.S. Research-CH)
40 credits (0-0-80)

Department of Chemistry

CYP100 Chemistry Laboratory
2 credits (0-0-4)
An integrated laboratory course consisting of 12-14 experiments from physical, inorganic and organic chemistry. The course exposes the student to inorganic and organic synthesis as well as basic quantitative and qualitative analysis and is designed to illustrate the underlying principles of chemical and electro-analytical techniques, dynamics and chemical transformations.

CYL110 Physical Chemistry: Concepts and Applications
4 credits (3-1-0)
(i) Chemical thermodynamics – Free energy and entropy changes in chemical processes, Phase rule and phase equilibria, Equilibrium electrochemistry. (ii) Quantum mechanical principles of structure and bonding in molecules and thermodynamic connection. (iii) Chemical dynamics – Reaction rates, Homogeneous and heterogeneous catalysis.

CYL120 Inorganic and Organic Chemistry: Concepts and Applications
4 credits (3-1-0)
Inorganic Chemistry:

(i) Transition metal complexes: Crystal field theory, basic concepts, crystal field effects in linear (ML2), tetrahedral, square planar (ML4) and octahedral geometry (ML6), pairing energies, weak field and strong field case, crystal field stabilization energy, factors affecting magnitude of 10Dq, high and low spin complexes, evidences for crystal field stabilization, tetragonal distortions from octahedral geometry, electronic spectra and magnetism.

(ii) Organometallics: EAN rule, metal carbonyls – synthesis, bonding and structure, metallocenes – synthesis and properties, Homogeneous and heterogeneous catalysis.

(iii) Bioinorganic chemistry: Metalloporphyrins, metalloproteins, hemoglobin and myoglobin – structure and function.

(iv) Inorganic solids: Structures and applications. Layered solids, Zeolites, magnetic and electronic properties of inorganic solids.

Organic Chemistry:

(i) Structure and Stereoisomerism: Conjugation and aromaticity, stereoisomerism, structural representation of stereoisomers, IUPAC conventions for optical and geometrical isomers. Conformations and conformational analysis - linear and cyclic compounds. Resolution of racemates - chemical and enzymatic methods.

(ii) Reactivity of molecules: Acids and bases. Factors influencing their relative strengths. Free energy criteria for reactivity. Kinetic and thermodynamic criteria for chemical reactions. Hammond's postulate and reaction coordinate - potential energy profiles. Kinetic vs. thermodynamic control of reactions. Determination of reaction mechanisms.

(iii) Applications: Formation, stability and aplication of reactive intermediates. Use of reactive intermediates in the design of synthesis of simple organic compounds.

CYL210 Applied Chemistry: Chemistry at Interfaces
6 credits (3-1-3)
Pre-requisites: CYP100 & CYL120
Unit processes in organic synthesis. Laboratory vs. industrial synthesis. Role of medium in directing synthetic outcomes, organised media. Natural and synthetic constrained systems (inorganic and organic) for control of reactivity in organic reactions. Phase transfer catalysis, polymer and other supported reagents for control of reactions. Green chemistry. Heterogeneous and homogeneous catalysis, surface chemistry, kinetics of catalysed reactions. Industrial catalysts.

CYL230 Polymer Chemistry
3 credits (2-1-0)
Pre-requisites: CYL120
Classification of polymers, Molecular weights, Chemical structure and morphology, Kinetics and mechanism of chain growth and step growth polymerisation. Fibre forming polymers. Epoxy and Phenolic Resins. Copolymerization, techniques of polymerization. Stereoregular polymerization.

CYL250 Special Topics in Organic Chemistry
4 credits (3-1-0)
Pre-requisites: CYL120
Structure - activity relationships in simple organic molecules. Strategies for carbon-carbon bond formation. Dienes, Polyenes and Pericyclic reactivity. Free radical reactions. Heterocyclic chemistry, Organometallic chemistry, Natural Product chemistry: Carbohydrates, Nucleic Acids, Lipids, Aminoacids and Proteins.

CYL330 Chemistry of High Temperature Materials
4 credits (3-1-0)
Pre-requisites: CYL120 and EC 60
Synthesis of molecular, non-molecular and composite materials. Physico-chemical characterization of materials; structure-property relationship among materials; Application in refractory catalysis, sensors, semiconductors and superconductors.

CYL340 Supramolecular Chemistry
4 credits (3-1-0)
Pre-requisites: CYL120 and EC 60
Chemistry beyond the molecule. Supramolecular, chemical and biochemical recognition, biomodels, molecular organization and aggregation, organized media and its use in developing new technologies. Host guest chemistry with cations and anions, clatherates, liquid crystals, use of weak interaction-weak bonds for obtaining new materials and morelcular catalysis, membrane mimetic chemistry and technologies, purpose linked molecular design and devices.

CYL410 Computational Methods and Analysis
3 credits (3-0-0)
Pre-requisites: CYL110 and EC 90
Structure, dynamics and equilibrium; Monte Carlo method, Brownian dynamics and molecular dynamics. Simple and associated liquids, aqueous solutions, colloids and simple polymers. Electronic Structure Calculations; Matrix methods for many particle Schrodinger equation, combining molecular dynamics methods with electronic structure calculations and quantum Monte Carlo etc. The systems to be considered as molecules, metals and semiconductors. Special methods for macromolecular systems; Energy minimization in multi-dimensions, visualization (exploration of steric and electrostatic complementarities) on systems such as biomolecules (protein and nucleic acids), Complex polymers. Zeolites. Implementation of all the above methods on computers.

Solved: Titrimetry, Surface tension and viscosity, Potentiometry, Conductometry, Preparations of metal complexes, Kinetic experiments, Thermo-chemical measurements, Quantitative estimation of organic compounds.

CYL501 Molecular Thermodynamics
3 credits (3-0-0)
Review of first, second and third laws of thermodynamics. Chemical equilibria. Ideal and non-ideal solutions. Electrolyte solutions. Equilibrium electrochemistry. Postulates of statistical thermodynamics, ensembles, monoatomic and polyatomic ideal gases, molar heat capacities. Classical statistical mechanics.

CYP501 Physical Chemistry Laboratory I
2 credits (0-0-4)
Experiments highlighting the principles of thermodynamics, chemical equilibrium, and electrochemistry are included in this course. Examples include thermodynamics of micellization, synthesis, stablization and spectroscopy of nanoparticles, photofluorometry, electrolyte solutions, thermodynamics of cell reaction etc.

CYL502 Stereochemistry and Organic Reaction Mechanism

3 credits (3-0-0)

Stereochemistry of acyclic and cyclic compounds including chiral molecules without a chiral centre. Reaction mechanisms (polar and free radical) with stereochemical considerations. Reactive intermediates: generation, structure and reactivity.

CYP502 Organic Chemistry Laboratory I

2 credits (0-0-4)

Experiments involving basic techniques in organic chemistry will be introduced.

CYL503 Main Group Chemistry and Inorganic Solids

3 credits (3-0-0)

Molecular symmetry. Point groups. Crystal symmetry. Space groups. Solid state structures. Bonding in solids. Rings, cages and clusters of main group elements. Synthesis, properties and structure of boranes, carboranes, borazines, silicates, zeolites, phosphazenes. Iso and hetero polyanions. Zintl phases. Bio-inorganic chemistry of main group elements.

CYP503 Inorganic Chemistry Laboratory I

2 credits (0-0-4)

The laboratory course teaches experimental techniques in synthesis and charaterization of metal complexes.

CYL504 Biochemistry I

3 credits (3-0-0)

Cell evolution. Structure and function of proteins, carbohydrates, nucleic acids and lipids. Biological membranes. Enzymes: kinetics, control and applications.

CYP504 Biochemistry Laboratory I

2 credits (0-0-4)

Quantitative and qualitative estimation/tests of biomolecules. Enzyme assay and studies of their properties.

CYL505 Instrumental Methods of Analysis

3 credits (3-0-0)

UV, visible spectroscopy. IR spectrometry. Atomic absorption and emission spectrometry. Fluorescence and phosphorescence based methods. Chromatographic methods of separation. Gas chromatography. HPLC. Potentiometric methods. ISE. Thermal analysis and voltammetric methods of analysis. Data evaluation.

CYL561 Quantum Chemistry

3 credits (3-0-0)

Basic concepts and postulates of quantum mechanics. Hydrogen atom. Quantization of angular momentum. Many electron atoms. Variation theorem. Perturbation theory. Molecular orbital and valence bond theories. Introductory treatment of semi-empirical and ab initio calculations on molecular systems.

CYP561 Physical Chemistry Laboratory II

2 credits (0-0-4)

Experiments are primarily concerned with chemical kinetics and computer simulations. Students are exposed to various classical and modern methods for following the kinetics of chemical reactions. Computer simulation methods as applied to chemistry are introduced.

CYL562 Organic Synthesis

3 credits (3-0-0)

Formation of carbon-carbon bonds including organometallic reactions. Synthetic applications of organoboranes and organosilanes. Reactions at unactivated C-H bonds. Oxidations. Reductions. Newer Reagents. Design of organic synthesis. Retrosynthetic analysis. Selectivity in organic synthesis. Protection and deprotection of functional groups. Multistep synthesis of some representative molecules.

CYP562 Organic Chemistry Laboratory II

2 credits (0-0-4)

Synthesis and characterization of organic molecules will be given in this course.

CYL563 Transition and Inner-transition Metal Chemistry

3 credits (3-0-0)

Bonding in metal complexes (ligand field and molecular orbital theories). Magnetic and spectral characteristics of transition metal and inner transition metal ions and complexes. Substitution, electron transfer and photochemical reactions of transition metal complexes. Metal-metal bonded clusters. Use of lanthanide compounds as shift reagents. Bio-inorganic chemistry of iron, cobalt and copper.

CYP563 Inorganic Chemistry Laboratory II

2 credits (0-0-4)

Developing experimental skills in inorganic chemistry applied to organometallics and bioinorganic chemistry.

CYL564 Biochemistry II

3 credits (3-0-0)

Metabolism: basic concepts and design. Bioenergetics. Biosynthesis and degradation of carbohydrates (including photosynthesis). Lipids and amino acids.

CYP564 Biochemistry Laboratory II

2 credits (0-0-4)

Enzyme characterization and applications; DNA & RNA isolation.

CYL565 Chemical Dynamics and Surface Chemistry

3 credits (3-0-0)

Reaction kinetics and molecular reaction dynamics. Experimental techniques for fast reactions. Femto chemistry. Surface phenomena. Homogeneous and heterogeneous catalysis. Physical methods for studying surfaces.

CYL566 Physical Methods of Structure Determination of Organic Compounds

3 credits (3-0-0)

Applications of UV, IR, NMR and mass spectral methods in structure determination of organic compounds.

CYL601 Group Theory & Spectroscopy

3 credits (3-0-0)

Symmetry operations. Review of point and space groups. Applications of group theoretical techniques in spectroscopy. Chemical bonding. Crystallography. Theoretical treatment of rotational, vibrational and electronic spectroscopy. Magnetic spectroscopy.

CYL602 Pericyclic Reactions and Photochemistry

3 credits (3-0-0)

Theory of pericyclic reactions - correlation diagrams. FMO and PMO methods. Cycloadditions. Molecular rearrangements (pericyclic and non-pericyclic). Photochemistry - basics and mechanistic principles. Reactivity of simple chromophores.

CYL603 Basic Organometallic Chemistry

3 credits (3-0-0)

Organometallc compounds of main group, transition and inner transition elements. Synthesis, structure and bonding in metal carbonyls, nitrosyls and alkyls, allyls and cyclopentadienyl derivatives. Organometallic clusters. Homogeneous catalysis (hydrogenation and hydroformylation) by organometallic species.

CYL604 Biochemistry III

3 credits (3-0-0)

Replication, transcription and recombination of DNA. Protein synthesis and processing. Gene expression and control. Molecular immunology. Microbial growth. Molecular cloning.

Departmental Electives [*Any four to be selected*: Two in III semester and two in IV semester]

CYL665 Solid State Chemistry

3 credits (3-0-0)

Solid state chemistry is a subject that is very relevant to modern technology from solid catalysts to superconducting magnets. The course is aimed at giving an overview of modern developments in solid state chemistry.

Contents: Crystal chemistry (8 lectures); bonding in solids (3 lectures); defects and non stoichiometry (3 lectures); X-ray diffraction of solids (6 lectures); synthesis of solids (5 lectures); electronic and magnetic properties of solids (5 lectures); superconductivity (2 lectures); optical properties (3 lectures); luminescence and lasers (1 lecture); recent trends in solid state chemistry(6 *lectures)*

CYL666 Chemistry of Macromolecules
3 credits (3-0-0)
Polymers from a large class of materials that have varied applications. This course provides insight into the physical chemistry of polymers.

Contents: Kinetics of condensation, free radical, and ionic polymerization (15 lectures); molecular weight determination (8 lectures), thermodynamics of polymer solutions (7 lectures), characterization of polymers by spectroscopic and thermal techniques (12 lectures).

CYL667 Selected Topics in Spectroscopy
3 credits (3-0-0)
Franck-Condon principle. Fermi Golden rule. Normal mode analysis. Multiphoton spectroscopy. Molecular beam techniques. Nonlinear laser spectroscopy. Two-level systems. Precession. Rabi frequency, nutation, Block equations. Multidimensional NMR techniques.

CYL668 Statistical Mechanics & Molecular Simulation Methods
3 credits (3-0-0)
Theory of ensembles. Classical fluids. Phase transitions and relaxation phenomena. Monte Carlo, molecular dynamics and Brownian dynamics computer simulations. Elucidation of structural dynamic and thermodynamic properties of chemical and biological systems.

CYL669 Biophysical Chemistry I
3 credits (3-0-0)
Structure and conformation of proteins, nucleic acids and other biological polymers. Techniques for the study of biological structure and function. Configurational statistics and conformational transitions. Thermodynamics and kinetics of ligand interactions. Regulation of biological activity. Bioinformatics: Genomics and proteomics.

CYL675 Chemistry of Heterocyclic Compounds
3 credits (3-0-0)
Chemistry of heterocyclic compounds containing one, two and three heteroatoms. Total synthesis of representative natural products.

CYL676 Bio-Organic and Medicinal Chemistry
3 credits (3-0-0)
Bio-Organic: *Amino acids, Polypeptides and enzyme models. Medicinal*: Deifinitions, Classifications. Pharmaceutical, pharmacokinetic and pharmacodynamic phases. Drug-receptor interactions. Intra- and intermolecular forces. Solvent effects. Ligand binding. Docking and design. Drug metabolism.

CY L677 Supramolecular Chemistry
3 credits (3-0-0)
Non-covalent associations. Molecular recognition. Molecular hosts: crown compound, cyclophanes, cyclodextrins etc., design and applications. Nano technology. Molecular clefts, molecular tweezers, molecular devices. Self assembly. Self replication.

CYL678 Recent Trends in Organic Chemistry
3 credits (3-0-0)
Recent advances in Organic Synthesis, spectroscopy and reaction mechanisms.

CYL685 Applied Organometallic Chemistry
3 credits (3-0-0)
Pi-ligand systems. Organometallics containing M=C:M=C bond and hybrids as ligands. Reactions at metal and organic ligands. Catalytic applications of organometallics: Wacker-Smidt synthesis, Monsanto acetic acid process, Zeigler-Natta polymerization of alkenes, Enantioselective functional group interconversions. Organometallics as protecting and activating groups in organic synthesis. Insertion at   M-

C bonds. Transmetallation and cyclization reaction of organometallics. Bioorganometallic chemistry and surface organometallic chemistry.

CYL686 Inorganic Polymers
3 credits (3-0-0)
Homo and heterocatenated inorganic polymers. Polyphosphazenes: synthetic routes and bonding features, polymerization of organo/organometallic substituted phosphazenes and their applications. Polysilanes: sigma bond delocalization in polysilanes and its implications, synthesis and characterization of polysilanes. Polysiloxanes: synthetic routes via anionic and cationic polymerization, properties and environmental aspects. Dendritic macromolecules based on inorganic elements. Coordination polymers.

CYL687 Bio-Inorganic Chemistry
3 credits (3-0-0)
Introduction of bio-inorganic chemistry. General properties of biological molecules. Physical methods in bio-inorganic chemistry. Binding of metal ions and complexes to biomolecule- active centres: synthesis and reactivity of the active sites. Atom and group transfer chemistry. Electron transfer in proteins. Frontiers of bio-inorganic chemistry: some topics of current research interest.

CYL688 Physical Methods in Inorganic Chemistry
3 credits (3-0-0)
Spectroscopic methods in inorganic chemistry: Multinuclear NMR (^{31}P, ^{119}Sn &^{195}Pt), EPR and Mossbauer specstrpscopy; X-ray diffraction methods (powder and single crystal), Finger printing of solids from powder data and determination of crystal structures by Rietveld analysis and single crystal studies. Electrochemical methods (cyclic voltammetry; differential pulse voltammetry, coulometry).

CYL695 Applied Biocatalysis
3 credits (3-0-0)
Introduction to enzymes. Transition states and enzyme catalysis. Bioseparation. Applications of enzymes as therapeutic agents and analytical reagents, biosensors, enzymatic degumming of edible oils. Use of enzymes in animal feed. Enzymes in chemical biotransformations. Pre-steady state and steady state kinetics. Kinetics in industrial processs. Enzymes structure determination. Enzyme stability and stabilization. Protein modification and bio-conjugation chemistry. Toxicological considerations and safety in handling enzymes. Catalytic antibodies and ribozymes. Enzyme immobilization and concept of protein and enzyme engineering.

CYL696 Nonaqueous Enzymology
3 credits (3-0-0)
Advantages associated with the use of enzymes in organic solvents. Hydration induced conformational flexibility and protein dynamics. Kinetics of enzymatic reactions in organic solvents. Enhanced thermal stability. Inactivation mechanisms. pH memory. Medium engineering. Biocatalyst engineering. Protein imprinting. Enzymes in reverse micelles. Applications and use of enzymes in non-aqueous media.

CYL697 Selected Topics in Biochemistry
3 credits (3-0-0)
Protein folding. Making machines out of proteins. Birth assembly and death of proteins. Protein stability. Evolution of new proteins/enzymes. Cellular basis of immunity. Structure and function of antibodies. Generation of antibody diversity. T cell receptors and MHC molecules. Cancer as a microevolutionary process. Tools and techniques in biochemistry including microbial biochemistry, recombinant techniques; immunological techniques; spectroscopic techniques like fluorescence and NMR; Recent applications.

CYL701 Electroanalytical Chemistry
5 credits (3-0-4)
Principles of electro-chemical methods, electrochemical reactions, electroanalytical voltammetry as applied to analysis and the chemistry of heterogeneous electron transfers, electrochemical instrumentation.

CYL702 Chemical Separations

5 credits (3-0-4)

Theory and applications of equilibrium and nonequilibrium separation techniques. Extraction, countercurrent distribution, gas chromatography, column and plane chromatographic techniques, electr-ophoresis, ultra-centrifugation, and other separation methods.

CYL703 Spectrochemical Methods

5 credits (3-0-4)

Principles of atomic and molecular spectrometric methods especially UV-visible, IR, fluorescence, AAS, AES, CD, and ORD; discussion of instrumentation, methodology, applications.

CYL704 Chemical Computations

3 credits (2-0-2)

Introduction to programming; solution of numerical problems in equilibrium, kinetics, and spectroscopy; overview of molecular modelling, molecular simulations, molecular design, and bioinformatics; use of spectroscopic and structural databases.

CYL705 Environmental Analytical Chemistry

3 credits (3-0-0)

Introduction to environmental analysis; Sampling methods; Environmental pollution from industrial effluents, radiochemical waste, nuclear waste, trace elements; Water and waste water analysis; Measurement, detection and monitoring of radiation; Air pollution and monitoring.

CYL707 Electronics and Chemical Instrumentation

3 credits (3-0-0)

Models of electronic systems, frequency response of inactive networks, amplification and amplifier feedback, signal processing, fundamental measuring operation, analog instrument design, digital instruments.

CYL711 X-ray and Electron Microscopic Methods

3 credits (3-0-0)

X-ray diffraction techniques of powders and single crystals; X-ray emission, absorption, fluorescence spectroscopy; Electron Microscopy (SEM, TEM).

CYL712 Characterization of Surfaces

3 credits (3-0-0)

Introduction to Surfaces, UHV Instrumentation, Photoelectron Spectroscopy: UV, XPS, Auger; Secondary Ion Mass Spectrometry, Scanning Probe Microscopies (STM, AFM), Vibrational Spectroscopies (Raman, IR, SFG); Mossbauer spectroscopy.

CYL713 Characterization of Polymers

3 credits(3-0-0)

Introduction to polymers; molecular weight and molecular size determination; thermoanalytical methods of characterization including TGA, DTA, and DSC; spectroscopy (IR, NMR, UV-visible) of polymers.

CYL714 NMR and Mass Spectrometric Methods

3 credits (3-0-0)

Modern NMR and mass spectrometry including fundamentals, instrumentation, and analytical applications.

CYL715 Bioanalytical Chemistry

3 credits (3-0-0)

Modern analytical and separation techniques used in biochemical analysis; free and immobilized proteins, dry enzyme chemistry, enzyme electrodes, immunochemical analysis, protein sequencing, nucleic acid sequencing, DNA fingerprinting.

CYL716 Data Analysis, Experimental Design, and Chemometrics

3 credits (3-0-0)

Error propagation, Descriptive statistics, introduction to regression, factor and principal component analysis, simplex and factorial experimental design, optimization, fourier transform.

CYL717 Principles of Chemical and Biosensors

3 credits (3-0-0)

General principles of molecular recognition, thermal, mass, electrochemical (potentiometric, amperometric, chemiresistors, micro-electrodes), optical sensors.

CYL718 On-line Methods of Chemical Analysis

3 credits (3-0-0)

Introduction to batch and continuous processes; Material and energy balance; Unit operations and unit processes; dynamics of unit operations and instruments; measurement and recording of pressure, temperature, concentration, flow rates, conductivity, and pH in processes, automatic and feedback control, Industrial research problems.

CYL721 Design, Synthesis and Characterization of Organic Molecules

3 credits (3-0-0)

Selectivity in organic synthesis: chemo-, regio-, stereo- and enantioselective reactions. Target oriented synthesis: Designing organic synthesis, Retrosynthetic analysis, disconnection approach, linear and convergent synthesis. Diversity-oriented synthesis: concept of forward-synthetic analysis, appendage diversity, skeletal diversity, stereochemical diversity, complexity and diversity. Combinatorial synthesis. Asymmetric synthesis: use of chiral catalysts and chiron approach. Green Synthesis. Concept of anionic, cationic, radical and metathetical polymerization. Industrial applications of polymers.

CYP722 Laboratory on Design, Synthesis and Characterization of Organic Molecules

3 credits (0-0-6)

Single and double stage preparation of organic compounds, experiments involving the concepts of protecting groups and selectivity in organic synthesis, purification of organic compounds using column chromatography and their identification by thin layer chromatography. Synthesis of some polymers of industrial importance. Characterization of synthesized organic compounds and polymers using IR, UV and NMR, and mass spectroscopic techniques.

CYL723 Principles and Practice of Optical and NMR Spectroscopy

3 credits (3-0-0)

Fundamentals of FT NMR spectroscopy, relation between structure and NMR properties, one-dimensional spectroscopy (1H, 13C, DEPT, steady state NOE, saturation transfer) and an introduction to two-dimensional NMR (COSY, NOESY, and HSQC) and their use in structure elucidation. Principles and analytical applications of optical spectroscopic methods including atomic absorption and emission, UV-Visible, IR absorption, scattering, and luminescence.

CYL725 Molecules to Materials

3 credits (3-0-0)

Principles of self assembly, overview of intermolecular interactions, kinetics and thermodynamics of self assembly, organic-inorganic self assembly, biological self assembly, mesoscale self assembly, molecular assembly for selected applications.

CYL726 Cheminformatics and Molecular Modeling

3 credits (3-0-0)

Chemistry & Information Technology, Data collation, Retrieval, Analysis & Interpretation, Applications in bibliographic, molecule and structure searches. Statistical methods for analyzing structure function /activity relationships, 2D, 3D-QSAR methods, Applications in design of synthetic polymers, pigments, pesticides, herbicides, materials, biomimetics and lead molecules. Building molecules, geometry optimization, conformation searching, Molecular mechanics, simulations, docking, scoring and discussion of modelling software & hardware. Preliminary Description of Error Analysis, How to Report and Use Uncertainties, Propagation of Uncertainties, Statistical Analysis of Random Uncertainties, The Normal Distribution, Rejection of Data, Weighted Averages, Least-Squares Fitting, Covariance and Correlation.

CYL727 Inorganic Synthesis and Analysis
3 credits (3-0-0)

Modern methods applied in inorganic and organometallic synthesis. Handling of air and moisture sensitive compounds, drybox, glove bag, schlenk line and vacuum line techniques. Methods of purification and drying of blanket gases and preparation, purification and handling of reactive industrial gases such as HCl, SO_2, acetylene, O_2, Cl_2, F_2 etc. Purification and storage methods for oxygen and moisture free solvents. Methods of purification and crystallization of solids for X ray analysis. General strategies, brief outline of theory and methodology used for synthesis of main group compounds, transition metal complexes, organometallic compounds, inorganic materials and macromolecules. A few examples of detailed specific synthesis in each type of compounds with justification of the methodology adopted. Characterization methods adopted for main group compounds, metal complexes, organometallic compounds, inorganic materials and macromolecules. Multinuclear NMR methods, Mass spectroscopic methods used in Inorganic chemistry, Determination of magnetic properties, Application of electro analytical tools in characterization of transition metal based compounds. Principles and methodology of elemental analysis, powder and single crystal X ray diffractometer.

CYP728 Inorganic Synthesis and Analysis Laboratory
2 credits (0-0-4)

Experiments based on the synthesis of complexes, organometallic compounds and inorganic materials. Characterization of the synthesized compounds with an emphasis on instrumental methods of analysis (emphasis on electrochemical, spectroscopic, and diffraction methods).

CYL729 Materials Characterization: Diffraction, Microscopy, and Thermal Analysis
3 credits (3-0-0)

Basic concepts of diffraction techniques (powder and single crystal) in elucidating the crystal structures of inorganic, organic and hybrid materials. Use of computer techniques, including molecular graphics for studying structural problems, data collection and data analysis. Analysis and creation of interactive databases bases for finding structural correlation. Applications of electron microscopic techniques (scanning and transmission) for morphological and nanostructural features. Thermal analysis (TGA, TMA, DTA & DSC) for correlating the structural information accompanied by dehydration, decomposition and phase transformation. Emphasis will be placed on hands-on application of X-ray crystallography, electron microscopy and thermal techniques for industrially important materials and the interpretation and evaluation of results obtained by structure determinations.

CYL731 Analytical Separations
3 credits (3-0-0)

Theory and applications of equilibrium and nonequilibrium separation techniques. Extraction, countercurrent distribution, gas chromatography, column and plane chromatographic techniques, electrophoresis, ultra-centrifugation, and other separation methods.

CYL732 Electroanalytical Chemistry
3 credits (3-0-0)

Principles of electro-chemical methods, electrochemical reactions, steady state and potential step techniques; polarography, cyclic voltammetry, chrono methods, rotating disc and ring disc electrodes, concepts and applications of AC impedance techniques.

CYL733 Chemistry of Industrial Catalysts
3 credits (3-0-0)

Fundamental aspects of Catalysis - Homogeneous & heterogeneous catalysis -The role of catalytic processes in modern chemical manufacturing -organometallic catalysts -catalysis in organic polymer chemistry -catalysis in petroleum industry - catalysis in environmental control.

CYL734 Chemistry of Nanostructured Materials
3 credits (3-0-0)

Introduction; fundamentals of colloidal chemistry; Synthesis, preparation and fabrication: chemical routes, self assembly methods, biomimetic and electrochemical approaches; Size controls properties (optical, electronic and magnetic properties of materials) - Applications (carbon nanotubes and nanoporous zeolites; Quantum Dots, basic ideas of nanodevices).

CYT735 Industrial Training
4 credits (0-0-8)

CYD799 Minor Project
3 credits (0-0-6)

CYS801 Independent Study
4 credits (0-4-0)

CYD801 Major Project I
6 credits (0-0-12)

CYD802 Major Project II
12 credits (0-0-24)

CYD803 Major Project I
4 credits (0-0-8)

CYD804 Major Project II
14 credits (0-0-28)

CYP803 Glass Blowing
1 credit (0-0-2)

Experiments in glass blowing using burner, hand torch and lathe.

CYC805 Seminar
2 credits (0-2-0)

Department of Civil Engineering

CEL100 Earth and Earth Processes

3 credits (3-0-0)

Environmental crisis, Earth as a closed system, Limitations of earth resources. Earth resources: Geologic Cycle, Minerals, Rocks, Soils, Water, Wind and Ice. Hazardous processes and mitigation: River flooding and fluvial processes, Volcanic activity, Earthquakes and related phenomena including seismic microzonation, Mass movements and land slides, Marine activity and coastal erosion. Soil resources: Problematic soils, Regional distribution, Erosion, Contamination of soils and ground water and remediation, Land reclamation. Rock-masses and stability: In-situ stresses, Discontinuities, Weathering, Tunnel collapses and Rock bursts. Mining and impact: Blasting, Subsidence, Mine fills and wastes. Waste disposal: Nuclear waste repositories. Land evaluation.

CEL110 Basic Concepts in Sustainable Development

4 credits (3-1-0)

Introduction; Basic characteristics of pollution and receiving environment; Concepts in sustainability; Contaminants and fate of contaminants; Noise Pollution, Sustainability and Bioenvironment, ISO 14000 Series.

CEN110 Introduction to Civil Engineering

2 credits (0-0-4)

Introductory lectures, demonstrations, field visits on activities of department and the Civil Engineering Profession.

CEL120 Pollution Prevention and Control

3 credits (3-0-0)

Legislative Framework for Environmental Management; Introduction to pollution: Sources, types, characteristics and impacts. Prevention versus control of pollution: Environmentally sound technology management; Tools for clean production: reuse, recycle, recovery, source reduction, raw material substitution, toxic use reduction and process modifications. Voluntary environmental programs: life cycle analysis; environmental cost accounting; use of a business-friendly, prevention-based approach; and the measurement of environmental performance, EIA.

Urbanization and Sustainability, Environmental consequences of personal choices and examples of social marketing of more environmentally responsible consumption; Public Participation: Structure, Processes and Trends; Conflict Resolution.

CEL140 Environmental Studies

3 credits (3-0-0)

Energy & Environment – basic concepts of energy resources, fossil fuel, geothermal, tidal, nuclear, solar, wind, hydropower & biomas.

Ecology & Ecosystem Dynamics- ecosystem divercity, habitat classification. Type of ecosystems- wetlands, marshlands, swamps, lakes forest ecosystems- Tropical, Himalaya, sub-Himalaya deserts, shelf ecosystem.

Pollutant Sources and Control- air, water, solid waste and noise pollution and their control measures.

Cleaner Production and Life Cycle Analysis- reuse/recycle/recovery/ source reduction/raw material substitution. Basics of EIA and environmental audits, public participation in environmental decision making. LCA methodology, steps and tools. ISO 14000: new business paradigms: eco-industrial parks and eco labels. Emerging technologies for sustainable environmental management, Identification and evaluation of emerging environmental issues in air, water, wastewater and solid waste.

Environment, Development and Society-comparative approaches to natural resource management: indigenous system of natural resource management-land, water, forest, air etc: environmental ethics. Urbanization and Sustainability, Environmentally responsible consumption. Environmental psychology, Environmental perceptions and attitudes, Coping with environmental stress in built environment.

CEP200 Design Concepts in Civil Engineering

2 credits (0-0-4)

Pre-requisites: CEN110

Design concepts in Structural Engineering, Design concepts in Water Resources Engineering, Design Concepts in Transportation Engineering, Design Concepts in Environmental Engineering, Design concepts in Geotechnical Engineering.

CEL212 Environmental Engineering

4 credits (3-0-2)

Pre-requisites: CEN110

Water supply: Sources, Water demand and forecasting. Quality of water, water borne diseases, standards, water quality index. Unit Processes: Systems and unit processes of water purification. Water distribution networks. Wastewater Engineering: Systems of sanitation, wastewater flows, Collection and conveyance of wastewater, layout systems. Characteristics and microbiology of wastewater. BOD kinetics. Disposal of treated wastewater on land and in water. Unit processes for wastewater treatment; Sludge management, introduction to solids and hazardous waste management, air and noise pollution and control.

CEL222 Engineering Geology and Soil Mechanics

5.5 credits (3-1-3)

Pre-requisites: AML110 & CEN110

Engineering Geology: Introduction; Dynamic Earth; Materials of Earth; Silicate Structures and Symmetry Elements; Formations of Rocks; Characterisation; Weathering Processes; Geological Work – Landforms; Formation of Soils; Geological Time Scale; Structural Features; Tectonics; Stress Distribution; Earthquakes; Geological Maps and Air Photos; Ground Water. Soil Mechanics: Origin and Classification of Soils; Phase Relationships; Effective Stress Principle; Effective Stress Under Hydrostatic and 1D flow; Permeability; Compressibilty; Consolidation; Terzaghi's 1D Consolidation Theory; Shear Strength; Drainage Conditions; Pore Water Pressure; Mohr's Circle; Failure Envelope and Strength Parameters; Factors Affecting Shear Strength; Laboratory: Geological Mapping – contouring, topo sheets, outcrops, apparent and true dips, three point problems, depth, thickness, joints, faults; Megascopic and Microscopic identification of Minerals and Rocks. Visual Soil Classification; Water Content; Atterberg Limits; Grain Size Analysis; Specific Gravity; Permeability; Introduction to consolidation and strength apparatus; Guided tour through representative geological formations and structures.

CEL231 Structural Analysis – I

5 credits (3-1-2)

Pre-requisites: AML110

Introduction to structures, loading and modeling. Internal forces in statically determinate structures – plane and space trusses, beams, frames, arches and cables. Deflection of statically determinate structures – moment area method, conjugate beam method, virtual work method. Static and Kinematic indeterminacy of structures. Force method of analysis of indeterminate structures including temperature changes and lack of fit. Analysis of rolling loads. Influence lines for statically determinate and indeterminate structures.

CEL232 Concrete Material and Design

6 credits (3-1-4)

Pre-requisites: AML110 / AML120

Chemistry: properties and types of cement; Properties of aggregates and fresh concrete; Concrete Mix Design; Properties of hardened concrete; Reinforcing steel. Design Philosophy: Working stress and limit state design concepts; Design of R.C. beam Sections in flexure, shear, torsion and bond; Design for serviceability; Design of R.C. beams; Design of one way and two way R.C. Slabs; Design of R.C. short and long columns; Design of R.C. footings.

CEL241 Transportation Engineering – I

4 credits (3-0-2)

Pre-requisites: CEN110

Transportation Systems and their classification and description. Role of Roads, Road Transport and Planning in India. Road User and the Vehicle. Geometric Design: Horizontal Alignment, Vertical Alignment, Cross-

section Elements. Highway Project Preparation: Surveys and Investigations. Pavements: Types of Pavements, Flexible and Rigid pavement Analysis and Design, Overlay Design. Road Construction Materials. Highway Maintenance. Traffic Engineering: Traffic Characteristics, Fundamental relationships, theories of traffic flow, shock waves, intersection design and traffic signs and signals - design, Highway Capacity.

CEL251 Hydrology and Hydraulics
6 credits (3-1-4)
Pre-requisites: CEN110 & AML110
Open Channel Flow: Channel Characteristics and parameters, Uniform flow, Critical flow, Specific Energy concepts, Gradually Varied Flows, Rapidly Varied flow with special reference to hydraulic jump.

Boundary Layer Theory:Navier Stokes Equation, Boundary Layer Equation in 2-dimensions, Boundary layer characteristics, Integral Momentum equation, onset of turbulence, properties of turbulent flow, skin friction, drag, lift and circulation. Pipe Flow: Laminar and Turbulent flow in Smooth and Rough pipes, pipe network analysis, Losses in pipes.

Hydrologic Cycle, Processes and Applied Methodologies: Rainfall, Evapotranspiration, Infiltration, Streamflow; Unit Hydrographs, Flood Routing and Frequency Analysis; Occurrence of Groundwater and Groundwater Flow.

CEL271 Elements of Surveying
3 credits (2-0-2)
Pre-requisites: CEN110
Introduction to Surveying, Instruments of Leveling, Theodolites and Plane-tables. Measurement of Distances, directions and elevations by different methods. Traversing. Vertical control, Precise levelling, Trigonometric levelling. Mapping of details and contouring. Measurement of areas, volumes. Application of above measurements in quantity computations. Errors of measurements and their adjustments. Curve setting: simple circular curves, compound and reverse curves. Introduction to GPS, Differential GPS.

CED310 Mini Project (CE)
3 credits (0-0-6)
Pre-requisites: EC 80
Design/fabrication/implementation work under the guidance of a faculty member. Prior to registration, a detailed plan of work should be submitted by the student to the Head of the Department for approval.

CEL311 Advanced Water and Wastewater Engineering
4 credits (3-0-2)
Pre-requisites: CEL212
Water purification: Theory, operation and design: Settling tanks, tube settlers, Coagulation and flocculation - Orthokinetic and Perikinetic, Slow and rapid sand filters. Methods, Theory and application of disinfection: chlorine, ozone, UV, Solar etc. Adsorption kinetics in water treatment. Design of water treatment plants; Wastewater characteristics, Wastewater Treatment: Theory, operation and design of aerobic (activated sludge and its variations, trickling filter, RBC and Oxidation ponds and ditches), anaerobic (anaerobic digestion, UASBR, anaerobic filter, lagoons); Secondary settling tanks. Tertiary wastewater treatment: Removal of N, P, K and other trace elements. Sludge treatment and disposal. Design of wastewater treatment plants. Advanced wastewater treatment systems: Root zone technology, wetlands, Duckweeds, Membrane processes (RO, Ultra and Nano filtration, Ion Exchange). Centralized vs decentralized systems, low cost water and wastewater systems. Disposal of treated wastewater: Inland surface water, land for irrigation, marine coastal areas.

CEL321 Geotechnical Engineering
5.5 credits (3-1-3)
Pre-requisites: CEL222
Soils of India; Engineering properties of Natural and Compacted Soils; Flow Through Soils – Laplace equation, flownets, seepage; Site Investigations; Foundations – types, selection, design considerations, bearing capacity and settlement of shallow foundations; deep

foundations; Slope Stability Analysis; Earth Dams – types and design aspects; Earth Pressures and Retaining Structures; Engineering Properties of Rocks; Rock as Construction Material; Geological Site Criteria for Tunnels and Underground Structures, Dams, Rock Slopes and Landslides.Laboratory: Compaction, consolidation, sample preparation, vane shear test, direct shear test, unconfined compression test, unconsolidated undrained test, consolidated drained test, consolidated undrained test with pore water pressure measurement, direct shear test, drilling and sampling, field density, engineering properties of rocks, refraction and resistivity methods.

CEL326 Geoenvironmental Engineering
3 credits (3-0-0)
Pre-requisites: EC 60
Sources of subsurface contamination and their effects; types of waste; integrated management of waste; transportation and disposal of solid waste on land; types of soils, permeability of soils, flow through soils, soil-waste interaction; ground water contamination; Waste containment principles; environmental control through liners, covers, leachate management and gas management; waste disposal in municipal solid waste landfills and in hazardous waste landfills; Waste disposal of coal-ash and mine tailings in ponds and mounds, of very hazardous waste in rocks in rocks; detection and monitoring of subsurface contamination; contaminated site characterization; control and remedial measures for contaminated sites; pollution control regulations.

CEL331 Structural Analysis – II
5 credits (3-1-2)
Pre-requisites: CEL231
Development of Slope-Deflection Equations of Equilibrium: Applications to Beams, frames undergoing user support settlement; Development of Moment Distribution Method; Distribution Factors; Application to Beams and Frames without side sway; Application to Frames with side sway; Beams and Frames with uneven loading; Support Settlement; Cases of Symmetry and anti symmetry; Strain energy method of analysis; Introduction to nature methods of analysis; Flexibility Method; Stiffness method; Direct Stiffness Methods for computer Application; Introduction to computer Software for Analysis.

CEL332 Design of Steel Structures
5 credits (3-1-2)
Pre-requisites: CEL231
Introduction to stability and buckling concepts; Structural steel and properties; Riveted, bolted and welded connections; Working stress and plastic design Methods; Design of tension, compression and flexural members (including built-up members); Column bases; Roof trusses.

CEL338 Infrastructure Planning and Management
3 credits (3-0-0)
Pre-requisites: EC 60
Overview of the course, Infrastructure's impact on development of a country, Status of various sectors in Indian Infrastructure, Infrastructure Financing, Private Sector participation in infrastructure models, Basics of infrastructure planning, Problems in Infrastructure Development and Management.

CEL339 Concrete Technology and Materials
3 credits (3-0-0)
Pre-requisites: EC 60
Cement Hydration: Cement Types, Paste Micro-structure; Workability; Durability; Factors affecting strength of concrete, Quality control; Concrete mix design; Types of concrete; Concrete production; Tests of concrete in structures; Failure criteria; Fracture mechanics; Hardening plasticity and fatigue; Creep and shrinkage; Fresh concrete modelling; Moisture/Ionic diffusion in concrete.

CEL341 Transportation Engineering – II
4 credits (3-1-0)
Pre-requisites: CEL241 and EC 60
Design of transportation facilities. (i) Rail Transport: location and route layout, section signals and intersections, earth work and pavement (track, stops, terminals, yard, parking etc.). (ii) Airports: Layout plan, terminal area, interconnection with other modes of transport, runways, circulation

patterns, traffic controllers. (iii) Ports and other transport technology: planning principles, operational requirements, Meglev, Hydrofoil, pipeline, etc. (iv) Transport Structure: FOBs, underground and multistoreyed parking, ramps, escalators, elevators, etc.

CEL351 Design of Hydraulic Structures
3 credits (2-0-2)
Pre-requisites: CEL251
Input studies, canal layout, regime canal design, design concepts for irrigation structures on permeable foundations, energy dissipation devices, design of diversion works, gravity dam, cross drainage works, canal falls.

CEL362 Construction Management
4 credits (3-1-0)
Pre-requisites: EC 60
Overview of the to the course, Linear programming, Problems in construction, Formulation, Graphical solution, Simplex method, Dual problem, sensitivity analysis and their application to Civil engineering, Transportation Assignment problems and their applications, Building Specifications, estimation and rate analysis. Project planning and network analysis, Time and cost control, Resource scheduling.

CEC410 Colloquium (CE)
3 credits (0-3-0)
Pre-requisites: registered for CET410
Presentation by each student on his/her practical training and other topics specified by the course coordinator.

CET410 Practical Training (CE)
Non credit
Pre-requisites: EC 90 at the end of 5th sem.
Practical Training of 50 working days in an Indian industry or R&D organization.

CED411 Major Project Part 1 (CE)
3 credits (0-0-6)
Pre-requisites: EC 120
To set the objectives, deliverables, work plan, logistics planning and milestones with discernible outputs and then to demonstrate the feasibility through some initial work.

CEL411 Industrial Waste Management
3 credits (3-0-0)
Pre-requisites: EC 90
Nature and characteristics of industrial wastes; Control and removal of specific pollutants in industrial wastewaters, i.e., oil and grease, cyanide. fluoride, toxic organics, heavy metals. Recent trends in industrial waste management; Prevention versus control of industrial pollution; Linkage between technology and pollution prevention; Tools for clean production, reuse, recycle, recovery, source reduction, raw material substitution, toxic use reduction and process modifications; Point, and area source: dispersion modeling of industrial air pollutants. Source reduction and control of industrial air pollution; Minimization of industrial solid and hazardous waste; Waste management case studies from various industries.

CED412 Major Project Part 2 (CE)
7 credits (0-0-14)
Pre-requisites: CED411
Preferably continuation of the topic of CED411.

CEL412 Environmental Assessment Methodologies
3 credits (3-0-0)
Pre-requisites: EC 90
Environmental issues related to developmental activities: Nature and characteristics of environmental impacts of urban and industrial developments. Linkages between technology, environmental quality, economic gain, and societal goals. Environmental indices and indicators for describing affected environment. Methodologies and environmental systems modeling tools for prediction and assessment of impacts on environmental quality (surface water, ground water, air, soil). Monitoring

and control of undesirable environmental implications. Environmental cost benefit analysis. Decision methods for evaluation of environmentally sound alternatives; Environmental health and safety: Basic concepts of environmental risk and definitions; Hazard identification procedures; Consequence analysis and modeling (discharge models, dispersion models, fire and explosion models, effect models etc.); Emerging tools for environmental management: Environmental Management Systems, Environmentally sound technology transfer, emission trading, international resource sharing issues, climate change, international environmental treaties and protocols. Case studies.

CEL421 Ground Improvement
4 credits (3-0-2)
Pre-requisites: CEL321
Compaction methods used in the laboratory and the field; shallow stabilization with cement, lime, flyash and other chemical admixtures; deep stabilization using vibroflotation, compaction piles, dynamic compaction, blasting, sand drains, stone columns, lime and cement columns; Grouting by permeation, displacement and jet methods; functions and applications of geosynthetics – geotextiles, geogrids, geomembranes; soil reinforcement using strips, bars and geosynthetics; soil nailing and ground anchors; dewatering techniques; Earthmoving machines and earthwork principles; piling and diaphragon wall construction; tunneling methods in soils; hydraulic barriers and containment systems for waste disposal in soils; control and remediation of soil contamination; Laboratory : Lab compaction methods – light, heavy, kneading, vibratory- for soils and soils with admixtures; plasticity and undrained strength behaviour of compacted and stabilized clays; drained strength behaviour of compacted / stabilized sands.

CEL422 Rock Engineering
3 credits (3-0-0)
Pre-requisites: CEL321
Overlaps with: CEL651
Geological classification, rock and rock mass classification, strength and deformation behaviour of rocks, pore pressures, failure criteria, laboratory and field testing, measurement of in-situ stresses and strains, stability of rock slopes and foundations, design of underground structures, improvement of in situ properties of rock masses and support measures.

CEL423 Design of Foundations, Earth and Earth Retaining Structures
4 credits (3-1-0)
Pre-requisites: CEL321
Overlaps with: CEL610, CEL704, CEL708
Shallow Founations: Bearing Capacity: Bearing failure, Terminology; Empirical methods, Generalized bearing capacity theory, Layered soil, Foundations on or near slopes, Limit state design principles; Deep Foundations: Pile Foundations: Types and their selection, Ultimate load of individual piles in compressive, uplift, and lateral loading, Pile load tests, Downdrag, Pile groups. Caissons; Machine Foundations: Principles of vibrations, Types of machine foundations, Design criteria, Design of block foundations; Earth Dams: Components, Factors influencing design, Design of components; Earth Retaining Structures: Types, Earth pressure, Design of rigid, flexible and reinforced soil retaining walls, and braced excavations.

CEL431 Advanced Structural Analysis
3 credits (2-0-2)
Pre-requisites: CEL331
Introduction to FEM for structural analysis with review of energy methods –2D plane stress and plane strain elements, beam element, 2D bending element, example problems, elements of structural dynamics- free and forced vibration of SDOF system, treatment of impact and arbitrary loading, frequency and time domain analysis; free vibration mode ships and frequencies of MDOF systems; normal mode theory for forced vibration analysis of MDOF system; example problems. Elements of plastic analysis; upper and lower bound theorems; method of collapse mechanism; application to beams and multistory frames; example problems.

CEL432 Design of Prestressed Concrete and Industrial Structures
4 credits (3-0-2)
Pre-requisites: CEL232 & CEL331
Prestressed Concrete Structures – Fundamentals of prestressing, Prestressing technology, Analysis of prestressed members, Prestress losses, Design for Flexure, Design for shear and torsion, Design of anchorage Zones in post-tensioned members. Industrial Structures-Analysis and design of Cylindrical shell structures, Folded plates, Chimneys, Silos, Bunkers.

CEL433 Advanced Structural Design
4 credits (3-0-2)
Pre-requisites: CEL232 & CEL332
Design of Reinforced Cement concrete (RCC) Structures – Building frames, Liquid retaining structures, Earth retaining walls, Flat slabs, Staircases.Design of Steel Structures – Plate girders, gantry girders and steel bridge components.

CEL442 Traffic and Transportation Planning
3 credits (2-1-0)
Pre-requisites: CEL241 and EC 90
Transportation Engineering System, Random utility theory, Supply and demand, Flow estimation and modeling, Planning and engineering evaluation, Transportation engineering management, Traffic flow theory and management, Air and water navigational control, Rehabilitation and satellite area accessibility, Network and graph theory application.

CEL443 Transportation Safety and Environment
3 credits (3-0-0)
Pre-requisites: EC 90
Multidisciplinary approach to planning for traffic safety and injury control; precrash, crash and post crash models; roles of vehicle, roadway, traffic, driver, and environment, crash and injury causations; Mixed traffic flow; Transport related pollution; Technology Vision-2020; Urban and non-urban traffic noise sources, Noise level factors, Noise pollution; Energy related ascpects of different transport technologies. Road transport related air pollution, Sources of air pollution, effects of weather conditions; Vehicular emission parameters, pollution standards, measurement and analysis of vehicular emission; Mitigative measures; EIA requirements of Highway projects, procedure; MOEF/World Bank/RC/UK guidelines; EIA practices in India.

CEL450 Introduction to Remote Sensing
3 credits (2-0-2)
Pre-requisites: EC 90
What is Remote Sensing? Historical development of remote sensing, Remote sensing components, Data collection and transmission, Sensors and satellite imageries, Electromagnetic energy and spectrum, Wavebands, Interactions of electromagnetic energy with atmosphere and earth's surface, radiometric quantities, Photogrammetry and aerial photography, Vertical and tilted photographs, Photographic materials, Photo-processes, Stereoscopic viewing, Fly view, Aerial mosaics, Various satellite systems and monitoring programs, Data Products, Satellite data, Data formats, Data acquisition for natural resources management and weather forecast, Random errors and least square adjustment, Coordinate transformation, Photographic interpretation, Image processing, Potential applications of remote sensing in diverse areas and decision making, Integrated use of remote sensing and GIS, Case studies.

CEL451 Water Power Engineering
4 credits (3-0-2)
Pre-requisites: CEL251 and EC 90
Basic principle of hydropower generation, Hydropower Project Planning, Site selection, Hydropower development schemes, Reservoir storage, Assessment of power potential, Hydrologic analysis: Flow duration and power duration curves, Dependable flow, Design flood, Reservoir operation; Hydraulic design of various components of hydropower plants: intakes, hydraulic turbines, centrifugal and axial flow pumps, conduits and water conveyance,

Penstocks; Performance characteristics of turbines, Specific and unit quantities, Electrical load on hydro-turbines, Power house dimension and planning, Water hammer and surge analysis, Surge tanks, Small hydro power development, tidal plants, Current scenarios in hydropower development, Project feasibility, Impact of hydropower development on water resources systems, environment, socioeconomic conditions and national economy.

CEP452 Computational Aspects in Water Resources
3 credits (1-0-4)
Pre-requisites: CEL251 and EC 90
Numerical Interpolation and Integration and application of water resource problems. Numerical solution of differential equations in water resources, such as, groundwater flow, pipe flows, open channel flows.

CEL453 Water Resources Management
4 credits (3-1-0)
Pre-requisites: CEL251 and EC 90
Scope of Water Resources Management, Global Trends in Water Utilization, Crop Water Requirements and Irrigation

Planning, Modern Irrigation methods such as Sprinkler and Drip Irrigation, Soil Salinity and Water Logging Hazard Mitigation, Drainage Design, Hydropower Systems Management, Economic Analysis of water Resources Projects, Flood Control studies.

CEL455 Introduction to Geographic Information Systems
3 credits (2-0-2)
Pre-requisites: EC 90
Overlaps with: CEL747
What is GIS. Geographic concepts for GIS. Spatial relationships, topology, spatial patterns, spatial interpolation. Data storage, data structure, non-spatial database models. Populating GIS, digitizing data exchange, data conversion. Spatial data models, Raster and Vector data structures and algorithms. Digital Elevation Models (DEM) and their application. Triangulated Irregular Network (TIN) model. GIS application areas, Spatial analysis, quantifying relationships, spatial statistics, spatial search. Decision making in GIS context.

CEL459 River Mechanics
3 credits (2-0-2)
Pre-requisites: CEL251 and EC 90
Introduction, river morpohology, drainage patterns, stream order. Properties of mixture of sediment and water, Incipient motion and quantitative approach to incipient motion, channel degradation and armoring. Bed forms and resistance to flow, various approaches for bed load transport, suspended load profile and suspended load equations, total load transport including total load transport equations. Comparison and evaluation of sediment transport equations. Stable channel design with critical tractive force theory.

CEL464 Construction Contract and Economics
3 credits (2-1-0)
Pre-requisites: EC 90
Overview of the to the course, Engineering economics of the projects, Time value of money, comparison of alternatives, Depreciation and depletion, Quantity surveying, Direct and indirect costs, Professional agreements; Contracts and specification; Disputes, Arbitration and other methods of dispute resolution. Bidding and bidding models.

CEL466 Construction Equipment and Methods
3 credits (2-1-0)
Pre-requisites: EC 90
Overview of the course; Basic principles of construction, selection and economy; General construction equipment – excavation, earthmoving, drilling, blasting, dewatering, shoring, strutting, disposal and underpinning, well sinking and pile driving, heavy lifting; Operations and maintenance of equipment, Productivity estimates, Cycle time, Planning and scheduling of equipment by networks, Formworks and scaffolding, Concrete construction practices. Prefabrication and modular coordination; Steel construction, special constructions such dams, bridges, high rise buildings, offshore platforms.

CEL610 Foundation Engineering
3 credits (3-0-0)

Note : This course is not meant for students specializing in Geotechnical and Geoenvironmental Engineering; Classification, Engineering behaviour of soils – effective stress concept, permeability, compressibility, shear strength. Parameters for short and long term stability, Stress distribution, Field explorations - scope and depth of investigations, SPT, DCPT, SCPT; Analysis of bearing capacity of shallow foundations, Plate load test; Settlement computations - Immediate and Consolidation; Codal provisions; Types of pile foundations, load carrying capacity of pile foundations including group effects and negative skin friction. Pile load test.

CEL612 Construction Methods in Geotechnical Engineering
3 credits (3-0-0)

(To be offered to specialization in Construction Technology and Management) Ground Engineering-Earthwork, earth-moving equipments, soil compaction and stabilization with additives. Ground improvement-Deep-in-situ improvement by (a) Vibroloation stone column, (b) compaction piles, (c) impact/dynamic compaction, (d) blasting, (e) pre-loading and drains, (f) in-situ mixing, cement and lime columns; Geotechnical Processes in Soil and Rocks-drilling, blasting, grouting, dewatering; Foundation-piles: (a) precast driven, (b) driven cast in-situ, (c) bored cast in-situ, (d) under-reamed. Caissons; Dams and Embankments-earth dams, earth cum-rock-fill dams, road and rail embankments; Earth Retaining Structures- retaining walls including reinforced earth, braced excavations, sheet piles, diaphragm walls; Underground Structures-tunneling in rock, soil, and in soft ground. Micro-tunneling.

CEL614 Geoenvironmental and Geohazards Engineering
3 credits (3-0-0)

Note: *This Course is not meant for Students Spcializing in Geotechnical and Geoenvironmental Engineering.*

Geoenvironmental Engineering; Waste generation; subsurface contamination, waste containment; Types of landfills, design and operation of landfills, subsurface contamination control and remediation; Geotechnical Earthquake Engineering: Engineering seismology, Strong ground motion, Seismic hazard analysis, Local site effects and design ground motions, liquefaction hazard evaluations and remedial measures; Landslides: Causes and phenomenon associated with landslides, effect of rainfall on slope stability, earthquake triggered landslides, landslide prevention, control and remedial measures; Other Hazards: ground subsidence, ground heave, erosion.

CEL651 Rock Engineering
3 credits (3-0-0)

Note: *This course is not meant for students specializing in Rock Engineering and Underground Structures.*

Introduction. Geological considerations. Index properties and rock mass classifications. Strength and failure criteria for rocks and rock masses; Insitu stresses in rocks and their measurement. Strength and deformation behaviour of discontinuities in rocks. Deformation behaviour of rocks and rock masses. Time dependent behaviour of rocks; Application of Rock Mechanics to Underground Structures, Slopes and Foundations. Improving the properties of insitu rock masses. Ground response support methods. Rock excavation.

CED701 Minor Project in Geotechnical and Geoenvironmental Engineering
3 credits (0-0-6)

CEL701 Engineering Behaviour of Soils
3 credits (3-0-0)

Origin, nature and distribution of soils. Description of individual particle. Clay mineralogy, clay-water-electrolytes. Soil fabric and structure; Effective stress principle. Steady state flow in soils. Effect of flow on effective stress. Determination of coefficient of permeability; Consolidation, one, two and three dimensional and radial consolidation. Variation of effective stress during consolidation. Various consolidation tests and determination of parameters; Stress-path. Triaxial and direct shear tests. Shear behaviour of granular soils. Factors affecting shear beahviour. Determination of parameters; Shear behaviour of fine grained soils. Pore-pressure parameters. UU, CU, CD tests. Total and effective stress-strength parameters. Total and effective stress-paths. Water content contours; Factors affecting strength : Stress history, rate of testing, structure and temperature. Anisotropy of strength, thixotropy, creep. Determination of in-situ undrained strength; Stress-strain characteristics of soils. Determination of modulus values; Critical state model; Engineering Behaviour of Soils of India : Black cotton soils, alluvial silts and sands, laterites, collapsible and sensitive soils, aeolin deposits.

CEP701 Soil Engineering Laboratory
3 credits (0-0-6)

Field Investigations and field tests: Drilling of bore hole, standard penetration test. undisturbed and representative sampling. DCP Test, SCP Test, Electrical resistivity. Plate load test. Pile load test; Laboratory Tests: Consolidation test, Direct shear test, Vane shear test. Unconfined compression test. Unconsolidated undrained triaxial test. Consolidated drained triaxial test. Consolidated undrained triaxial test with pore water pressure measurement. Free swell index test. Swelling pressure test. Flow net solutions by Electrical analogy.

CEL702 Slope Stability and Earth Dams
3 credits (3-0-0)

Slope Stability: Short term and long term stabilities; Limit equilibrium methods; Infinite slopes; Finite height slopes – Swedish method, Bishop's simplified method, other methods; Stability charts; Conditions of analysis – steady state, end of construction, sudden draw down conditions; Factor of safety; Codal provisions; Earthquake effects; Seepage Analysis: Types of flow; Laplace equation; Flownet in isotropic, anisotropic and layered media; Entrance-exit conditions; Theoretical solutions; Determination of phreatic line; Earth Dams: Introduction; Factors influencing design; Design of components; Construction; Instrumentation – piezometer, settlement gauge, inclinometer; Road and rail embankments. Reinforced Slopes: Steep slopes; Embankments on soft soils; Reinforcement design; Landslides: Remedial measures for unstable slopes – soil nailing, gabions, drainage.

CEP702 Geoenvironmental and Geotechnical Engineering Laboratory
3 credits (0-0-6)

Engineering properties and compaction characteristics of waste - coal ash , mine tailings. Permeability of clays and bentonite amended soils. Tensile strength of geomembranes, geotextiles. Soil – geomembrane interfacial shear strength. Project based laboratory for evaluation of engineering properties of soils for design of embankments and foundations.

CEL703 Site Investigations and Ground Improvement
3 credits (3-0-0)

Site Investigations:

Planning of investigation programmes, Information required for planning different stages of investigations. Geophysical methods: electrical resistivity, and seismic refraction methods. Methods of site investigations: Direct methods, semi-direct methods and indirect methods, Drilling methods. Boring in soils and rocks, methods of stabilizing the bore holes, measurement of water table, field record. Field tests: In-situ shear test, in-situ permeability test, SPT, DCPT, SCPT, in-situ vane shear test, pressure meter test, plate load test. Codal provisions; Sampling techniques, Sampling disturbances, storage, labeling and transportation of samples, sampler design, influence on properties; Report writing. Safety measures; Geotechnical Processes: Principles of compaction, Laboratory compaction, Engineering behaviour of compacted clays, field compaction techniques- static, vibratory, impact, Earth moving machinery, Compaction control. Shallow Stabilization with Additives: Lime, flyash, cement and other chemicals and bitumen; Deep Stabilization: sand column, stone column, sand drains, prefabricated drains, electro-osmosis,lime column. soil-lime column. Grouting : permeation, compaction and jet. Vibro-floatation, dynamic compaction, thermal, freezing. Dewatering systems.

CEL704 Shallow and Deep Foundations

3 credits (3-0-0)

Types of foundations.
Shallow Foundations : Design considerations – factors of safety (including limit state), allowable settlements, location and depth of foundations, Codal provisions. Presumptive bearing capacity . Bearing capacity theories. Layered soils. Choice of shear strength parameters . Bearing capacity from N-values, static cone tests, plate load tests; Settlement : Total and differential settlement. Stress distribution. Consoli-dation settlement in clays (with correction factors). Immediate settle-ment. Settlement in sands from N-values, elastic solutions. Static cone tests, Plate load tests; Deep foundations : Types of piles. Construction methods. Axial capacity of single piles – dynamic formulae, soil mechanics approach. Skin friction and end bearing in sands and clays. Deep foundation. Axial capacity of groups. Settlement of single piles and groups. Uplift capacity (including under-reamed piles). Negative skin friction. Pile load tests. Pile integrity tests. Codal provisions; Caissons; Foundations in difficult soils : expansive soils, chemically aggressive environment, soft soils, fills, regions of subsidence.

CEL705 Geoenvironmental Engineering

3 credits (3-0-0)

Sources and effects of subsurface contamination; Physical, chemical and biological characteristics of solid wastes; Soil-waste interaction; Contaminant transport; Laboratory and field evaluation of permeability; Factors affecting permeability; Waste disposal on land; Types of landfills: Siting criteria; Waste containment principles; Types of barrier materials; Planning and design aspects relating to waste disposal in landfills, in ash ponds and tailing ponds, and in rocks; Environmental monitoring around landfills; Detection, control and remediation of subsurface contamination; Engineering properties and geotechnical reuse of waste materials such as coal ash, mining waste, demolition waste etc; Reclamation of old waste dumps; Regulations; Case studies.

CEL706 Geosynthetics

3 credits (3-0-0)

Geosynthetics and Reinforced Soil Structures:
Types and functions; Materials and manufacturing processes; Testing and evaluations; Principles of soil reinforcement; Design and construction of geosynthetic reinforced soil retaining structures – walls and slopes; Codal provisions; Bearing capacity improvement; embankments on soft soils; Indian experiences; Geosynthetics in Pavements: Geosynthetics in roads and railways; separations, drainage and filtering in road pavements and railway tracks; overlay design and construction; AASHTO and other relevant guidelines; french drains; Geosynthetics in Environmental Control: Liners for ponds and canals; covers and liners for landfills – material aspects and stability considerations; Landslides – occurrences and methods of mitigation; Erosion – causes and techniques for control.

CEL707 Soil Dynamics and Geotechnical Earthquake Engineering

3 credits (3-0-0)

Engineering problems involving soil dynamics; Role of inertia; Theory of Vibrations: Single and two-degree freedom systems, vibration-measuring instruments, vibration isolation, Wave propagation in elastic media; General nature of soil behaviour under cyclic/dynamic loading; Field and Laboratory tests for measurement of small strand and large strain, dynamic properties of soils; Design criteria for machine foundations, elastic homogeneous half space solutions, lumped parameter solutions. Codal provisions; Strong Ground Motion: Measurement, characterization and estimation; Amplification theory and ground response analysis. Densification and liquefaction of granular soils, Seismic slope stability analysis, Seismic bearing capacity and earth pressures. Codal provisions.

CEL708 Earth Pressures and Retaining Structures

3 credits (3-0-0)

Earth Pressure: Types – at rest, active and passive; Rankine's theory; Backfill features – soil type, surface inclination, loads on surface, soil layers, water level; Coulomb's theory; Effects due to wall friction and wall inclination; Graphical methods; Earthquake effects; Rigid Retaining Structures: Types; Empirical methods; Stability analysis; Flexible Retaining Structures: Types; Material; Cantilever sheet piles; Anchored

bulkheads – free earth method, fixed earth method, moment reduction factors, anchorage; Braced Excavation: Types; Construction methods; Pressure distribution in sands and clays; Stability – bottom heave, seepage, ground deformation; Reinforced Soil Walls: Elements; Construction methods; External stability; Internal stability; Laterally Loaded Piles: Short and long piles; Free head and fixed head piles; Lateral load capacity of single piles; Lateral deflection; Elastic analysis; Group effect; Lateral load test; Codal provisions; Underground Structures in Soils: Pipes; Conduits; Trenchless technology; Tunnelling techniques – cut-and-cover method, shield tunnelling.

CEL709 Offshore Geotechnical Engineering

3 credits (3-0-0)

Submarine soils: Origin, nature and distribution. Terrigenic and pelagic soils. Submarine soils of India. Engineering behaviour of submarine soils: under-consolidated soils, calcareous soils, cemented soils, corals; Offshore site investigations: sampling and sampling disturbance, insitu testing, wireline technology. Offshore pile foundations for jacket type structures. Foundations of gravity structures; Foundations for jack-up rigs. Anchors and breakout forces; anchor systems for floating structures. Stability of submarine slopes. Installation and stability of submarine pipelines.

CEL712 Landfills and Ash Ponds

3 credits (3-0-0)

Integrated solid waste management of municipal solid waste, hazardous waste, coal ash and other wastes; Landfilling practice for different types of solid wastes; Municipal solid waste landfills: acceptability of waste; planning, design, construction, operation and closure including management of leachate and gas; Hazardous waste landfills: Waste compatibility and acceptability; planning, design, construction, operation, closure and environmental monitoring; Ash ponds: Slurry disposal versus dry disposal; Engineering properties of bottom ash, fly ash and pond ash; planning and design; incremental raising of height by upstream and downstream methods; closure and reclamation.

CEL714 Special Topics in Geotechnical and Geoenvironmental Engineering

3 credits (3-0-0)

A course which will vary from year to year to study new and exicting developments in the broad spectrum of Geotechnical and Geoenvironmental Engineering. The course will also focus on new offshoots of Geotechnical and Geoenvironmental Engineering.

CEL715 Soil-Structure Interaction Analysis

3 credits (3-0-0)

Introduction: Analysis of foundations and flexible retaining structures by conventional method- isolated and combined footings, mats, pile caps, eccentrically loaded foundations, transmission tower foundations, sheet pile walls; Soil-structure interaction : Subgrade reaction method; Beam and plate theories; Analysis of footings, mats, pile caps, laterally loaded piles, sheet pile walls, water front structures; Elastic half-space method: Closed form solutions, charts and FEM- footings, mats, reinforced foundations and embankments. Evaluation of relevant material parameters. Use of appropriate software packages.

CEL717 Advanced Structural Analysis

3 credits (3-0-0)

Matrix methods in skeletal structural analysis : force and displacement methods including analysis using substructures. Non-linear and elasto-plastic analysis. Analysis of plates, folded plates and singly curved shells: conventional and approximate methods.

CEL718 Design of Steel Structures

3 credits (2-1-0)

Structural steels. Brittle fracture and fatigue. Stability of beam columns, frames and plates. Plastic design of steel structures. Plate girders. Codal provisions. Prestressed steel construction.

CEL719 Structural Dynamics

3 credits (3-0-0)

Free and forced vibration of single degree of freedom (SDOF) systems, response to harmonic, periodic, inpulsive and general dynamic loading,

response of SDOF to earthquake. Free vibration of lumped multidegree of freedom systems. Approximate methods for obtaining natural frequencies and mode shapes. Frequency domain analysis of lumped multi-degree of freedom system using normal mode theory. Time domain analysis using numerical integration scheme. Free and forced vibration of continuous systems. Dynamic soil-structure interaction.

CEL721 Design of Concrete Structures
3 credits (2-1-0)
Limit state design concepts in flexure, shear, torsion and combined stresses; Slender columns. Safety and serviceability : control of cracks and deflections. Yield line analysis of slabs : Work and equilibrium methods. Introduction to limit design of beams and frames. Design of statically determinate prestressed concrete structures for flexure and shear.

CEL722 Solid Mechanics in Structural Engineering
3 credits (3-0-0)
Theories of Stress and strain; Finite deformations and linearization; Compatibility relations; Equations of motion; General theory of constitutive equations; Stress-strain relations for linear elastic solids. Types of elasticity problems and methods of their solution with illustrative examples for isotropic solids. Displacement potentials and stress functions; Torsion; Mechanical principles; Energy theorems; Hypoelastic and hyperelastic solids; Conservative structures. St.Venant's principle; Limitations of the structural theory; Elastic Waves; Thermoelasticity ; Theory of perfect plasticity; Yield criteria, and Flow rules; Viscoelasticity; Rheological odels;Superposition and correspondance principles. Viscoplasticity.

CEL724 Earthquake Analysis and Design
3 credits (3-0-0)
Seismology, seismic risk and hazard, Soil dynamics and seismic inputs to structures, Response spectrum analysis, Spectral analysis, Nonlinear and push over analysis, Dynamic soil-structure interaction. Earthquake design philosophy, codal provisions for seismic design, retrofitting and strengthening of structures, concept of base isolation design and structural control.

CEP724 Water Resources Management Laboratory
3 credits (1-0-4)
Field based experiments: Soil moisture tension measurement, Capillary pressure, Soil moisture, Infiltration capacity, Soil salinity, Soil nutrients, Water quality; Map reading, impact of changes in land use through map preparation, Use of GIS and remote sensing, Computer based simulation/design, Database design, Water hammer analysis, Design of water distribution network, Applications of Kriging and Neural networks in water resources.

CEP726 Structural Engineering Laboratory
3 credits (0-0-6)
Concrete : Concrete mix design and testing, non-destructive testing of concrete. Reinforced concrete : under-reinforced and over-reinforced beams, columns under eccentric loading, two-way reinforced slabs.

Model testing : Models of plates and shells and frames under static and dynamic loading, free and forced vibrations using MTS, dynamic modulus. Stress analysis : Two and three- dimensional photoelasticity.

CEL727 Design of Industrial Structures
3 credits (2-1-0)
Planning of industrial structures. Design of single and multibay industrial structures in steel and concrete. Bunkers and silos. Pressure vessels and chimneys. Cooling towers. Large span roof structures. Suspended roof structures. Structural aspects of machine foundations.

CEL729 Advanced Design of Bridges
3 credits (2-1-0)
Introduction and selection of type of bridges; Loads and forces. Grillage analogy. Theories of lateral load distribution and design of superstructure. Abutments, piers and their foundations. Bearings. Expansion joints. Construction methods. Maintenance of bridges. Evaluation of existing bridges.

CEL731 Prestressed/ Composite Structures
3 credits (3-0-0)
Need for prestressing; Pretensioning and Post-tensioning methods; Behaviour of prestressed concrete beams; Loss of prestress; Deflections; Bursting forces in anchorage zone; Design methods; Partial prestressing; Analysis of indeterminate structures. Need of composite construction; Design methods for composite beams, slabs, columns and box–girders; Behaviour of masonry elements and walls; Design methodology; Stability of columns and walls; Seismic design of reinforced and prestressed masonry.

CEL733 Finite Element Method in Structural Engineering
3 credits (2-1-0)
Review of principles of virtual work and minimum potential energy. Elements of theory of elasticity. Various types of finite elements. Solution procedures. Detailed study of application to structures such as dams, frame-shear walls, grid floors and rafts. Application to vibration and buckling problems.

CEL734 Mathematical and Numerical Methods
3 credits (2-1-0)
Linear equations and eigenvalue problems. Accuracy of approximate calculations. Non-linear equations, Interpolation. Differentiation and evaluation of single and multiple integrals. Initial and boundary value problems of finite difference method. Newton's method, variational and weightened residual methods. Introduction to finite element method.

CEL735 Hydrologic Processes and Modeling
3 credits (3-0-0)
Land surface processes. Subsurface and channel processes. Unit Hydrograph and GIUH, Flood Propagation and Routing, Watershed Models, Conceptual Models. Hydrologic Forecasting.

CEL736 Environmental Dynamics and Management
3 credits (3-0-0)
Environmental property and processes, Environmental simulation models, Elements of environmental impact analysis, Impact assessment methodologies, Framework of environmental assessment, Environ-mental impact of water resources projects, Assessment of hydrological hazards, Environmental management, Case studies.

CEL737 Optimisation Techniques in Water Resources
3 credits (3-0-0)
Optimization techniques; linear programming, non-linear programming, geometric programming, dynamic programming, Network flow algorithm and Goal programming; Introduction to modern heuristic methods like generic algorithm and simulated annealing.

CEL738 Advanced Hydraulics
3 credits (3-0-0)
Energy and momentum principles in open channel, Curvilinear Flows, Backwater computations, Controls, Rapidly varied flows, Spatially varied flows, Unsteady flow, Surges, Flood wave passage, Roll waves, Sediment transport, Incipient motion criteria, Resistance to flow and bed forms, Bed load theory, Stratified flows, Fluvial Systems, Industrial Hydraulics.

CEL739 Groundwater Hydrology
3 credits (3-0-0)
Occurrence and movement of groundwater. Surface and subsurface investigation of groundwater, Flowthrough saturated porous medium. Mechanics of well flow, Aquifer parameters, Pumping tests, Design of water wells, Monitoring well design and consutruction, Well development, well maintenance and rehabilitation, Natural and Artificial recharge of ground water, Salt water intrusion, Introduction to analog and numerical models to solve ground water problems, Application of finite difference method in ground water.

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CEP740 Simulation Laboratory
4 credits (1-0-6)

Hydrological database design and its management, Basics of computing, Discrete event simulation, Random number generation, Monte Carlo simulation, Simulation of queuing systems, Computer based hydraulic and hydrologic simulation exercises, Application of specific hydrologic and hydraulic software packages, Real time operation and online forecasting.

CEL741 Surface Water Quality Modeling and Control
3 credits (3-0-0)

River hydrology and derivation of the stream equation, Derivation of the estuary equation, Distribution of water quality in rivers and estuaries, Physical and hydrological characteristics of lakes, Finite difference steady state river, estuary and lake models, Dissolved oxygen models in rivers, estuaries and lakes, Fate of indicator bacteria, pathogens and viruses in water, Basic mechanisms of eutrophication, Lake phytoplanckton models, River eutrophication analysis, finite segment models, Elements of toxic substance analysis.

CEL742 Finite Element in Water Resources
3 credits (3-0-0)

Introduction to finite element method, Mathematical concepts and weighted residual techniques, Spatial discretization, Shape Functions, Isoparametric elements, Explicit and implicit time marching schemes, Equation assembly and solution techniques, Application: Navier-Stokes equations, dispersion of pollutants into ground and surface water, Flow through earthen dams, seepage beneath a hydraulic structure, Groundwater flow in confined and unconfined aquifers, Incompressible turbulent flow in pipes.

CEL743 Economic Aspects of Water Resources Devlopment
3 credits (3-0-0)

Data requirements and survey: topographical, geological, hydrological, socioeconomic, technological; market survey; identification of alternate options and associated data requirements and survey, Project feasibility, Demand assessment: planning period and time horizon, economic-demographic projections, integrated and disaggregated analysis and model building; demand resilience and consumer behaviour, Basic economic concepts: present worth, future worth, annuities, discounting techniques, depreciation, Production function and cost curves: components of cost curves, learning curve, expansion path, long term and short term, Estimation of project benefits and costs, Tangible and intangible values, Indifference curves, Pricing concepts: oligopolies, kinked demand curve model, skimming price and penetration price, Economics of natural resources management, Fields of finance, Financial analysis, Economic and financial models, Analysis of water resources projects in real-world settings, Benefit-cost analysis, Risk considerations, Project optimality, Mathematical models for multipurpose and multi-objective projects, Technological forecasting, Welfare and environmental economics, Capital budgeting and cost allocation.

CEL744 Groundwater Flow and Pollution Modeling
3 credits (3-0-0)

Subsurface processes and concepts for groundwater resources evaluation, Unsaturated zone properties: Soil moisture levels, Retention curves, Flow through unsaturated porous media, infiltration and Wetting front, Groundwater contamination, Sources and causes of groundwater pollution, Pollution dynamics, Hydrodynamics dispersion, Biodegradation, Radioactive decay, Reactive processes, Multiphase contamination, NAPLs, VOCs, Site specific groundwater quality problems in Indian context, Numerical models, Finite difference methods, Numerical modeling of steady and transient flows in saturated and unsaturated domain, Contaminant transport modeling, Application of FEM and BIEM in groundwater modeling, Regional aquifer simulation, Contaminated groundwater systems and their rehabilitation, Development and optimization based management of aquifer systems, Stochastic models, Random field concepts in groundwater models; Application emerging techniques to groundwater management.

CEL745 Water Management
3 credits (3-0-0)

Moisture-crop relationship, Irrigation requirements, Irrigation efficiencies, Design of conventional and modern methods of irrigation, Irrigation of arid lands, Drainage of irrigated land, Salinity of soil, Salinity control, Quality of irrigation water, Contaminants and their effects on various crop types, Rain water management, Planning and operation of irrigation systems, Conjunctive use of water, Participatory irrigation management, Water management policy during droughts, Predicting effect of water shortage on crops.

CEL746 Hydroelectric Engineering
3 credits (3-0-0)

Planning of hydropower development, Hydropower potential, Operation of power plants for peaking and base load, Characteristics of power market, Integration of various types of plants, Augmentation of power plants, Pump storage plants, Small hydro power, Surge tanks and hydraulic transients, Penstocks and pressure shafts, Intakes, Reservoir operation for hydropower generation in a multipurpose projects, Basin scale hydropower generation in a multipurpose projects, Basin scale hydropower development, Mathematical models for reservoir sizing and operation.

CEL747 Geographical Information Systems (GIS)
3 credits (2-0-2)

Introduction to Geographical Information Systems (GIS), Databases and database management systems, Spatial databases, Coordinate systems and georeferencing, Interpolation methods: Deterministic and Statistical; Digital elevation models and their applications, Strategies for development, implementation and management of GIS, Case studies on use of GIS selected from various areas such as water and land resources, environment, transportation, etc., Projects involving creation of small GIS modules related to water resources problems and other generic areas.

CEL748 Hydrologic Applications of Remote Sensing Technology
3 credits (2-0-2)

Data capture for simulation of land surface processes, inventory, Geomorphology, Landuse classification, Landuse planning and landcover mapping, Flood plain mapping, Flood plain zoning, Principles of remote sensing and its applications in water resources, agriculture and environmental monitoring, Applications in snow and glacier studies, Snow line, Ice cover, Snow-pack properties, Integrated use of remote sensing and GIS, Database preparation and Decision support analysis, Estimation of damages due to hydrologic extremes and preparation of contingency plans, Case studies.

CEL749 Water Resources Systems
3 credits (3-0-0)

Systems concepts and its application in irrigation, flood control, hydropower generation, water supply and drainage, Storage-yield analysis, Rule curves, Reservoir sizing, Multireservoir systems, Real time operation, Water conflicts, River basin planning, Engineering heuristics, Systems reliability, Case studies.

CEL751 Engineering Properties of Rocks and Rock Masses
3 credits (3-0-0)

Introduction. Rock materials, Physical properties, Strength behaviour in uniaxial compression, tension and triaxial state. Laboratory testing methods. Stress-strain relationships. Factors influencing strength. Failure mechanism. Anisotropy. Failure criteria, Coulomb, Mohr's, Griffiths and Modified Griffiths criteria and Empirical criteria. Brittle – ductile transition, Post failure behaviour.

Strength and deformation behaviour of discontinuities. Rockmass behaviour, Shear strength of jointed rocks, roughness, peak and residual strengths. Strength criteria for rockmass.

Intact and rockmass classifications, Terzaghi, RQD, RSR, RMR and Q classifications, Rating, Applications. Creep and cyclic loading. Weathered rocks. Flow through intact and fissured rocks. Dynamic properties

CEP751 Rock Mechanics Laboratory
3 credits (0-0-6)

Tests and test procedures, Specimen preparation, coring, cutting and lapping. Tolerance limits.

Physical Properties: Water absorption, density, specific gravity, porosity, void index, electrical resistivity and sonic wave velocity tests.

Mechanical Properties: Uniaxial compression, Point load index and Brazilian strength tests, Elastic properties. Effect of L/D ratio and saturation. Strength anisotropy.

Shear tests: Single, double, oblique tests, Triaxial compression tests, Direct shear test. Slake durability and Permeability tests. Compilation of test data. Classification. Codal provisions.

CEL752 Slopes and Foundations
3 credits (3-0-0)
Introduction, Short-term and long-term stability. Influence of ground water, Seismic effects. Types of rock slope failures. Infinite slopes, Circular and non-circular slip surface analysis, Stability charts.

Plane failure analysis. Wedge failure analysis analytical, Stereographic methods. Buckling and toppling failures, Rock falls, Landslides. Foundations: Bearing capacity, settlement and stress distribution in intact and layered rocks. Foundations of dams. Deep foundations. Tension foundations, Codal provisions. Foundation improvement. Use of appropriate software packages.

CEP752 Rock Mechanics Laboratory II
3 credits (0-0-6)
Pre-requisite: (CEP751) Project based Laboratory

CEL753 Structural Geology
3 credits (2-0-2)
Origin, interior and composition of the earth. Rock cycle, Igneous, Metamorphic and Sedimentary rocks. Rock structures. Plate tectonics, Continental drift and sea floor spreading. Geological time scale. Layered formations, Attitude, true and apparent dips, topographic maps, outcrops. Measurement of attitude of formations.

Folds, types of folds, classification, field study of folds, mechanics of folds, causes of folding. Joints, rock mass concept, Joint description and classification. Three point problems, Depth and thickness problems. Faults, mechanics of faulting, normal, reverse and thrusts, faults. Lineations. Foliations, Schistocity. Fault problems. Stereographic projection methods, Use of DIPS software, presentation of geological data and analysis, Applications, Field visit.

CEL754 Geotechnical Processes in Rock Engineering
3 credits (3-0-0)
Ground improvement techniques, assessment. Compaction of disintegrated and weathered rocks. Grouting, type of grouts, suspensions, solutions and resins, Rheological models. Viscous and viscoplastic flows. Spherical and radial flows. Groutability.
Grouting techniques, materials, equipment, specifications, evaluation and quality control. Case histories, Shotcrete, method and materials, factors. Fibre reinforced shotcrete.

Ground anchors, principles of reinforcement, rock bolts, mechanism, mechanical, friction, grouted tensioned and untensioned bolts. Design of bolts. Installation. Equipment. Testing. Cable anchors. Dewatering techniques, classification, assessment of insitu permeability, filter criteria and design of wells, Codal provisions.

CEL756 Excavation Methods and Machinery
3 credits (3-0-0)
Principles of rock breakage, explosive energy, energy balance, blasting mechanism. Types of explosives, initiators, delay devices, primer and booster selection. Blast hole design. Drilling methods and machines

Blast hole timing. Pattern design, open pit and underground blasting, production, estimation and damage criteria of ground vibrations. Controlled blasting. Directional blasting. Safety aspects. Case histories.

TBM tunnelling, cutter head, propulsion, shield, erector, spoil remover and backup systems. Factors influencing and evaluation, Excavation mechanics, trapanner, ranging drum shearer, continuous miner twin rotor Marnetta borer, boom machines, transverse boom tunnelling machines and Robins mobile miner. Drag pick cutting, cutting tool materials and wear, disc cutters. Cuttability. Case studies.

CEL757 Field Exploration and Insitu Measurements
3 credits (3-0-0)
Surface and sub surface exploration methods. Aerial and remote sensing techniques, Geophysical methods, electrical resistivity, seismic refraction, applications. Rock drilling: percussion, rotary drilling, drill bits. Core samplers, Core boxes, Core orientations.

Logging, stratigraphic profile, scan line survey, classification. Planning of laboratory tests, report. Stresses in rocks, gravity, tectonics, residual, thermal and induced stresses. Stress anisotropy and stress ratio. Stress relief and compensation techniques, USBM, door stopper cells, flat jack, hydrofrac, strain rossette and dilatometers. Soft and rigid inclusions.

Deformability, plate load, pressure tunnel and bore hole tests. Strength tests, insitu compression, tension and direct shear tests. Pull out tests. Borehole extensometers, piezometers, embedment gauges, inclinometers, Slope indicators, packer tests for insitu permeability, Codal provisions.

CEL758 Analysis and Design of Underground Structures
3 credits (3-0-0)
Introduction. Types and classification of underground openings. Factors affecting design. Design methodology. Functional aspects. Size and shapes. Support systems. Codal provisions. Analysis: Stresses and deformations around openings, Stresses and deformations around tunnels and galleries with composite lining due to internal pressure, Closed form solutions, BEM, FEM.

Design : Design based on analytical methods; Empirical methods based on RSR, RMR, Q systems; Design based on Rock support interaction analysis; Observational method- NATM, Convergence-confinement method.

Design based on Wedge failure and key block analysis. Design of Shafts and hydraulic tunnels. Stability of excavation face and Tunnel portals. Use of appropriate software packages.

CED760 Minor Project in Rock Engineering Under Ground Structures
3 credits (0-0-6)

CEL760 Finite Element Method in Geotechnical Engineering
3 credits (3-0-0)
Introduction. Steps in FEM. Stress-deformation analysis:One-,Two-dimensional formulations;

Three-dimensional formulations; Boundary conditions; Solution algorithms; Descretization; use of FEM2D Program and Commercial packages. Analysis of foundations, dams, underground structures and earth retaining structures. Analysis of flow (seepage) through dams and foundations.

Linear and non-linear analysis. Insitu stresses. Sequence construction and excavation. Joint/interface elements. Infinite elements. Dynamic analysis. Evaluation of material parameters for linear and non-linear analysis, Recent developments.

CEL761 Underground Space Technology
3 credits (3-0-0)
Tunnels, energy storage caverns, nuclear waste disposal repositories, metros, underground chambers and defence installations. Geological considerations, layout, survey and alignment. Analysis and design methods. Construction methods.

Ventilation, provisions, equipment. Control and monitoring system, services, operations and maintenance. Lighting, specifications, maintenance, emergency lighting. Power supply and distribution, Water supply and distribution.

Safety provisions, localized hazards, fire hazards in highway tunnels, rapid transit tunnels. Surveillance and control system for highway tunnels. Tunnel finish, Rehabilitation. Inspection methods, Repairs, Tunnel construction contracting.

CEL762 Special Topics in Rock Engineering
3 credits (3-0-0)
A course which will vary from year to year to study new and emerging developments in the broad spectrum of Rock Engineering. The course will also focus on new offshoots of Rock Engineering.

CEL763 Environmental Rock Engineering
3 credits (3-0-0)
Hazardous Earth processes. Temperature, pressure and water related problems, stress relaxation, high ground stresses, rock bursts, subsidence. Karst formations. Landslides and rock falls, slopes stabilization, mitigation, Case studies.

Earthquakes, tectonic stresses, creep, ground motions, damage, prediction. Volcanic activity and hazard. Tsunamis. Case studies. Waste disposal, Radioactive and hazardous wastes, repositories, location and design, VLH, VDH and KBS3 concepts. Waste container, barriers, rock structure, embedment, buffers and seals. Performance assessment, quality control and monitoring. Case histories.

CEL766 Systems Design and Value Analysis
3 credits (3-0-0)
Analysis synthesis, Appraisal, System design procedure, objectives and constraints, application to buildings, value analysis. Indtroduction, function analysis. Job plan. Value savings during construction. Value management. Case studies in Value engineering.

CEL767 Construction and Contract Management
3 credits (3-0-0)
Project cost estimation, rate analysis, overhead charges, bidding models and bidding strategies. Qualification of bidders, Owner's and contractor's estimate.

Tendering and contractual procedures, Indian Contract Act1872, Definition of Contract and its applicability, Types of contracts, International contracts, FIDIC, Conditions and specifications of contract.

Contract administration, Claims, compensation and disputes, Dispute resolution techniques, Arbitration and Conciliation Act 1996, Arbitration case studies, Professional ethics, Duties and responsibilities of parties.

Management Information systems.

CEL768 Recent Advances in Construction Materials
3 credits (3-0-0)
Foams and light weight materials, fibre-reinforced concrete. Types of fibres, workability, mechanical and physical properties of fibre reinforced concrete. Industrial waste materials in concrete, their influence on physical and mechanical properties and durability of concrete, Concrete at high temperature. High strength concrete. Changes in concrete with time, Corrosion of concrete in various environments. Corrosion of reinforcing steel. Electro-chemical process, measures of protection. Ferro-cement, material and properties. Polymers in Civil Engineering Polymers, fibres and composites,Fibre reinforced plastic in sandwich pancels, modeling. Architectural use and aesthetics of composties. Adhesives and sealants. Structural elastomeric bearings and resilient seating. Moisture barriers, Polymer foams and polymers in Building Physics. Polymer concrete composites.

CEL769 Project Planning and control
3 credits (2-1-0)
Work-study, work breakdwon structure, Time estimates, Applications of CPM/PERT, statistical concepts, Man-Material-Machinery-money optimization, scheduling, monitoring, updating. Cost functions, time-cost trade off, resource planning-levelling and allocation. Resources - based networks, crashing, master networks, interface activities and dependencies, line of balancing techniques, application of digital computers.

Material management- purchases management and inventory control, ABC analysis.

Human Resource management.

CEP770 Computation Lab for Construction Management
3 credits (0-0-6)
Programming and use of spreadsheet and software in estimation, quantity survey, Network preparation and computations, scheduling and allocation etc., application of L.P. in construction problem, statistical quality control at site.

CEL771 Civil Engineering Materials
3 credits (3-0-0)
Cement selection for civil works. Concrete making materials. Fresh concrete and its rheology. Mechanical, deformational behavior and microstructure of hardened concrete. Creep and shrinkage. Testing of concrete. Durability of plain and reinforced concrete, Structural steels including alloyed and cold - worked steels.

CEL772 Quantitative Methods in Construction Management
3 credits (2-1-0)
Introduction and concepts of probability and statistics, Linear programming, Transportation and assignment problems. Dynamic programming, Queuing theory, Decision theory, Games theory. Simulations applied to construction, Modifications and improvement on CPM/PERT techniques.

CEL773 Management of Quality and Safety in Construction
3 credits (2-1-0)
Introduction to quality. Planning and control of quality during design of structures. Quantitative techniques in quality control. Quality assurance during construction. Inspection of materials and machinery. In process inspection and test. Preparation of quality manuals, check-list and inspection report. Establishing quality assurance system. Quality standards/codes in design and construction. Concept and philosophy of total quality management (TQM). Training in quality and quality management systems (ISO-9000).

Concept of safety. Factors affecting safety: Physiological, Psychological and Technological. Planning for safety provisions. Structural safety. Safety consideration during construction, demolition and during use of equipment. Management of accidents/injuries and provision of first aid. Provisional aspect of safety. Site management with regard to safety recommendations. Training for safety awareness and implementation. Formulation of safety manuals. Safety legislation, standards/codes with regard to construction. Quality vs Safety. Case Studies.

CEL774 Construction Engineering Practices
3 credits (3-0-0)
Concrete Construction methods: form work design and scaffolding, slip form and other moving forms, pumping of concrete and grouting, mass concreting (roller compacted concrete), ready mixed concrete, various methods of placing and handling concrete, Accelerated curing, Hot and cold weather concreting, Under water concreting, Prestressing.

Steel and composites construction methods: Fabrication and erection of structures including heavy structures, Prefab construction, Industrialized construction, Modular coordination.

Special construction methods: Construction in Marine environments, High rise construction, Bridge construction including segmental construction, incremental construction and push launching techniques, River valley projects.

CEP775 Construction Engineering and Information Technology Laboratory
3 credits (0-0-6)
Test related to quality control at site, In-situ test methods, Tests related to damage assessment and performance monitoring of structures.

Spreadsheet software application in construction management, AUTOCAD, Estimation of project costs, Application of project planning software.

CEL776 Functional Planning, Building Services and Maintenance Management
3 credits (3-0-0)
Components of urban forms and their planning. Concepts of neighourhood unit. Street system and layout in a neightourhood.

Functional planning of buildings, optimization of space: Spatial Synthesis graphical techniques, heuristic procedures, formulation of linear and non-linear optimization problem. Space requirements and relationships for typical buildings, like residential offices, hospitals, etc.

Standard fire, fire resistance, classification of buildings, means of escape, alarms, etc.

Engineering services in a building as a systems. Lifts, escalators, cold and hot water systems, waster water systems, and electrical systems.

Building Maintenance: Scheduled and contingey maintenance planning. M.I.S. for building maintenance. Maintenance standards. Economic maintenance decisions.

CEL777 Building Science
3 credits (3-0-0)
Climatic factors, classfication of tropical climates, site climate, microclimate of human settlements, ventilation requirements for health, mechanisms and estimation of natural ventilation, airflow patterns in building. Thermal comfort factors, comfort indices, thermal quantities, heat exchange in buildings, periodic heat flow. Mechanical and structural means of thermal control. Moisture control in buildings. Propagation of sound, sound insulation absorption and transmission, reverberation, Design of floor, roofing and walling system for sound absorption and insulation. Design of auditaria Noise control in buildings, Day lighting, Design of fenestration in buildings for day light of various types, illumination design, luminaries and their characteristics, codal requirements.

CEL778 Construction Methods and Equipment
3 credits (3-0-0)
Factors affecting selection of equipment - technical and economic, construction engineering fundamentals, Analysis of production outputs and costs, Charateristics and performances of equipment for Earth moving, Erection, Material transport, Pile driving, Dewatring, Concrete construction (including batching, mixing, transport, and placement) and Tunneling.

CEL779 Construction Economics and Finance
3 credits (3-0-0)
Construction accounting, Profit & Loss, Balance Sheet, Income statement, Ratio analysis. Depreciation and amortization. Engineering economics, Time value of money, discounted cash flow, NPV, ROR, PI, Basis of comparison, Incremental rate of return, Benefit-cost analysis, Replacement analysis, Break even analysis. Risks and uncertainties and management decision in capital budgeting. Taxation and inflation.

Work pricing, cost elements of contract, bidding and award, revision due to unforeseen causes, escalation. Turnkey activities, Project appraisal and project yield. Working capital management, financial plan and multiple source of finance. International finance, Budgeting and budgetary control, Performance budgeting. appraisal through financial statements, Practical problems and case studies, Project cash flow.

CEL781 Urban and Regional Transportation Planning
3 credits (2-0-2)
Fundamentals of transportation planning. Components of transportation system and their interaction.Historical development and current status of techniques used in travel demand forecasting; Economic and Social Theory of travel demand forecasting; Trip generation, trip distribution, mode choice, traffic assignment. Dimension of the widening role of urban transportation systems planning, the planning process and use, and transport system models. Role of Environment, City structure and fabric. Comparison and evaluation of various models. Simultaneous travel demand models: Parameter Estimation and Validation. Transportation impact study methodologies. Regional analysis and development concepts. Data collection and use of surveys. The role of transportation planning in the overall regional system. Methodology and models for regional transportation system, planning, implementation framework and case studies. Applications to passenger and freight movement in urban and regional contexts. Implications for policy formulations and analysis.

CEL782 Pavement Materials and Construction Techniques
3 credits (2-0-2)
Subgrade: Various Tests and interpretation in pavement design. Aggregates: Types of aggregates and their properties and tests, batching processes. Binder: types of binders, Physical and chemical properties; Polymer and Rubber Modified binders. Relevant IS and IRC codes, Concrete as Pavement Material: Properties and testing, Concrete Technology in Pavements. Fly ash and its characterisation. Performance based mix Design approaches. Viscoelastic properties of bitumen and bituminous mixtures. Construction Methods: Bituminous and Concrete Pavements. Synthetic, Slog, Waste material. Resolunt Modulus. Finite Element.

CEL783 Traffic Engineering
4 credits (3-0-2)
Traffic studies: Survey and analysis. *t*ypes of Distributions: Speed, Flow and Headways. Composite Distributions. Traffic Forecasting.Concept of level of service and capacity.Intersection studies. Parking Studies, O-D Study and other traffic data collection methods, Gap Acceptance methods. Traffic Signs and Markings. Miscellaneous Traffic Control Devices. Road Lighting. Signalised traffic intersection design round about, signal co-ordination. Traffic flow, delay models. Highway Capacity.

CEL784 Design and Maintenance of Pavements
4 credits (3-0-2)
Design pavement structure. Stresses in rigid and flexible pavements, sub-grade evaluation. Design of flexible, semi-flexible and rigid pavements. Temperature stresses and joints. Pavement management System; Rehabilitation of Pavements; Pavement Inventories and Evaluation; Quality Control; Pavement Lifecycle and cost analysis. Finite Element Approach.

CEL785 Advaced Transportation Modelling
3 credits (2-0-2)
Introduction to transportation systems. Transportation innovations, social and economic impacts of transportation. Decision makers and their options, demand modeling and prediction. Stated and Revealed Preference approaches; Modeling transportation technologies. Analysis of network flows. Transportation networks. Network Theory. Shortest Path Methods: Simple, Multiple, K-Shortest Paths. Path Finding Algorithms and applications in Real time vehicle routing Wardrop's external principles of traffic assignments, evaluation of impacts. Basic physics of transportation Entropy. Location models. Systems approach and its application to transportation engineering and planning; prediction of flows and level of service; production function and cost optimization; network analysis and equilibrium assignment; decision analysis and multidimensional evaluation of transportation projects. Transportation and economic policy, mathematical programming and other modes for selecting network investments. Traffic Pollution.

CEL786 Geometric Design of Streets and Highways
3 credits (2-0-2)
Design control and criteria, relationship of traffic to highway design, design speed, design vehicle. Highway classification, sight distances. Superelevation, highway curves: horizontal and vertical, highway alignment and profile. Geometric design of intersections; grade separation and interchanges. Relevant IRC standards for urban and rural roads.

CEL787 Transportation Safety and Environment
3 credits (3-0-0)
Multidisciplinary approach to planning for traffic safety and injury control; precrash, crash and post crash models; roles of vehicle, roadway traffic, driver, and environment, crash and injury causations; Road Safety Audit; Mixed traffic flow; Transport related pollution; Technology Vision-2020; Urban and non-urban traffic noise sources, Noise level factors, Noise pollution; Energy related aspects of different transport technologies. Traffic Calming Measures. Road transport related air pollution, Sources of air pollution, effects of weather conditions, Vehicular emission parameters, pollution standards, measurement and analysis of vehicular emission; Mitigative measures; EIA requirements of Highway projects, procedure; MOEF World Bank/RC/UK guidelines; EIA practices in India.

CEL788 Public Transportation Systems
3 credits (3-0-0)
Transit System; Estimation of Transit Demand; Route planning techniques; Bus Scheduling; Transit Corridor identification and planning; Mass Transport Management Measures; Integration of Public Transportation Modes. Public transport Infrastructure; Case Studies. Multimodal Transportation Systems.

CEL789 Transportation Systems Management
3 credits (3-0-0)
Quick response travel evaluation procedure, TSM actions: Traffic management techniques for improving vehicular flow, preferential treatment for high occupancy modes, demand management technique for reduced traffic damand, staggered hours, vehicle restrictions. Small area management: individual sites, residential neighbourhoods, planning for pedestrians, parking planning. Travel demand management and telematics in travel planning.

CEP789 Environmental Chemistry and Microbiology
3 credits (1-0-4)
Chemical Equilibria and Kinetics Fundamentals. Acids and Bases; Titrations; Acidity; Alkalinity; Buffers and Buffer Intensity; Chemical equilibrium calculations; pC-pH diagram, Langelier index, Solubility diagram; Oxidation and Reduction reactions. Structure of cell; Types of microorganisms found in the environment; Metabolic classification of organisms. Laboratory Procedures for determining the physical, chemical and microbial parameters of water and wastewater.

CEP790 Advanced Environmental Engineering Laboratory
4 credits (1-0-6)
Principles of instrumentation. Use of advance electronic instruments for analyzing quality of water, waste and air. Experimental data interpretation. Operation of batch scale models for various processes : Activated sludge process, Disinfection, Settlers, Coagulation, Filtration, Anaerobic digestion, Adsorption. Design and operation of treatability studies and microbial growth kinetics. Package programmes for water and wastewater conveyance, treatment and disposal.

CEL793 Air Pollution and Control
4 credits (3-0-2)
Air–pollution – definition, sources, classification. Dynamics of pollutant dispersion and disposal. Effects on environment including living and non-living matter. Ambient air quality monitoring techniques. Air pollution indices, standards, norms, rules and regulations. Removal processes. An introduction to air pollution meteorology. Air Laboratory – High Volume Sampling, Handy Sampler, Bioaerosols sampler, Indoor Air Sampler, Stack Sampling.

CEL794 Solid and Hazardous Waste Management
3 credits (3-0-0)
Municipal Solid Waste : Generation, Rate Variation, Characteristics (Physical, Biological and Chemical); Management Options for Solid Waste, Waste Reduction at the Source, Collection techniques, Materials and Resources Recovery / Recycling. Transport of Municipal Solid Waste, Routing and Scheduling, Treatment, Transformations and Disposal Techniques (Composting, Vermi Composting, Incineration, Refuse Derived fuels, Landfilling). Norms, Rules and Regulations.Biomedical, Hazardous and Nuclear waste Management. Economics of the on-site v/s off site waste management options. Integrated waste management.

CEL795 Water and Wastewater Treatment Processes
3 credits (3-0-0)
Water Demands and Sources, Water quality parameters; Epidemiological and toxic aspects. Physical and chemical interactions due to various forces, suspensions and dispersions. Surface and colloidal chemistry. Settling of particles in water, coagulation and flocculation, floatation, filtration-mechanisms and interpretations, ion exchange and adsorption, Chemical oxidation/reduction processes. Disinfection using chlorine, UV, Ozonation. Water stabilization, aeration and gas transfer. Reverse osmosis, Electrodialysis, Desalination. Treatment and sludge management.

CEL796 Advanced Wastewater Treatment
3 credits (3-0-0)
Microbiological concepts; cells, classification and characteristics of living organisms, charaterisation techniques, reproduction, metabolism, microbial growth kinetics and kinetics of biochemical operations; Modelling of suspended growth systems, techniques for evaluation of kinetic and stoichiometric parameters. Optimal selection of water and waste water treatment chain, Engineered systems, concepts and principles of carbon oxidation, nitrification, denitrification, methanogenasis. Biological nutrient removal; Anaerobic treatment (process options, components of anaerobic reactions that influence process design); Attached growth reactors (process description, design and applications). Decentralised wastewater treatment systems; Low cost options, constructed wetlands. Reliability and cost effectiveness of wastewater systems.

CEL797 Environmental Impact Assessment
3 credits (3-0-0)
Planning and Management of Environmental Impact Studies. Impact indentation methodologies: base line studies, screening, scooping, checklist, networks, overlays. Prediction and assessment of impacts on the socio-economic environment. Environmental cost benefit analysis. Decision methods for evaluation of alternatives. Case Studies. Environmental impact assessment at project level, regional level, sectoral level, and policy level. Sustainable development; Environmental policy in planned, mixed and market economies. Preventive environmental management.

CEL801 Advanced Rock Mechanics
3 credits (3-0-0)
Stress-strain behaviour of rocks and rock masses : Elastic, elasto-plastic and brittle, Anisotropy. Crack phenomena and mechanisms of rock fracture.

Continuum and discontinuum theories : Equivalent material, Block and Distinct element. Fluid flow through intact and fissured rocks

Time dependent behaviour of rocks : Creep, Viscoelasticity and Viscoplasticity. Effect of temperature on rock behaviour. Rock dynamics. Physical modelling.

CES810 Independent Study (Geotechnical and Geoenvironmental Engineering)
3 credits (0-3-0)

CED811 Major Project in Geotechnical and Geoenvironmental Engineering Part I
6 credits (0-0-12)

CED812 Major Project in Geotechnical and Geoenvironmental Engineering Part II
12 credits (0-0-24)

CEL817 Structural Safety and Reliability
3 credits (3-0-0)
Fundamentals of set theory and probability, probability distribution, regression analysis, hypothesis testing. Stochastic process and its moments and distributions, Concepts of safety factors, Safety, reliability and risk analysis, first order and second order reliability methods, simulation based methods, confidence limits and baysean revision of reliability, reliability based design, examples of reliability analysis of structures.

CEL818 Design of Plates and Shells
3 credits (2-1-0)
Prismatic folded plate systems. Shell equations. Approximate solutions. Analysis and design of cylindrical shells. Approximate design methods for doubly curved shells.

CEL819 Concrete Mechanics
3 credits (3-0-0)
Introduction; Rheological modelling of fresh concrete; Constitutive equations; Nonlinear elasticity, plasticity, visco-elasticity and fracture

mechanics of hardened concrete; Confinement and ductility; Moisture diffusion; Drying shrinkage; Solid and structural mechanics of reinforced concrete, Skew bending, modified compression field and unified theories of R.C. beams under bending, shear and torsion; Bond-slip and phenomenon of cracking in reinforced concrete; Statical and dynamical analysis of R.C. Structures; Trends.

CES820 Independent Study (Structural Engineering)
3 credits (0-3-0)

CED821 Major Project Part-1 (Structural Engineering)
6 credits (0-0-12)

CED822 Major Project Part-2 (Structural Engineering)
12 credits (0-0-24)

CEL822 Stability Theory in Structural Engineering
3 credits (3-0-0)
Finite deformation of Structures Elastic buckling of columns; Statical, dynamical and energy-based approaches. Eccentric loading; Nonlinear viscoelastic and elasto-plastic buckling; Flexural-torsional and lateral bucking of beams ; Imperfection sensitivity; Post-buckling and Catastrophe theories; Stability of nonconservative structures; Nonlinear dynamical systems theory; Chaos theory; Recent trends.

CEL824 Design of Offshore Structures
3 credits (2-1-0)
Design of offshore platforms : Introduction, fixed and floating platforms. Steel, concrete and hybrid platforms. Design criteria. Environmental loading. Wind, wave and current loads after installation. Stability during towing. Foundations : Site investigations. Piled foundation. Foundations for gravity structures. Behaviour under dynamic loading. Static and dynamic analysis of platforms and components.

CEL826 Advanced FEM and Programming
3 credits (2-0-2)
Isoparametric formulation for plate and shell elements; various types of elements; Hybrid elements; FEM in dynamic problems, consistent mass matrix; vibration of bars, beams and plate elements; FEM in buckling problems, geometric matrix, buckling of struts and plate elements; Structural modeling by FEM for structures such as shear walls, core walls, bridges and cooling towers; Computational aspects; Interpretation of results; Comparison with other methods.

CEL828 Wind Resistant Design of Structures
3 credits (3-0-0)
Causes and types of wind; atmospheric boundary layer and turbulence, wind velocity measurements and distribution, Bluffbody aerodynamics, random vibrations and spectral analysis, Alongwind and acrosswind response of tall buildings, towers and slender structures, aeroelastic phenomena, vibration of cable supported bridges and power lines due to wind effects, wind pressure on cooling towers, design of cladding and wind damping devices, Wind tunnel simulations and tornado effects.

CEL832 Design of Tall Buildings
3 credits (2-1-0)
Structural systems and concepts. Matrix and approximate methods. Interaction of frames, and shear walls. Twist of frames. Analysis of coupled shear walls. Effect of openings. Large panel construction. Foundation-superstructure interaction. Earthquake effects and design for ductility.

CEL836 Structural Health Monitoring
3 credits (2-0-2)
Pre-requisite : CEL719/AML734/MEL733/MEL831/MEL841/ EEL731
Concept of structural health monitoring, sensor systems and hardware requirements, global and local techniques, computational aspects of global dynamic techniques, experimental mode shapes, damage localization and quantification, piezo-electric materials and other smart materials, electro-mechanical impedance (EMI) technique, adaptations of EMI technique. Laboratory : Sensor installation and diagnostics, model shape extraction, location and quantification of damage using global dynamic techniques, damage detection using electro - mechanical impedance technique, remote monitoring.

CEL840 Stochastic Hydrology
3 credits (3-0-0)
Probability concepts and advance distribution, Stochastic processes, Regression and correlation, Auto-regressive and moving average processes, FGN, Power Spectra, Sequential generation of data, Generation of stochastic fields, Markovian process, Dis-aggregation, Intervention analysis, Time series analysis and modeling, Stochastic models, Spatial and temporal modeling of hydrological variables, Risk analysis in hydrology.

CES840 Independent Study (Water Resources Engineering)
3 credits (0-3-0)

CED841 Major Project Part-1 (Water Resources Engineering)
6 credits (0-0-12)

CED842 Major Project Part-2 (Water Resources Engineering)
12 credits (0-0-24)

CEL843 Traffic Modelling and Simulation
3 credits (2-0-2)
Evaluation of various qualitative and quantitative descriptors of traffic flow, car-following analogy, Theories of Traffic Flow: Catastrophe theory, Modelling Process; Taxonomy of model types: Primitive Models; Forecasting pattern Recognition Static Equilibrium; Model's Linear Dynamical Structure; Growth and Decay processes; Pedestrian Flow Modelling and dynamics; Simulation of Discrete and Continuous processes; Application of macro and micro simulation packages.

CEL844 Transportation Economics and Finance
3 credits (3-0-0)
Overview of Transportation Economics; Transportation Investments and Economic Development. Basics of Engineering economics. Money value of time, discounted cash flow, NPV, ROR, PI, Bases of comparison, incremental rate of return, benefit-cost analysis, replacement analysis, break even analysis, risks and uncertainties and management decision in capital budgeting. Road User Costs; Public Transportation economics; Social Cost of Transportation; project appraisal and project yield. Legal Framework in transport Sector. Financing Transport Infrastructure; Appraisal through financial statements, practical problems and case studies.

CEL845 Transportation and Traffic Infrastructure Design
3 credits (3-0-0)
Design and drawing of grade intersections, Rotaries, Mini- roundabouts, interchanges (cloverleaf, trumpet), multilevel intersections; On-street parking facilities; Off-street parking facilities (parking lots and garages); Layout for buses and trucks; Bridges and Fly-overs; Guard rails; Culverts; Retaining Sides; Mix wells; Pedestrian sideways; Foot bridges; River Spans; Tunnels and Underpasses; Design of Superstructures (T-beam slab, Solid slab right skew and curved spares). Airport Terminal, Sea Port Infrastructure, Railway and Metro Structure.

CES850 Independent Study (Rock Engineering and Underground Structures)
3 credits (0-3-0)

CED851 Major Project Part-1 (Rock Engineering and Underground Structures)
6 credits (0-0-12)

CED852 Major Project Part-2 (Rock Engineering and Underground Structures)
12 credits (0-0-24)

CEL866 Infrastructure Development and Management
3 credits (3-0-0)

Introduction of Indian infrastructure programme, qualitative and quantitative description of various sectors of infrastructure; life cycle; methodologies for planning - economic evaluation and feasibility study; Issues related to environmental and social impact of infrastructure projects; Regulatory framework for different sectors.

Financial modeling - life cycle cost; cash flow; internal rate of return; Benefit cost analysis. Financing schemes; Grant, Government policies and incentives; Fixing of Toll charges/Tariff, Option pricing.

Infrastructure risks - type and impacts. Assessment of impacts through Earned value analysis, Kalman Filter and time series analysis techniques. Risk Modeling - Monte Carlo simulation; decision tree; fault tree; utility theory, AHP. Policies and guidelines.

Private sector participation - public-private-partnership models, BOT, BOOT, BOO. Forms of concession agreement, financial closure.

Domestic and international experiences; case studies.

CED870 Independent Study (Construction Engineering & Management)
3 credits (0-3-0)

CED871 Major Project Part-1 (Construction Engineering & Management)
6 credits (0-0-12)

CED872 Major Project Part-2 (Construction Engineering & Management)
12 credits (0-0-24)

CES874 Independent Study (Construction Technology & Management)
3 credits (0-3-0)

CED875 Major Project Part-1 (Construction Technology & Management)
6 credits (0-0-12)

CED876 Major Project Part-2 (Construction Technology & Management)
12 credits (0-0-24)

CEL879 Industrial Waste Management and Audit
3 credits (3-0-0)

Nature and characteristics of industrial wastes; Prevention versus control of industrial pollution; Linkage between technology and pollution prevention; Tools for clean processes, reuse, recycle, recovery, source reduction, raw material substitution, toxic use reduction and process modifications; Flow sheet analysis; Energy and resource (material and water) audits for efficient usage and conservation; Waste audits, emission inventories and waste management hierarchy for process industries; Environmental performance indicators; Concept of industrial ecology and symbiosis of eco-parks; Case studies of various industries, e.g., dairy, fertilizer, distillery, sugar, pulp and paper, iron and steel, metal plating, refining, thermal power plants.

CED881 Major Project Part-1
6 credits (0-0-12)

CEL882 Major Project Part-2
12 credits (0-0-24)

CEL886 Environmental Systems Analysis
4 credits (3-0-2)

Introduction to natural and man-made systems. Systems modeling as applied to environmental systems. Nature of environmental systems, the model building process addressing to specific environmental problems. Introduction to Water pollution and transport and atmospheric processes. Strategies for analyzing and using environmental systems

models. Application of optimization methods such as search techniques, linear programming, dynamic programming and integer programming. Integrated management strategies addressing multi-objective planning : Optimization over time. Laboratory – Simulation of Environmental Processes, Application of Environmental Databases and Environmental Software Packages, including systems Optimisation.

CEL889 Emerging Technologies for Enviromental Management
3 credits (3-0-0)

Identification and evaluation of current and emerging technological issues that impact environmental decision-making. Linkages between technology, environmental quality, economic gain, and societal goals; Contemporary issues: Environmentally sound technology transfer, emission trading, international resources sharing issues, climate change, international environmental treaties and protocols.

CES890 Independent Study (Environmental Engineering and Management)
3 credits (0-3-0)

Comprehensive review of problems and solutions related to air, water, wastewater, and solid waste management. Identification and evaluation of current and emerging local, regional and global environmental, and socio-economic issues.

CED891 Major Project Part-1 (Environmental Engineering and Management)
6 credits (0-0-12)

CEL891 Thermal Techniques for Waste Treatment
3 credits (3-0-0)

Fundamentals of Thermodynamics, combustion, Heat transfer and Mass transfer as applied to waste incineration. Introduction to fuels, reactor design and furnace technology. Combustion of gases, liquids and solids. Products of combustion. Low Temperature Techniques: Autoclaving, Wet Air Oxidation, Microwaving. High Temperature Techniques : Incineration, Gasification, Pyrolysis. Advanced Technologies : Circulating Fluidized Bed Systems, Plasma Arc Pyrolysis, Co-burning, Oxygen Lancing, Starved Air Incineration, Heat recuperation and Energy Recovery, Boilers and Heat Exchangers. Pollution control and management options for thermal techniques. Economics of thermal techniques.

CED892 Major Project Part-2 (Environmental Engineering and Management)
12 credits (0-0-24)

CEL892 Air Quality Modelling
3 credits (3-0-0)

Introduction to Air Quality Modelling. Approaches to model formulation. Model classification, criteria for model selection. Air pollution meteorology – meteorological parameters, stability classification; plume rise; plume behaviour, dispersion parameters. Wind and Pollution rose diagram Basic diffusion equation, deterministic, numerical and statistical modeling approach. Introduction to boundary layer, turbulence – physical modeling approach. Stochastic modeling approach to air pollution dispersion. Theory of Gaussian plume model and its application. Introduction to Air Quality Models. Case studies.

CEL894 Management of Water, Waste and Sanitation Utilities
3 credits (3-0-0)

Introduction to sustainable management of Water and Sanitation (WATSAN) sector, Development programmes, Feasibility planning. Project Appraisal : Economic, Institutional and Environmental aspect., Institutional & Economical analysis of urban water and sanitation utilities, Contract management, Public-Private Partnerships and related issues. Strategic Management : Change Management, Financial & Marketing Management for water managers, Management, Water quality surveillan programmes. Unaccounted for Water, Customer Service, and Tariff fixation. Case Studies. Globalization and the State's Changing Role in Infrastructure Development, the Financial Institution's role in policy making for water management, Concept of Water Markets and the role of National and Federal Governments.

CED895 Major Project (M.S. Research)
40 credits (0-0-80)

CEL895 Ecology and Eco-System Dynamics
3 credits (3-0-0)

Concepts of diversity. Diversity in eco-systems and habitat classification, important types of eco-systems (e.g. Wetland eco-system including estuaries, tidal marsh lands, swamps, lakes, etc.), Forest eco-system (including tropical forests, Himalayan and sub-Himalayan forest eco-system etc.), Desert eco-system, Coastal shelf eco-system, Temperature and Tundra eco-system, Grasslands etc. Abiotic factors affecting the distribution and productivity of various terrestrial life forms. Leibig's law of minimum. Census techniques, random sampling, various indices of species dominance, richness and abundance, species evenness and diversity. Statistical models, cluster and principal component analysis for similarity studies. Links between diversity and stability. Concept of succession and its use in reclaimation. Facilitation, enablement, Trophic structure, food webs, energy flow diagram, nutrient cycles. Restoration, Reclamation, and Regeneration of Degraded or Destroyed Ecosystems.

CEL896 Design of Water and Wastewater Facilities
3 credits (3-0-0)

Design and analysis of water distribution system, Design and analysis of wastewater conveyance system. Water treatment : Source selection process, selection of treatment chain, plant siting, Treatability studies. Design of physicochemical unit operations : screening, flow measurement and pumping, grit removal, equalisation, sedimentation, floatation, coagulation-flocculation, filtration, disinfection. Wastewater Treatment : Design of pre-treatment, secondary treatment, and tertiary treatment, disposal systems. Design of processes for nitrogen and phosphorus removal. Sludge stabilization, treatment, sludge thickening, sludge drying, aerobic and anaerobic digestion of sludges. Hydraulics of treatment plants; flow measurement and hydraulic control points, hydraulic profile through the treatment plant.

CEL897 Membrane Processes for Water and Waste Treatment
3 credits (3-0-0)

Introduction to membrane separation processes, Membrane filtration, dead end filtration, Cake filtration. Equation of Ruth, Kozney-Carman law, Cross flow filtration, Reverse osmosis, Nanofiltration, Ultrafiltration, Microfiltration, Membranes and modules, MF/UF experimental set up, Laws of MF/UF, Limiting Phenomena : Concentration polarization and membrane fouling, Mass transport, and Energy balance. Functioning in closed loop, open loop and with re-circulation. Module arrangement: series or parallel and optimisation. Applications : drinking water, municipal wastewater. Case studies.

CEL898 Life Cycle Analysis and Design for Environment
3 credits (3-0-0)

Engineering products and processes : Environmental health and safety, Product life cycle stages, Material toxicity, pollution, and degradation, Environmentally conscious design and manufacturing approaches, Sustainable development and industrial ecology. System life-cycles from cradle to reincarnation, Product life-extension, Organizational issues. Pollution prevention practices, Manufacturing process selection and trade-offs. Design for Environment : Motivation, concerns, definitions, examples, guidelines, methods, and tools. Recyclability assessments, Design for recycling practices. Re-manufacturability assessments, Design for Remanufacture / Reuse practices. Industrial ecology and Eco-industrial parks. Eco-Labels and Life-Cycle analysis (LCA) : LCA methodology, steps, tools and problems, Life-Cycle Accounting and Costing. ISO 14000 Environmental Management Standards. New business paradigms and associated design practices.

CEL899 Environmental Risk Assessment
3 credits (3-0-0)

Basic concepts of environmental risk and definitions; Hazard identification prodedures; Environmental Risk Zonation; Consequence analysis and modeling (discharge models, dispersion models, fire and explosion models, effect models etc). Estimation of incident frequencies from historical date, frequency modeling techniques e.g., Fault Tree Analysis (FTA) and Event Tree analysis (ETA). Case studies. Human factors in risk analysis; Calculation and presentation of risk (individual risk, societal risk); Risk management. Rules, regulations and conventions.

Department of Computer Science and Engineering

CSL101 Introduction to Computers and Programming
4 credits (3-0-2)
Overlaps with: CSL102
Concept of an algorithm: termination and correctness. Algorithms to programs: specification, top-down development and stepwise refinement. Use of high level programming language for the systematic development of programs. Introduction to the design and implementation of correct, efficient and maintainable programs. Introduction to computer architecture: memory, ALU, CPU, I/O devices. Introduction to system software; operating systems, compilers and multi-user environments.

CSL102 Introduction to Computer Science
4 credits (3-0-2)
Overlaps with: CSL101
Design of algorithms; iterative versus recursive style; problem solving using a functional style; correctness issues in programming; efficiency issues in programming; time and space measures; Imperative style of programming; Assertions and loop invariants; programming in an imperative language using advanced features: procedures, functions, list handling using references; file handling; objects and classes.

CSL105 Discrete Mathematical Structures
4 credits (3-1-0)
Overlaps with: MAL180
Fundamental structures: Functions (surjections, injections, inverses, composition); relations (reflexivity, symmetry, transitivity, equivalence relations); sets (Venn diagrams, complements, Cartesian products, power sets); pigeonhole principle; cardinality and countability. Basic logic: Propositional logic; logical connectives; truth tables; normal forms (conjunctive and disjunctive); validity; predicate logic; limitations of predicate logic; universal and existential quantification; modus ponens and modus tollens. Proof techniques: Notions of implication, converse, inverse, contrapositive, negation, and contradiction; the structure of formal proofs; direct proofs; proof by counterexample; proof by contraposition; proof by contradiction; mathematical induction; strong induction; recursive mathematical definitions; well orderings. Basics of counting: Counting arguments; pigeonhole principle; permutations and combinations; inclusion-exclusion, recurrence relations, generating functions.

CSN110 Introduction to Computer Science and Engineering
2 credits (0-0-4)
Overview of the Department's academic/research programmes; state of the computer industry in India and abroad.

CSL201 Data Structures
5 credits (3-0-4)
Pre-requisites: CSL101 / CSL102
Introduction to object-oriented programming through stacks, queues and linked lists. Dictionaries: skip-lists, hashing, analysis of collision resolution techniques. Trees, traversals, binary search trees, Balanced BST, Tries. Priority queues and binary heaps. Object oriented implementation and building libraries Applications to discrete event Simulation Sorting: merge, quick, radix, selection and heap sort. Graphs: Breadth first search and connected components. Depth first search in directed and undirected graphs. Union-find data structure and applications. Directed acyclic graphs: topological sort .

CSL211 Computer Architecture
5 credits (3-1-2)
Pre-requisites: (CSL101/CSL102) & (EEL201&EEP201)
(Concurrent registration in EEL201&EEP201 is acceptable)
Overlaps with: EEL308, EEP308
Subsystems of a computer; Instructions and their formats; Assembly programming; Performance metrics; Performance comparison; Information representation; Integer and floating point arithmetic; Processor datapath design; Control unit design; Microprogramming; Performance improvement with pipelining; Memory organization - cache and virtual memory; Input/Output organization; Interrupts and DMA.

CSP301 Design Practices in Computer Science
3 credits (0-1-4)
Pre-requisites: CSL201
Basic design methodology – introduction to the steps involved, Familiarization with software practices, tools and techniques, Software project involving conceptualization, design, analysis, implementation and testing using the tools and techniques learnt.

CSL302 Programming Languages
5 credits (3-0-4)
Pre-requisites: CSL201
Overlaps with: MAL375
Notions of syntax and semantics of programming languages; introduction to operational/natural semantics of functional and imperative languages. Data abstractions and control constructs; block-structure and scope, principles of abstraction, qualification and correspondence; parameter passing mechanisms; runtime structure and operating environment; practical and implementation issues in run-time systems and environment; abstract machines; features of functional and imperative languages; the untyped and simply-typed Lambda calculus, type systems for programming languages including simple types and polymorphism; objects, classes and inheritance in object-oriented languages.

CSL303 Logic for Computer Science
4 credits (3-0-2)
Pre-requisites: CSL201
Review of the principle of mathematical induction; the principle of structural induction; review of Boolean algebras; Syntax of propositional formulas; Truth and the semantics of propositional logic; Notions of satisfiability, validity, inconsistency; Deduction systems for propositional logic; Completeness of a deduction system; First order logic; Proof theory for FOL; introduction to model theory; Completeness and compactness theorems; First order theories. Programming exercises will include representation and evaluation; conversion to normal-forms; tautology checking; proof normalization; resolution; unification; Skolemization; conversion to Horn -clauses; binary-decision diagrams.

CSD310 Mini Project (CS)
3 credits (0-0-6)
Pre-requisites: EC 80
Design/fabrication/implementation work under the guidance of a faculty member. Prior to registration, a detailed plan of work should be submitted by the student to the Head of the Department for approval.

CSR310 Professional Practices (CS)
2 credits (0-1-2)
Pre-requisites: EC 60
The course would consist of talks by working professionals from industry, government and research organizations. It may also include site visits to various organizations.

CSS310 Independent Study (CS)
3 credits (0-3-0)
Pre-requisites: EC 60
Research oriented activities or study of subjects outside regular course offerings under the guidance of a faculty member. Prior to registration, a detailed plan of work should be submitted by the student to the Head of the Department for approval.

CSP315 Embedded System Design Laboratory
4 credits (0-1-6)
Pre-requisites: CSL211
This course is a project oriented course where a group of students (normally 3 to 5) would be required to work on an innovative embedded system design project. Though the emphasis would be on implementation, they would be required to go through all aspects of system design including drawing up proper specifications as well as evaluation of alternatives. The tutorial hour would be utilized both for preliminary introduction to embedded components by the instructor(s) as well as regular presentation by each group for sharing with other groups.

CSL316 Digital Hardware Design
5 credits (3-0-4)
Pre-requisites: CSL211 & EEL201 & EEP201
Overlaps with: EEL324
Combinational circuit design using MSI/LSI and programmable logic modules; Iterative and tree networks; Sequential circuit design and implementation; Algorithmic state machine design; Asynchronous and pulse mode circuit design; Hardware description language and synthesis; Microprogrammed control design; Testing of digital systems; Introduction to hardware-software codesign.

CSL332 Introduction to Database Systems
4.5 credits (3-0-3)
Pre-requisites: CSL201
Overlaps with: MAL710
The world of Database Systems, The E-R Model, The three database models, Representation and Evaluation of Relationship, The Relational Database Model, Functional Dependencies, Multi-valued and join Dependency, Normaliztion Theory, Concurrency Control in Relational Databases, Object Oriented Data Models.

CSL333 Artificial Intelligence
4 credits (3-0-2)
Pre-requisites: CSL201
Overlaps with: EEL758
Problem solving, search techniques, control strategies, game playing (minimax), reasoning, knowledge representation through predicate logic, rule-based systems, semantic nets, frames, conceptual dependency formalism. Planning. Handling uncertainty: Bayesian Networks, Dempster-Shafer theory, certainty factors. Fuzzy logic, Learning through Neural nets- Back propagation, radial basis functions, Neural computational models - Hopfield Nets, Boltzman machines. PROLOG programming.

CSL356 Analysis and Design of Algorithms
4 credits (3-1-0)
Pre-requisites: CSL201
Overlaps with: MAL342
RAM model and complexity: O(log n) bit model, Integer sorting and string sorting, Review of fundamental data structures: Red-black trees, mergeable heaps, interval trees Fundamental design methodologies and their implementations: Search Techniques, Dynamic Programming, Greedy algorithms, Divide and Conquer, Randomized Techniques. Algorithms for set manipulations, their implementations and applications: Union-Find Randomized data structures: Skip Lists, Universal Hash functions, Graph Algorithms with implementation issues; Depth-First Search and its applications, minimum Spanning Trees and Shortest Paths. Convex hulls, sorting, Selection Matrix multiplication, pattern matching, integer and polynomial arithmetic, FFT. Introduction to the Theory of Lower Bounds, NP-Completeness and Reductions. Approximation algorithms.

CSL361 Numerical and Scientific Computing
5 credits (3-1-2)
Pre-requisites: CSL101 / CSL102 and EC 60
Overlaps with: MAL230, EPL333
Introduction to Scientific Computing, Review of matrices and linear systems, Linear Least Squares, Eigenvalue Problems, Nonlinear Equations. Optimization, Interpolation, Numerical Integration and Differentiation, Initial and Boundary Value Problems for Ordinary Differential Equations, Partial Differential Equations, Fast Fourier Transform. Throughout the course, implementation of the various methods and their comparisons with professionally written software such as LINPACK, ITPACK, EISPACK, LAPACK, SPARSE PACK will be emphasized with the understanding of various data-structures, storage schemes etc. Existence and uniqueness, sensitivity and condition, convergence and error analysis will be part of every topic.

CSL362 Simulation and Modelling
4 credits (3-0-2)
Pre-requisites: CSL201 & MAL250
Fundamentals of modelling; Classification of simulation models; The simulation process: System investigation; model formulation, validation and translation; Time flow mechanisms; Design of computer simulation experiments; Simulation of complex discrete-event systems with applications in industrial and service organizations. Tactical planning and management aspects; Random variable generation and analysis.

CSL373 Operating Systems
5 credits (3-0-4)
Pre-requisites: CSL201 & CSL211 & CSL302
Overlaps with: CSL633, EEL358, MAL358
Overview: functions of Operating Systems, layered architecture; basic concept; interrupt architecture, system calls and notion of a process and threads; synchronization and protection issues; scheduling; memory management including virtual memory and paging techniques; input-output architecture and device management; file systems; distributed file systems; Case studies of Unix , Windows NT. Design and implementation of small operating systems.

CSL374 Computer Networks
4.5 credits (3-0-3)
Pre-requisites: EEL205 & CSL211 & CSL201
Overlaps with: EEL703
Fundamentals of Digital Communications, including channel capacity, error rates, multiplexing, framing and synchronization. Broadcast network and multi-access protocols, including CSMA/CD. Data link protocols, Network protocols including routing and congestion control, IP protocol. Transport protocol including TCP. Network application services and protocols including email, www, DNS. Network security and management.

CSC410 Colloquium (CS)
3 credits (0-3-0)
Pre-requisites: Registered for CST410
The students will deliver talks on their experience during the 50 working days of practical training, and topics of current interest in the computer science and engineering field. These would include technology, research as well standards issues.

CST410 Practical Training (CS)
Non credit
Pre-requisites: EC 90 at the end of 5th sem.
Expose the students to the actual Industrial environment. Fifty (50) working days or 400 hours of practical training in an industry/research laboratory.

CSD411 Major Project Part 1 (CS)
4 credits (0-0-8)
Pre-requisites: EC 120
This project spans also the course CSD412. Hence it is expected that the problem specification and the milestones to be achieved in solving the problem are clearly specified.

CSD412 Major Project Part 2 (CS)
8 credits (0-0-16)
Pre-requisites: CSD411
The student(s) who work on a project are expected to work towards the goals and milestones set in CSD411. At the end there would be a demonstration of the solution and possible future work on the same problem. A dissertation outlining the entire problem, including a survey of literature and the various results obtained along with their solutions is expected to be produced.

CSL630 Data Structures and Algorithms
4 credits (3-0-2)
Review of basic data structures and their realization in object oriented environments. The following topics will be covered with emphasis on formal analysis and design. Dynamic Data structures: 2-3 trees, Red-black trees, binary heaps, binomial and Fibonacci heaps, Skip lists, universal hashing. Data structures for maintaining ranges, intervals and disjoint sets with applications. Basic algorithmic techniques like dynamic programming and divide-and-conquer. Sorting algorithms with analysis, integer sorting, selection. Graph algorithms like DFS with applications, MSTs and shortest paths.

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CSL632 Introduction to Data Base Systems
4 credits (3-0-2)
Evolution and architecture of DB systems, DB models. The relational DB model, operations on the relational model. The database language SQL, constraints and triggers in SQL, system aspects of SQL. Object-oriented query languages. XML databases.

CSL633 Resource Management in Computer Systems
4 credits (3-0-2)
Overview: functions of operating systems, layered architecture; basic concepts; interrupt architecture, system calls and notion of a process and threads; synchronization and protection issues; scheduling; memory management including virtual memory management and paging techniques; i/o architecture and device management; file systems; distributed file systems; Case studies of Unix, Windows NT. Design and implementation of small operating systems.

CSL671 Artificial Intelligence
4 credits (3-0-2)
Problem solving, search techniques, control strategies, game playing (minimax), reasoning, knowledge representation through predicate logic, rule based systems, semantics nets, frames, conceptual dependency. Planning. Handling uncertainty: probability theory, Bayesian Networks, Dempster-Shafer theory, Fuzzy logic, Learning through Neural nets - Back propagation, radial basis functions, Neural computational models - Hopfield Nets, Boltzman machines. PROLOG programming. Expert Systems.

CSL672 Computer Networks
4 credits (3-0-2)
Networks, goals, applications, classification, layered architecture. Open system interconnection model. Statistical multiplexing; Point to point and broadcast communications, multi access protocols: Aloha, CSMA and its variations, Token Ring; Error Control techniques; Flow control; Data link layer protocols; Bridges, Repeaters, switches and the spanning tree protocol. Routing, Congestion control, Internet protocols; Multicast Routing and reliable Multicast. Mobile IP. Laboratory exercises will focus on the students ability to use these protocols in practical systems.

CSP701 Software Systems Laboratory
3 credits (0-0-6)
A set of four project oriented assignments which will be announced at the start of each semester with definite submission deadlines. The set of assignments will be designed to develop skills and familiarity with a majority of the following: make, configuration management tools, installation of software, archiving and creation of libraries, version control systems, documentation and literate programming systems (noweb and LaTeX), lex, yacc, perl and other scripting languages, sockets and RPCs, usage of standard libraries like pthreads, numerical packages, XML and semi-structured data, simulation environments, testing and validation tools.

CSL705 Theory of Computation
4 credits (3-1-0)
Pre-requisites: CSL105 & EC90
Regular Languages, Finite Automata, equivalence, minimization, Myhill-Nerode Theorem, introduction to non-determinism, Context free grammars, Pushdown automata, equivalence, and applications Turing machines, Recursive and Recursively enumerable sets, non-determinism, RAMs and equivalence, Universal Turing Machines, undecidability, Rice's theorems for RE sets Post machines, Basics of Recursive function theory, equivalence, Church's thesis Computational Complexity, space and time complexity of Turing Machines, Relationships, Savage's theorem, Complexity classes, Complete problems, NP completeness, Cook-Levin theorem.

CSL718 Architecture of High Performance Computers
4 credits (3-0-2)
Pre-requisites: CSL373
Classification of parallel computing structures; Instruction level parallelism - static and dynamic pipelining, improving branch performance, superscalar and VLIW processors; High performance memory system; Shared memory multiprocessors and cache coherence; Multiprocessor interconnection networks; Performance modelling; Issues in programming multiprocessors; Data parallel architectures.

CSL719 Synthesis of Digital Systems
4 credits (3-0-2)
Pre-requisites: CSL316
After a basic overview of the VLSI design flow, hardware modelling principles and hardware description using the VHDL language are covered. This is followed by a study of the major steps involved in behavioural synthesis: scheduling, allocation, and binding. This is followed by register-transfer level synthesis, which includes retiming and Finite State Machine encoding. Logic synthesis, consisting of combinational logic optimisation and technology mapping, is covered next. Popular chip architectures - standard cells and FPGA are introduced. The course concludes with a brief overview of layout synthesis topics: placement and routing.

CSL724 Advanced Computer Networks
4 credits (3-0-2)
Pre-requisites: CSL374
Review of the internet architecture, layering; wired and wireless MAC; intra and inter-domain internet routing, BGP, MPLS, MANETs; error control and reliable delivery, ARQ, FEC, TCP, congestion and flow control; QoS, scheduling; mobility, mobile IP, TCP and MAC interactions, session persistence; multicast; Internet topology, economic models of ISPs/CDNs/content providers; future directions.

CSL728 Compiler Design
4.5 credits (3-0-3)
Pre-requisites: CSL302
Overlaps with: EEL702
Compilers and translators; lexical and syntactic analysis, top-down and bottom up parsing techniques, internal form of source programs; semantic analysis, symbol tables, error detection and recovery, code generation and optimization. Type checking and static analysis. Algorithms and implementation techniques for type-checking, code-generation and optimization. Students will design and implement translators, static analysis, typechecking, and optimization.

CSL730 Modern Parallel Programming
4 credits (3-0-2)
Pre-requisites: CSL201 and CSL373
Parallel performance metrics, Models of parallel computation, Parallel computer organization, Parallel programming environments, Load distribution, Throughput, Latency and Latency hiding, Memory and Data Organizations, Inter-process communication, Distributed memory architecture, Interconnection network and routing, Shared memory architecture, Memory consistency, Non-uniform memory, Parallel Algorithm techniques: Searching, Sorting, Prefix operations, Pointer Jumping, Divide – and – Conquer, Partitioning, Pipelining, Accelerated Cascading, Symmetry Breaking, Synchronization (Locked/ Locked-free).

CSL740 Software Engineering
4 credits (3-0-2)
Pre-requisites: CSL201 & CSL302
Overlaps with: MAL745
Concepts and techniques relevant to production of large software systems: Structured programming. Requirements specification and analysis. Top-down design and development. Information hiding, abstraction, modularity, object-oriented techniques. Separate compilation, configuration management, program libraries. Design patterns; UML. Documentation. Validation. Quality assurance, safety. Testing and test case generation. Software metrics. Cost analysis and estimation, manpower and time management. Organization and management of large software design projects.

CSD745 Minor Project
4 credits (0-1-6)
Research and development projects based on problems of practical

and theoretical interest. Evaluation will be based on periodic presentations, student seminars, written reports, and evaluation of the developed system (if applicable).

CSD750 Minor Project (CO)
4 credits (0-1-6)
Pre-requisites: EC 120
A semester-long project usually involving design and implementation under the guidance of any faculty member approved by the department, is undertaken by one or two students.

CSL750 Foundations of Automatic Verification
4 credits (3-0-2)
Pre-requisites: CSL302 & CSL705
A selection from the following topics, and experiments with the mentioned tools:

Review of first-order logic, syntax and semantics. Resolution theorem proving. Binary Decision Diagrams (BDDs) and their use in representing systems. (Programming exercises coding and using logic programming frameworks). Transition systems, automata and transducers. Buechi and other automata on infinite words; Linear Time Temporal Logic (LTL), and specifying properties of systems in LTL; the relationship between temporal logic and automata on infinite words, LTL Model checking (exercises using Spin or similar tools); Computational Tree Logic (CTL and CTL*); CTL model checking (exercises); Process calculi such as CSP and CCS. Notions of program equivalence — traces, bisimulation and other notions. Hennessy-Milner Logic (HML) and Mu calculus (exercises using tools such as CWB — Concurrency Work Bench). Symbolic model checking, exercises using tools such as SMV. Sat-based model checking and Davis-Putnam procedure; (exercises using tools such as nuSMV). Possible additional topics include: equational logic frameworks, real-time frameworks, reactive frameworks, pi-calculus (exercises using tools such as the Mobility Workbench), Tree automata and Weak Second-order Logic with k successors (WSkS), (exercises using Mona or similar tools).

CSL758 Advanced Algorithms
4 credits (3-0-2)
Pre-requisites: CSL356/CSL630
Overlaps with: MAL760
Topics from some or all of the following areas:

Advanced data structures: self-adjustment, persistence and multidimensional trees. Randomized algorithms: Use of probabilistic inequalities in analysis, Geometric algorithms: Point location, Convex hulls and Voronoi diagrams, Arrangements applications using examples. Graph algorithms: Matching and Flows. Approximation algorithms: Use of Linear programming and primal dual, Local search heuristics. Parallel algorithms: Basic techniques for sorting, searching, merging, list ranking in PRAMs and Interconnection networks.

CSL759 Cryptography and Computer Security
4 credits (3-0-0)
Pre-requisites: CSL356 or equivalent, MAL250 or equivalent
Overlaps with: MAL724, MAL730, MAL786
Classical ciphers; private key encryption; hash functions; SHA1, MD5; message authentication; HMAC; pscudorandom permutations: AES, DES; theoretical foundations: one-way functions, pseudorandom generators, number theory; public key encryption: RSA, Rabin, knapsack; digital signatures: RSA, E1 Gamal, Rabin; key distribution: Diffie-Hellman; protocols: oblivious transfer, bit commitment, coin flipping, secret sharing, digital cash, elections; other topics: payments, biometrics, virus & worms, large scale cryptanalysis, identity based encryption etc.

CSL765 Introduction to Logic and Functional Programming
4 credits (3-0-2)
Introduction to declarative programming paradigms. The functional style of programming, paradigms of development of functional programs, use of higher order functionals and pattern-matching. Introduction to lambda calculus. Interpreters for functional languages and abstract machines for lazy and eager lambda calculi, Types, type-checking and their relationship to logic. Logic as a system for declarative programming. The use of pattern-matching and programming of higher order functions within a logic programming framework. Introduction to symbolic processing. The use of resolution and theorem-proving techniques in logic programming. The relationship between logic programming and functional programming.

CSL771 Database Implementations
4 credits (3-0-2)
Pre-requisites: CSL332 & CSL201
Overlaps with: CSL630
Relational Algebra, Database Language SQL and System Aspects of SQL, Constraints and triggers, Disk Storage, Disk and Memory Organization for Relational Operators, Representing Data Elements, Index Structures, Query Execution, Query Compilation, Query Optimization, Coping with System Failures, Concurrency Control, Transaction Management, Representation of Data.

CSL781 Computer Graphics
4.5 credits (3-0-3)
Pre-requisites: CSL201 and EC 90
Overlaps with: MAL754, EEL754
Graphics pipeline; Graphics hardware: Display devices, Input devices; Raster Graphics: line and circle drawing algorithms; Windowing and 2D/3D clipping: Cohen and Sutherland line clipping, Cyrus Beck clipping method; 2D and 3D Geometrical Transformations: scaling, translation, rotation, reflection; Viewing Transformations: parallel and perspective projection; Curves and Surfaces: cubic splines, Bezier curves, B-splines, Parametric surfaces, Surface of revolution, Sweep surfaces, Fractal curves and surfaces; Hidden line/surface removal methods; illuminations model; shading: Gouraud, Phong; Introduction to Ray-tracing; Animation; Programming practices with standard graphics libraries like openGL.

CSL783 Digital Image Analysis
4.5 credits (3-0-3)
Pre-requisites: EEL205 & CSL201 and EC 90
Overlaps with: MAL715, EEL715
Digital Image Fundamentals; Image Enhancement in Spatial Domain: Gray Level Tranaformation, Histogram Processing, Spatial Filters; Image Transforms: Fourier Transform and their properties, Fast Fourier Transform, Other Transforms; Image Enhancement in Frequency Domain; Color Image Processing; Image Warping and Restoration; Image Compression; Image Segmentation: edge detection, Hough transform, region based segmentation; Morphological operators; epresentation and Description; Features based matching and Bayes classification; Introduction to some computer vision techniques: Imaging geometry, shape from shading, optical flow; Laboratory exercises will emphasize development and evaluation of image processing methods.

CSS799 Independent Study
3 credits (0-3-0)
Research oriented activities or study of advanced subjects outside regular course offerings under the guidance of a faculty member. Prior to registration, a detailed plan of work should be submitted by the student, in concurrence with a faculty guide, to the Head of the Department for approval.

CSL812 System Level Design and Modelling
3 credits (3-0-0)
Pre-requisites: CSL719
Embedded systems and system-level design, models of computation, specification languages, hardware/software co-design, system partitioning, application specific processors and memory, low power design.

CSL821 Reconfigurable Computing
3 credits (3-0-0)
Pre-requisites: CSL316 and EC 120
FPGA architectures, CAD for FPGAs: overview, LUT mapping, timing analysis, placement and routing, Reconfigurable devices - from fine-grained to coarse-grained devices, Reconfiguration modes and multi-context devices, Dynamic reconfiguration, Compilation from high level languages, System level design for reconfigurable systems: heuristic temporal partitioning and ILP-based temporal partitioning, Behavioral synthesis, Reconfigurable example systems' tool chains.

CSL830 Distributed Computing
3 credits (3-0-0)
Pre-requisites: CSL373 & CSL705
Models of Distributed Computing; Basic Issues: Causality, Exclusion, Fairness, Independence, Consistency. Specification of Distributed Systems: Transition systems, Petri nets, process algebra. Properties: Safety, Liveness, stability.

CSL831 Semantics of Programming Languages
3 credits (3-0-0)
Pre-requisites: CSL302 & CSL303 and EC 120
Study of operational, axiomatic and denotational semantics of procedural languages; semantics issues in the design of functional and logic programming languages, study of abstract data types.

CSL832 Proofs and Types
3 credits (3-0-0)
Pre-requisites: CSL302 & CSL303 and EC 120
Syntax and semantic foundations: Ranked algebras, homomorphisms, initial algebras, congruences. First-order logic review: Soundness, completeness, compactness. Herbrand models and Herbrand's theorem, Horn-clauses and resolution. Natural deduction and the Sequent calculus. Normalization and cut elimination. Lambda-calculus and Combinatory Logic: syntax and operational semantics (beta-eta equivalence), confluence and Church-Rosser property. Introduction to Type theory: The simply-typed lambda-calculus, Intuitionistic type theory. Curry-Howard correspondence. Polymorphism, algorithms for polymorphic type inference, Girard and Reynolds' System F. Applications: type-systems for programming languages; modules and functors; theorem proving, executable specifications.

CSL838 Wireless Networks
3 Credits (3-0-0)
Pre-requisites: CSL374 / CSL672
Radio signal propagation, advanced modulation and network coding, medium access techniques, cross layer interactions, self – configurable networks, mesh networks, TCP over wireless, mobility, wireless security, emerging applications and pervasive computing.

CSL840 Computer Vision
4 credits (3-0-2)
Pre-requisites: EC 120
Overlaps with: EEL806
Camera models. Calibration, multi-views projective geometry and invariants. Edge/feature extraction, correspondence and tracking. 3D structure/motion estimation. Object recognition. Scene and activity interpretation.

CSL847 Distributed Algorithms
3 credits (3-0-0)
Pre-requisites: CSL356 & CSL373 and EC 120
Models of synchronous and asynchronous distributed computing systems: synchronous networks, asynchronous shared memory, asynchronous networks etc.; basic algorithms for synchronous and asynchronous networks: leader election, breadth first search, shortest path, minimum spanning tree etc.; advanced synchronous algorithms: distributed consensus with failures, commit protocols; asynchronous shared memory algorithms: mutual exclusion and consensus; relationship between shared memory and network models; asynchronous networks with failures.

CSD851 Major Project Part 1 (CO)
6 credits (0-0-12)
Pre-requisites: EC 165
Overlaps with: CSD853
This project spans also the course CSD852. Hence it is expected that the problem specification and the milestones to be achieved in solving the problem are clearly specified.

CSL851 Algorithmic Graph Theory
3 credits (3-0-0)
Pre-requisites: CSL356 and EC 120
Overlaps with: MAL376
Intoroduction to graphs. Max-flow Min-cut theorem. Algorithms for computing maximum s-t flows in graphs. Algorithms for computing the minimum cut in a graph. Edge and vertex connectivity of graphs and Menger's theorem. Maximum matching, Hall's theorem, algorithms for computing maximum matching in weighted and unweighted graphs. Arborescences and algorithm for computing minimum arboresence. Edmonds theorem for disjoint arborescences. Planar graphs and algorithms for checking for planarity. Edge and vertex coloring of graphs. Independent sets and perfect graphs. Extremal graph theory.

CSD852 Major Project Part 2 (CO)
14 credits (0-0-28)
Pre-requisites: CSD851
Overlaps with: CSD854
The student(s) who work on a project are expected to work towards the goals and milestones set in CSD851. At the end there would be a demonstration of the solution and possible future work on the same problem. A dissertation outlining the entire problem, including a survey of literature and the various results obtained along with their solutions is expected to be produced by each student.

CSL852 Computational Geometry
4 credits (3-0-2)
Pre-requisites: CSL356
Visibility problems and triangulation. Line sweep and angle sweep: segment intersection, area, perimeter, diameter, width. Planar Point location: Kirkpatrick's hierarchy, Persistent data structure, Multidimensional data structures: Segment trees, range trees, orthogonal range searching, Convex hulls and Voronoi diagrams: 2d, 3d hulls, 2d Voronoi diagrams, dynamic maintenance, Duality between hulls and Voronoi diagrams, Duality between lines and points, higher order Voronoi diagrams Arrangements : Construction and bounds, k-sets, Zone theorem Algebraic lower bounds: Linear Decision model Ben-Or's theorem Randomized algorithms: Random sampling, Incremental construction, Backward analysis Optimization : Monge matrices, Fixed dimensional linear programming, Prune and Search Parametric search: kth intersection, k-th nearest neighbour. Recent topics : Instructor's choice.

CSD853 Major Project Part 1 (CO)
4 credits (0-0-8)
Pre-requisites: EC 165
Overlaps with: CSD851
This project spans also the course CSD854. Hence it is expected that the problem specification and the milestones to be achieved in solving the problem are clearly specified.

CSL853 Complexity Theory
3 credits (3-0-0)
Pre-requisites: CSL705 & CSL356
Turing machines and non-determinism, models of computation like RAM and pointer machines, Relations between complexity classes, time-space tradeoffs for some fundamental problems. Reductions and completeness, Randomized complexity classes, Boolean circuit complexity. Cryptography and one-way functions. Polynomial hierarchy, P-space completeness. Interactive proofs and Hardness of approximation, Parallel complexity classes.

CSD854 Major Project Part 2 (CO)
16 credits (0-0-32)
Pre-requisites: CSD853
Overlaps with: CSD852
The student(s) who work on a project are expected to work towards the goals and milestones set in CSD853. At the end there would be a demonstration of the solution and possible future work on the same problem. A dissertation outlining the entire problem, including a survey of literature and the various results obtained along with their solutions is expected to be produced by each student.

CSL854 Approximation Algorithms
3 credits (3-0-0)
Pre-requisites: CSL356 and EC 120
NP-hardness and approximation algorithms. Different kinds of approximability. Linear programming and Duality. Randomized Rounding. Covering and packing problems. Facility location, machine scheduling

and bin packing. Primal dual approximation algorithms in graph connectivity and Network design. Multi-commodity flows and cuts. Graph embeddings and their application to sparsest cuts, separators and bandwidth minimzation. Feedback arc sets and Linear ordering problems. Shop scheduling: Open, flow and job shop. Semi definite programming and applications to max-cut, graph coloring. Concept of best possible approximation algorithms, Hardness of approximations.

CSL855 Models of Computation
3 credits (3-0-0)
Pre-requisites: EC 120, CLS 356 / CLS 630
Computing and the notion of an effective procedure. RAM model. Primitive and partial recursive functions. Lambda calculus and combinatory logic. Logic — completeness and incompleteness. Decidability and Church-Turing hypothesis. Limitations of the standard model. Coding and Information theory. Thermodynamics of computation. Quantum computation and quantum algorithms. Physical aspects of computation.

CSL856 Mathematical Programming
3 credits (3-0-0)
Pre-requisites: EC 120, CSL 356 or (CSL 105 and MAL 124)
Overlaps with: MAL365
Linear Algebra and Complexity. Theory of Lattices and Linear Diophantine Equations. Algorithms for Linear Diophantine Equations. Diophantine Approximation and Basis Reduction. Fundamental Concepts and Results on Polyhedra, Linear Inequalities, and Linear Programming.The Structure of Polyhedra. Polarity, and Blocking and Anti-Blocking Polyhedra. Sizes and the Theoretical Complexity of Linear Inequalities and Linear Programming.The Simplex Method, Primal-Dual, Elimination, and Relaxation Methods. The Ellipsoid Method for Polyhedra More Generally. Karmarkar's method for linear programming. Introduction to Integer Linear Programming. Estimates in Integer Linear Programming. The Complexity of Integer Linear Programming. Totally Unimodular Matrices: Fundamental Properties and Examples. Integral Polyhedra and Total Dual Integrality. Cutting Planes. Further Methods in Integer Linear Programming.

CSL857 Randomized Algorithms
3 credits (3-0-0)
Pre-requisites: CSL356
Overlaps with: CSL630, CSL758, CSL851, CSL854
Moments and deviations; Chernoff bounds; Occupancy problems; The probabilistic method; Markov chains and random walks; Martingales; Randomized Rounding; Hashing; Randomized data structures and geometric algorithms; Approximation algorithms and approximate counting; Randomized graph algorithms; Online algorithms.

CSL859 Advanced Computer Graphics
4 credits (3-0-2)
Pre-requisites: CSL781
Rendering: Ray tracing, Radiosity methods, Global illumination models, Shadow generation, Mapping, Anti-aliasing, Volume rendering, Geometrical Modeling: Parametric surfaces, Implicit surfaces, Meshes, Animation: spline driven, quarternions, articulated structures (forward and inverse kinematics), deformation — purely geometric, physically-based, Other advanced topics selected from research papers.

CSL860 Special Topics in Parallel Computation
4 credits (3-0-2)
Pre-requisites: CSL201, CSL373 and EC 120
The course will focus on research issues in areas like parallel computation models, parallel algorithms, Parallel Computer architectures and interconnection networks, Shared memory parallel architectures and programming with OpenMP and Ptheards, Distributed memory message-passing parallel architectures and programming, portable parallel message-passing programming using MPI. This will also include design and implementation of parallel numerical and non-numerical algorithms for scientific and engineering, and commercial applications. Performance evaluation and benchmarking high-performance computers.

CSL861 Special Topics in Hardware Systems
3 credits (3-0-0)
Pre-requisites: EC 120
Under this topic one of the following areas will be covered: Fault Detection and Diagnosability. Special Architectures. Design Automation Issues. Computer Arithmetic, VLSI.

CSL862 Special Topics in Software Systems
3 credits (3-0-0)
Pre-requisites: EC 120
Special topic that focuses on state of the art and research problems of importance in this area.

CSL863 Special Topics in Theoretical Computer Science
3 credits (3-0-0)
Pre-requisites: EC 120
Under this topic one of the following areas will be covered: Design and Analysis of Sequential and Parallel Algorithms. Complexity issues, Trends in Computer Science Logic, Quantum Computing and Bioinformatics, Theory of computability. Formal Languages. Semantics and Verification issues.

CSL864 Special Topics in Artificial Intelligence
3 credits (3-0-0)
Pre-requisites: CSL433
Under this topic one of the following areas will be covered: Issues in Expert Systems. Theorem Proving. Natural Language Processing. AI in Speech and Computer Vision. Higher Order Logic Programming, Machine Learning, Advanced Neural Networks.

CSL865 Special Topics in Computer Applications
3 credits (3-0-0)
Pre-requisites: EC 120
Special topic that focuses on special topics and research problems of importance in this area.

CSL866 Special Topics in Algorithms
3 credits (3-0-0)
Pre-requisites: EC 120
The course will focus on specialized topics in areas like Computational Topology, Manufacturing processes, Quantum Computing, Computational Biology, Randomized algorithms and other research intensive topics.

CSL867 Special Topics in High Speed Networks
3 credits (3-0-0)
Pre-requisites: EC 120
Research level issues and problems of current interest in the area.

CSL868 Special Topics in Database Systems
3 credits (3-0-0)
Pre-requisites: EC 120
The contents would include specific advanced topics in Database Management Systems in which research is currently going on in the department. These would be announced every time the course is offered.

CSL869 Special Topics in Concurrency
3 credits (3-0-0)
Pre-requisites: EC 120
The course will focus on research issues in concurrent, distributed and mobile computations. Some of the following topics will be covered: Models of Concurrent, Distributed and Mobile computation. Process calculi, Event Structures, Petri Nets an labeled transition systems. Implementations of concurrent and mobile, distributed programming languages. Logics and specification models for concurrent and mobile systems. Verification techniques and algorithms for model checking. Type systems for concurrent/mobile programming languages. Applications of the above models and techniques.

CSV880 Special Module in Parallel Computation
1 credit (1-0-0)
Pre-requisites: EC 120
Special module that focuses on special topics and research problems of importance in this area.

CSV881 Special Module in Hardware Systems
1 credit (1-0-0)
Pre-requisites: EC 120
Special module that focuses on special topics and research problems of importance in this area.

CSV882 Special Module in Software Systems
1 credit (1-0-0)
Pre-requisites: EC 120
Special module that focuses on special topics and research problems of importance in this area.

CSV883 Special Module in Theoretical Computer Science
1 credit (1-0-0)
Pre-requisites: EC 120
Special module that focuses on special topics and research problems of importance in this area.

CSV884 Special Module in Artificial Intelligence
1 credit (1-0-0)
Pre-requisites: EC 120
Special module that focuses on special topics and research problems of importance in this area.

CSV885 Special Module in Computer Applications
1 credit (1-0-0)
Pre-requisites: EC 120
Special module that focuses on special topics and research problems of importance in this area.

CSV886 Special Module in Algorithms
1 credit (1-0-0)
Pre-requisites: EC 120
Special module that focuses on special topics and research problems of importance in this area.

CSV887 Special Module in High Speed Networks
1 credit (1-0-0)
Pre-requisites: EC 120
Special module that focuses on special topics and research problems of importance in this area.

CSV888 Special Module in Database Systems
1 credit (1-0-0)
Pre-requisites: EC 120
Special module that focuses on special topics and research problems of importance in this area.

CSV889 Special Module in Concurrency
1 credit (1-0-0)
Pre-requisites: EC 120
Special module that focuses on special topics and research problems of importance in this area.

CSD893 Major Project - Part1
6 credits (0-0-12)
Research and development projects based on problems of practical and theoretical interest. First part of a two semester long project activity. Problem definition, background research, development of overall project plan (detailed design, milestones, etc.), and meeting the research and development targets set up for the first part. Evaluation will be based on student seminars, written reports, and evaluation of the developed system and/or theories.

CSD894 Major Project - Part 2
12 credits (0-0-24)
Second part of the two semester project. The primary objective is to meet the milestones defined in the first part. Evaluation will be held periodically, and will be based on written reports, oral presentations and demonstration of results. The project will culminate in the production of a thesis by each individual student. Final evaluation will be according to the M.Tech. project evaluation guidelines.

CSD895 Major Project (M.S. Research)
40 credits (0-0-80)

Department of Electrical Engineering

EEL101 Fundamentals of Electrical Engineering
4 credits (3-0-2)
Overlaps with: EEL102
DC circuits, KCL, KVL, Network theorems, Mesh and nodal analysis, Step response and transients. RC, RL and RLC circuits, Phasor diagram solution of AC circuits. Power in 1- and 3-phase AC circuits. Two port networks. Operational amplifiers: model and applications. Magnetic circuits. Transformers: modeling and analysis. Energy in magnetic field, production of force and EMF. Electro-mechanical energy conversion. Principles of measurement. Electrical and electronic materials. Laboratory experiments will be based on these topics.

EEL102 Principles of Electrical Engineering
4 credits (3-0-2)
Overlaps with: EEL101
DC circuits, KCL, KVL, Network theorems, Mesh and nodal analysis, Step response and transients. RC, RL and RLC circuits, Phasor diagram solution of AC circuits. Power in 1- and 3-phase AC circuits. Diodes, rectifiers, clipping and clamping. Operational amplifiers and their applications. Magnetic circuits. Transformers. Energy in magnetic field, production of force and EMF. Electro-mechanical energy conversion. Principles of rotating machines. Electrical and electronic materials. Laboratory experiments will be based on these topics.

EEN110 Introduction to Electrical Engineering
2 credits (0-0-4)
Discussion with faculty about different aspects of Electrical Engineering; practical sessions on Electrical Components, Circuit drawing, PCB design, Winding of transformer, assembly of a motor, dissasembly of a computer, assembly of electronic circuits like audio amplifier, radio receiver/ transmitter, etc.

EEN120 Introduction to Electrical Engineering (Power)
2 credits (0-0-4)
Discussions with faculty about different aspects of Electrical Power Engineering, practical sessions on electrical components, circuit drawing, PCB design, winding of a transformer, assembly of a motor, etc.

EEL201 Digital Electronic Circuits
4 credits (3-1-0)
Pre-requisites: EEL101 / EEL102
Review of Boolean Algebra, Karnaugh Map and Logic Gates;Designing combinational Circuits using gates and/or Multiplexers; Introduction to logic families: TTL, ECL, CMOS; PLAs and FPGAs; Sequential Circuits: Flip Flops,Counters and Registers; Design of Sequential Circuits: STD and applications; Pipelining and Timing issues; Memories.

EEP201 Electronics Laboratory - I
1.5 credits (0-0-3)
Pre-requisites: EEL101 / EEL102
The laboratory is divided into two parts. In the first part, the student is required to perform some set experiments to familiarize himself/ herself with basic digital electronic techniques. In the second half of the semester, the student is required to design and fabricate a digital module. A formal presentation of the design is required at the end of the semester.

EEL202 Circuit Theory
4 credits (3-1-0)
Pre-requisites: EEL101 / EEL102
Overview of network analysis techniques, Network theorems, Transient and steady state sinusoidal response. Network graphs and their applications in network analysis. Tellengen's theorem, Two-port networks, z, y,h and transmission parameters, combination of two ports, Analysis of common two ports, Resonance, Coupled circuits, Scattering matrix and its application in network analysis. Network functions, parts of network functions, obtaining a network function from a given part. Network transmission criteria; delay and rise time, Elmore's and other definitions of cascading. Elements of network sythesis techniques. Butterworth and Chebyshev Approximation.

EEL203 Electromechanics
4 credits (3-1-0)
Pre-requisites: EEL101 / EEL102
Review of 1-phase, 3- phase circuits and magnetic circuits, transformers-1-phase and 3-phase, special multiphase transformers and their applications, Electro mechanical Energy conversion principles and rotating machines, DC machines- construction, characteristics, commutation, armature reaction, speed control of DC motors and applications in drives; Synchronous machine-construction, characteristics, regulation, V-curves, parallel operation; Induction machines- 3-phase and 1- phase- construction, characteristics, starting, braking and speed control, Induction generators and applications-Fractional kW motors, special machines- PM machines, SRM, stepper motors and their applications.

EEP203 Electromechanics Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL203
Experiments on Transformers, DC and AC machines.

EEL204 Analog Electronics Circuits
4 credits (3-1-0)
Pre-requisites: EEL101 / EEL102
Review of working of BJT, JFET and MOSFET and their small signal equivalent Circuit; Biasing of BJT, JFET and MOSFET circuits; Analysis and Design of various single stage amplifier configurations; Multi Stage Amplifiers; Differential Amplifier and Operational Amplifier; Feedback Amplifiers; Tuned Amplifiers; Oscillators.

EEP204 Electronics Laboratory - II
1.5 credits (0-0-3)
Pre-requisites: EEL101 / EEL102
To design and test single stage and multi stage amplifiers, power amplifiers and oscillators on bread board. The students will be given the specification and the design to be verified before wiring up the circuit. The students are encouraged to trouble shoot with hints from the instructor and TAs.

EEL205 Signals and Systems
4 credits (3-1-0)
Pre-requisites: EEL101 / EEL102 / MAL110 / MAL111 / MAL115
Classification of signals and systems, various system representation techniques, differential, difference and state-space representations, Fourier transforms and series, application to analysis of systems, Laplace transform, its properties, and its application to system analysis, Z-transforms, its properties and applications, Random variables and random process, characterization of random variables and random process, linear systems and random signals.

EEL207 Engineering Electromagnetics
4 credits (3-1-0)
Pre-requisites: PHL110
Review of Maxwell's equations, wave propagations in unbounded medium.Boundary conditions, reflection and refraction of plane waves.Transmission Lines: distributed parameter circuits, traveling and standing waves, impedance matching, Smith chart, analogy with plane waves.Waveguides: parallel-plane guide, TE, TM and TEM waves, rectangular and cylindrical waveguides, resonators.Planar transmission lines: stripline, microstripline, application of numerical techniques.Dielectric guides and optical fibres.Radiation: retarded potentials, Hertzian dipole, short loop, antenna parameters.Radio-wave propagation: ground-wave, sky-wave, space-wave.

EEL209 Power Electronics Devices and Circuits
4 credits (3-1-0)
Pre-requisites: EEL101 / EEL102
Basic features of semiconductor junctions, the BJT operations at high currents, switching features of the BJT and MOS transistors. The thyristor operation, distributed gates. IGBT operation, principles and ratings. Boost and buck converters using BJT and IGBT circuits-problems, design and operation. Snubber designs and protection. Firing circuits. Thyristor and BJT based converters-design, phase control, effects on power

factor and harmonics, firing circuits and their designs. Inverter circuits operation. Designs using BJT's and MOS devices. Base and gate drive circuits, snubbers, operational problems. The basic concept of PWM control and advantages against phase control. AC voltage controllers, choppers and cycloconverters.

EEP209 Power Electronics Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL209
Experiments on measurement of turn on and off characteristics of various devices on storage CRO computation of losses. Assembly and testing of converters and inverters on resistive and inductive loads. Fabrication and testing of firing circuits, base and gate drives. Study of turn on and turn off characteristics of junction and MOS devices Performance of low rating boost and buck converters Design and Testing of firing circuits for: (a)Thyristorised boost/buck converters.(b) BJT/IGBT based boost/buck converters Phase controlled operation of a six pulse thyristorised converter, and harmonics analysis of performance. Performance study of a commercial, low rating, BJT PWM inverter, and harmonics analysis of performance

EEP211 Design (EE)
2 credits (0-0-4)
Pre-requisites: EEL101 / EEL102
Design activities related to various aspects and applications of electrical engineering.

EEL212 Measurements and Instrumentation
3 credits (3-0-0)
Pre-requisites: EEL101 / EEL102
Principles of Measurement, bridge measurements, oscilloscope, measurements of analog waveforms, Q-meter, Spectrum Analysis, Special transducers, A/D and D/A, Telemetering, Data recording and display, Computer-aided Measurement systems.

EEL218 Physical Electronics
3 credits (3-0-0)
Pre-requisites: EEL101 / EEL102
Overlaps with: EPL213, EPL439
Band model of solids, electrons and holes in semiconductors, carrier statistics, current flow in semiconductors, Junction devices, Metal-oxide-semiconductor devices, Schottky and optoelectronic devices.

EEP221 Design (EP)
2 credits (0-0-4)
Pre-requisites: EEL101 / EEL102
Design activities related to various aspects and applications of electrical power engineering.

EEL301 Control Engineering - I
4 credits (3-1-0)
Pre-requisites: EEL205
Overlaps with: MEL312, CHL261
Introduction to the control problem, Industrial control examples, Transfer function models of suitable mechanical, electrical, thermal and pneumatic systems. Systems with dead time, Control hardware and their models: Potentiometers, synchros, LVDT, DC and AC servo motors, tachogenerators, electro-hydraulic valves, pneumatic actuators. Closed loop control systems, Block diagram and signal flow analysis, Basic Characteristics of feedback control systems : stability, steady-state accuracy, transient accuracy, disturbance rejection, insensitivity and robustness.Basic modes of feedback control :Proportional, Integral, Derivative. Concept of stability and Routh stability criterion.Time response of 2nd order system, steady state error and error constants, Performance specifications in the time domain. Root locus method of design. Lead and lag compensation. Nyquist stability criterion. Frequency response analysis: Nyquist plots, constant M circles, constant N-circles, Bode plots, Nichols Charts Performance specifications in frequency domain, Frequency-domain methods of design. Lead and lag.

EEP301 Control Engineering Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL301
First and Second Order Electrical Systems, A.C and D.C Servo Motors, Synchro Characteristics, D.C Integral Servo Systems, Characteristics of Hydraulic Servo, Amplifier and Servo motor, Pneumatic Process Controller, Process Control Simulator, Microprocessor based speed control of stepper motor.

EEL303 Power Engineering - I
4 credits (3-1-0)
Pre-requisites: EEL203
Energy resources, power generation: Thermal, hydro and nuclear power plants. Transmission lines, line parameters, corona, interference of power lines with communication circuits, line insulators. Cables, per unit system, symmetrical components, fault analysis, switching surges. Integrated operation of power systems, basic concepts of load flow, economic operation, stability, protection, HVDC transmission. Load management and tariffs.

EEP303 Power Engineering Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL303
Experiments related to EEL303 Power Engineering - I

EEL305 Electric Drives
4 credits (3-1-0)
Pre-requisites: EEL203
Requirements, components and benchmarks of electric drives. Review of induction motor theory, distinction between wound rotor and cage rotor, cases of multiple cages, energy efficient motors, synchronous motor theory-equivalent circuit, extensions as reluctance motors, and permanent magnet motors. Stepper motor features and operation. Speed control of induction motor-basic issues, the ac power controller, and slip energy recovery schemes. VSI and CSI fed induction motors. Speed control of synchronous motors and associated machines. Organisation of micro-controllers, key issues like actuation and signal sensing, interrupt handling, timing, and priority of tasks in a microcomputer controlled drives.

EEP305 Drives Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL305
Experiments related to course EEL305 Electric Drives.

EEL306 Communication Engineering
4 credits (3-1-0)
Pre-requisites: EEL205
Review of Fourier Series and Transforms. Hilbert Transforms, Bandpass Signal and System Representation. Random Processes, Stationarity, Power Spectral Density, Gaussian Process, Noise. Amplitude Modulation, DSBSC, SSB, VSB: Signal Representation, Generation and Demodulation. Frequency Modulation: Signal Representation, Generation and Demodulation. Mixing, Superheterodyne Receiver, Phase Recovery with PLLs. Noise: in AM Receivers using Coherent Detection, in AM Receivers using Envelope Detection, in FM Receivers. Sampling, Pulse-Amplitude Modulation. Quantization, Pulse-Code Modulation. Noise Considerations in PCM, Time Division Multiplexing, Delta Modulation.

EEP306 Communication Engineering Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL306
Laboratory experiments on analog, pulse, and basic digital modulation and demodulation techniques.

EEP307 Electromagnetics Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL207
Laboratory experiments on different transmission lines, antennas, microwave sources and passive devices.

EEL308 Computer Architecture

4 credits (3-1-0)
Pre-requisites: EEL201
Overlaps with: CSL211

Organization of a Computer: von Neumann and Harvard architecture; Instruction Set Architecture: RISC and CISC processors; Computer Arithmetic: fixed point and floating point arithmetic; Design of ALU: hardware algorithms for addition, multiplication and division of fixed point and floating point numbers; Processor design: Data Path and Control Design, Microprogramming, Exception Processing, Pipelining; Memory Organisation: memory hierarchy, cache organization, virtual memory; System Design: bus structure, bus transactions; Input-output Systems: programmed I/O, DMA and interrupt driven I/O. Illustrations with examples of CISC processors from Intel and RISC processors like MIPS and ARM.

EEP308 Computer Technology Laboratory

1.5 credits (0-0-3)
Pre-requisites: EEL201 & EEP201
Overlaps with: CSL211

Laboratory Experiments will be on: (a) Use of ALU; (b) Design and implementation of special purpose hardware for application specific computation, like HCF; (c) Design and implementation of interfacing hardware, eg. Serial I/O; (d) Assembly Language programming and interfacing experiment with microprocessor/microcontroller kit; (e) Use of Hardware Description Language like VHDL; (f) Controller synthesis on FPGA.

EED310 Mini Project (EE)

3 credits (0-0-6)
Pre-requisites: EC 80

Project activity of one semester duration emphasizing design activity in any area of electrical engineering, under the guidance of a faculty member. Prior to registration for the course, a proposal will have to be prepared and approval obtained from the department.

EES310 Independent Study (EE)

3 credits (0-3-0)
Pre-requisites: EC 80

Study of subjects in electrical engineering outside course offerings or research-oriented activities under the guidance of a faculty member. A proposal detailing the envisaged activities will have to be submitted to the department for approval and prior permission obtained to register for the course.

EEL311 Graph Theory and its Application to Electrical Engineering

3 credits (3-0-0)
Pre-requisites: CSL201
Overlaps with: MAL376, MAL468

Basic of graph theory: trees, f-circuits, f-cutsets, connected and seperable graphs etc. Matrices of a graph and relations between them. Generation of network functions of one and two-port networks using spanning tree and directed tree algorithms. Graph searches like BFS and DFS. Path problems like shortest paths, all paths between a pair of nodes etc. Generation of directed graphs and their use in the determination of transfer functions of networks. Applications of graph algorithms in routing, assignment and other problems in VLSI design.

EEL315 Analog Integrated Circuits

3 credits (3-0-0)
Pre-requisites: EEL 204 & EEL 202

Review of basic amplifiers. Current Mirrors, Reference Current and Voltage Sources. CMOS Operational Amplifier: Structure, Analysis and Design, Frequency Response and Compensation Techniques. Switched Capacitor Circuits: Principles of operation, Filter and non filter applications. Sample and Hold Circuits, Comparators. ADC: Characterization, Types of ADC and their relative merits and demerits, Design issues. DAC: Characterization, Types of DAC and their relative merits and demerits, Design issues.

EEL316 Digital Communications

4 credits (3-0-2)

Pre-requisites: EEL306

Matched Filter, Error Rate due to Noise. Intersymbol Interference, Nyquist's Criterion, Duobinary Signaling. Optimum Linear Receiver. Geometric Representation of Signals. Coherent Detection of Signals in Noise, Probability of Error. Coherent Digital Modulation Schemes: MPSK, MFSK, MQAM; Error Analysis. Noncoherent FSK, Differential PSK. Comparison of Digital Modulation Schemes, Bandwidth Efficiency. Pseudo-Noise Sequences and Spread Spectrum. Information Theory, Entropy, and Source-Coding.

EEL319 Digital Signal Processing

4 credits (3-0-2)
Pre-requisites: EEL205
Overlap with: EEL731

Review of Signals and Systems, Sampling and data reconstruction processes. Z transforms. Discrete linear systems. Frequency domain design of digital filters. Quantization effects in digital filters. Discrete Fourier transform and FFT algorithms. High speed convolution and its application to digital filtering.

EED320 Mini Project (EP)

3 credits (0-0-6)
Pre-requisites: EC 80

Project activity of one semester duration emphasizing design activity in electrical power engineering, under the guidance of a faculty member. Prior to registration for the course, a proposal will have to be prepared and approved obtained from the department.

EES320 Independent Study (EP)

3 credits (0-3-0)
Pre-requisites: EC 80

Study of subjects in electrical power engineering outside course offerings or research-oriented activities under the guidance of a faculty member. A proposal detailing the envisaged activities will have to be submitted to the department for approval and prior permission obtained to register for the course.

EEP321 Measurements and Instrumentation Laboratory

1.5 credits (0-0-3)
Pre-requisites: EEL212

The laboratory is divided into two parts. In the first part, the student is required to perform some set experiments to familiarize himself with basic electronic techniques. In the second half of the semester, the student is required to design and produce a demonstrable instrument, together with its operating and maintenance manual.

EEL322 Integrated Circuits Technology

3 credits (3-0-0)
Pre-requisites: EEL204

Fabrication of active and passive devices and integrated circuits. Basic technological steps – pattern definition, impurity introduction, layer deposition, etching. Simplified process sequences for bipolar, NMOS and CMOS.

EEL324 Digital Hardware Design

3 credits (3-0-0)
Pre-requisites: EEL201
Overlaps with: CSL316

Review of combinational and sequential logic; Finite state machines and optimization of finite state machines; Hardware Description Languages (HDL), HDL based design; Introduction to data path and control path synthesis; Asynchronous state machine based design; Considerations of technology; testability and fault-tolerance in design.

EEL325 Control Engineering - II

3 credits (3-0-0)
Pre-requisites: EEL301

Introduction to digital control systems,Principles of signal conversion, sampling and reconstruction. Principle of discretization. Impulse and

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step invariance. Finite difference approximation. Bilinear transformation, Mathematical models discrete time signals and systems. Transfer function and system response. Stability on the z-domain. Closed loop digital control systems. System with dead time. Commonly used digital devices. Examples of industrial control systems. Transform design of digital controllers. Root locus methods and frequency domain method.State variable representation of continious and discrete time systems. Conversions state variable models to transfer function models. Conversion of transfer function to canonical models. Eigen values and eigen vectors. Solution of state equations. Controllability and observability properties. Pole placement design using state feedback. Dead beat control.

EEL326 Micromotors and their Applications
3 credits (3-0-0)
Pre-requisites: EEL203
Micromotors: dc micromotors: PCB motors, voice coilmotors, ultrasonic wave motors, coreless motors, PM motors, disc motors, servo motors, brushless motors, step motors, ac servo motors, synchronous motors, induction motors, universal motors axial field motors. Applications to information technology equipments, Computers FDD, HDD, printers and plotters, instruments, Consumers products such as cameras, camcorders, timers, clock, VCR, VCP Wipers, fax machines, casette recorders, copiers etc.

EEL327 Fault Diagnosis of Digital Circuits
3 credits (3-0-0)
Pre-requisites: EEL201
Concepts of faults and fault models; test generation, test selection, and fault dictionaries. Test generation for fault detection, fault location and fault correction. Some basic reliability-enhancing design techniques for digital circuits and systems.

EEL329 VLSI Technology and Design
4 credits (3-0-2)
Pre-requisites: EEL201
Overlaps with: EEL734
MOS transistors. CMOS and Pseudo NMOS inverters. Pass transistors. Designing Logic gates in CMOS. CMOS sequential circuits. Timing issues, Basic CMOS technology, Layout design rules and CMOS gate layout, Circuit and Logic simulation. Layout generations- partitioning, placements and routing.

EEL330 Selected Topics in Communication Engineering - I
3 credits (3-0-0)
Pre-requisites: EEL306
Topics of recent interest in the area of Commnication Engineering.

EEL331 Electromagnetics and Advanced Electromechanics
3 credits (3-0-0)
Pre-requisites: EEL203
Review of electromagnetic field concepts, Maxwell's equations for quasi-stationary fields. Boundary values problems in electrostatics: Laplace and Poisson's equations. Solutions in rectangular, spherical and cylindrical coordinates: method of Images: field plotting. Conformal transformation techniques, numerical methods: finite difference methods, finite element based software. Magnetostatic fields - vector potential: Boundary value problems. Current sheet and flux sheets. Relation between field theory and circuit theory for electric machines. Advanced topics in electromechanics, dynamic modelling of D.C., synchronous and induction machines, d-q transformaions. Transient/dynamic analysis of machines using classical and numerical methods. Short circuit studies in synchronous machines. Effects of saliency, automatic voltage regulators. Unbalanced operation of Induction motors. Speed control of induction motors.Variable reluctance, permanent magnet and stepper motors.

EEL338 Antennas and Propagation
3 credits (3-0-0)
Pre-requisites: EEL207
Antennas: Introduction to various types of antennas. Fundamentals of electromagnetic radiation, radiation from thin wires and small loops. Different types of linear arrays. Pattern multiplication, long wire antennas, aperture antennas. Waveguides.

EEL339 Power Conditioning
3 credits (3-0-0)
Pre-requisites: EEL209
Concepts of nonlinear loads and electric power conditioning unity power factor rectifier STATCON, (Static condenser) SMPS: analysis, design and control. UPS on-line and off-line, power supplies in telecommunication systems. High frequency induction heating, dielectric heating Power supplies in automobiles. Passive filters, active filters for harmonic and reactive power compensation in two wire, three wire and four wire ac systems. Harmonic standards, power quality, surge suppressors, compensation of arc furnace and traction loads. Microwave ovens, light and temperature controllers. Power supplies for appliances such as camera, X-ray equipment. Case studies on microcomputer and DSP control in active filters and power supplies.

EEL340 Selected Topics in Power and Machines
3 credits (3-0-0)
Pre-requisites: EEL203
Topics of interest in the relevant areas.

EEL341 Selected Topics in Power Electronics and Drives - I
3 credits (3-0-0)
Pre-requisites: EEL203 & EEL209
Topics of special interest in power electronics and drives.

EEL342 DSP based Control of Electric Drive
3 credits (3-0-0)
Pre-requisites: EEL203
Features of a DSP in comparison to those of ordinary processors, computational advantage handicaps regarding analog and digital interface. Communication advantages. Harmonic analysis in real time using a DSP specific assembly language features for a DSP. On chip RAM and external RAM I/O interface. PWM and firing pulse generation through a typical DSP, look-up tables and real-time computation. Interfacing and actuation circuits for DSP based controllers. Realization of computationally intensive algorithms like variable structure, adaptive and neural network schemes for drive systems.

EEL344 Electric Transportation
3 credits (3-0-0)
Pre-requisites: EEL203
Battery powered vehicles: electric cars, pallet truck, fork lift trucks, electric bus, solar powered electric vehicles and boats etc. drives used in electric vehicles, d.c. drives,vector controlled ac motor drives, PMBL motor drives, switched reluctance motor drives, Electric traction, trains, trams and trolleys, nature of tractive loads, supply systems, power factor and harmonics, traction motors and drives, Diesel electric traction, a.c. induction motor drives, marine propulsion systems and aircraft system.

EEL346 Electrical Machines and Industrial Drives
3 credits (3-0-0)
Pre-requisites: EEL203
Engineering aspects of electric rotating machines, industrial practices of manufacture and design. Convertor fed operation of d.c. motors, electronically commutated and permanent magnet motors. Electrical Engineering Applications in electric traction, steel milldrives, process industries, audio equipment, automobiles, computers and robotics. Computer aided modelling and analysis of d.c. drives. Modelling of synchronous machines. Saliency effects, steady-state and transient. Brushless synchronous generators using electronic circuits, induction motor operation and control. Variable frequency inverter fed motors for drive applications. Power electronics control of a.c. motors with application to variable speed drives. Energy conservation in motors. Microprocessor and microcontroller applications for a.c. drives. Single phase induction motor and applications in domestic appliances, electronic instrumentation, etc. Stepper motor and control applications in robotics, CNC, computer peripherals, permanent magnet motors,

switched reluctance motors, linear motors and their applications. Special generators for renewable energy systems such as wind, biogas, small hydro, solar etc.

EEL349 Advanced Electrical Machines
3 credits (3-0-0)
Pre-requisites: EEL203
Details of PWM inverter fed ac drives with different forms of feedback control, bang-bang and sliding mode structures, realisation on microcomputer based systems. Vector control of ac motor; flux estimators and their shortcomings, hardware realisation, start up control of induction motors with PWM and flux vector structures. Present day shortcomings of inverter fed induction motor drives-bearing erosion, shaft fracture and efficiency problems involvement of soft switching inverters and impact on ac drive performance SR motors and PM motors drive control. Design of power electronic modules and microprocessor controllers.

EEL358 Operating Systems
3 credits (3-0-0)
Pre-requisites: EEL308
Overlaps with: CSL373, MAL358, EEL602
Introduction to OS; Process and Thread management; Scheduling; Concurrent threads and processes: mutual exclusion, synchronization, inter-process communication; Memory management: Cache and Virtual Memory management; Resource management: deadlock and its prevention; File management; I/O management; Introduction to real time systems; Elements of distributed operating systems.

EEL359 Electric Machine Design and CAD of Electric Machines
3 credits (3-0-0)
Pre-requisites: EEL203 & EEP203
Basic design methodology and engineering considerations. Properties of electric magnetic and insulating materials. Choice of materials, frames etc. Computerisation of design procedures, Optimization techniques and their application to design problems. Design of large and FHP motors. Database and knowledge based expert systems. Development of PC based software, Exercise on design using standard software.

EEL360 Selected Topics in Control Engineering - I
3 credits (3-0-0)
Pre-requisites: EEL301
Select topics in control engineering; details will be decided by the instructor.

EEL361 Selected Topics in Power Systems - I
3 credits (3-0-0)
Pre-requisites: EEL303
Topics of interest in power systems; will be decided by the instructor.

EEL365 Intelligent Control
3 credits (3-0-0)
Pre-requisites: EEL301
Conventional control review, Feedback linearization, Robust and adaptive control, Fuzzy system: Introduction to fuzzy logic, Examples, fuzzy logic based identification and control, adaptive fuzzy control, Neural networks: Basics, Neural network based identification and control of nonlinear systems, examples. Various other soft computing techniques for control applications. Introduction to reinforcement learning.

EEL370 Selected Topics in Computers - I
3 credits (3-0-0)
Pre-requisites: CSL201
Topics of current interest in computers; details will be decided by the instructor.

EEL375 Embedded Systems
5 credits (3-0-4)
Pre-requisites: EEL308
Overlaps with: CSP413, MEL432, EEL705
Overview of Embedded Systems; Embedded System Architecture: processor examples - ARM, PIC, etc.; features of digital signal processor; SOC, memory sub-system, bus structure (PC-104, I2C etc.), interfacing protocols (USB, IrDA etc), testing and debugging, power management; Embedded System Software: Program Optimization, Concurrent Programming, Real-time Scheduling and I/O management; Networked Embedded Systems: special networking protocols (CAN, Bluetooth); Applications.

EEL380 Selected Topics in Electronics - I
3 credits (3-0-0)
Pre-requisites: EEL202 and EC 60
Topics of interest in areas of electronics; details will be provided by the instructor.

EEL388 Stepper Motors
3 credits (3-0-0)
Pre-requisites: EEL203
Discretisation of angular position by stepper structures, stepping angle and frequency of excitation. VR and PM rotor structures and their torque production, torque angle characteristics. The hybrid structure and torque production by permanent magnet and excitation fluxes. Power electronic converters for stepper motors, control by load angle. Hardware and software based control. Trajectory and motion definition in angle and angular speed. Transfer function of stepper motors, and control of damping by one-step and one-and-a-half step excitation.

EEL389 Computer Aided Testing of Electric Machines
3 credits (2-0-2)
Pre-requisites: EEL203
Data acquisition system, sensors, transducers such as speed torque, temperature, noise, voltage, current, power, power factor, harmonics, crest factor etc. Digital signal processing and instrumentation. Recorders, computer interface. Case Studies of Computer Aided testing of different electric machines.

EEL390 Selected Topics in Information and Communication Technology – I
3 credits (3-0-0)
Pre-requisites: CSL201 & EEL205 and EC 60
Topics in the emerging areas of information and communication technology and the interface between the two.

EEL394 Permanent Magnet Motors
3 credits (3-0-0)
Pre-requisites: EEL203
Permanent magnet materials and circuits; Characteristics, parameters, properties, classification and calculations, Permanent magnet motors, D.C. brushed motors, design analysis and control and applications, PM synchronous motors, rotor construction such as surface mounted PM, buried PM, inset type PM and interior type PM rotor and cageless rotor motors, line start and inverter fed control and applications. PM brushless dc motor, theory, operation, control and applications, axial field disc construction, PM step motors, hybrid step motors, sensorless control, reduction of torque pulsations; Case studies such electric vehicles, marine propulsion, spindle drives, commercial and industrial drives, PV fed water pumping.

EEL398 Machines and Drives Dynamics
3 credits (3-0-0)
Pre-requisites: EEL203
General volt-ampere and torque equations under stationary and rotating reference frames. Instantaneous symmetrical components and generalised operational equivalent circuits. Space vector concepts. Modeling of D.C. machines: analysis under motoring and generating. Simulation for transient and dynamic conditions. Modeling of synchronous machines: d-q transformations fixed to field structure-steady state and dynamic equations. Phasor diagram for cylindrical rotor and salient pole machines-electromagnetic and reluctance torque. Response under short circuit conditions Modeling of induction machines: Equations under stationary and rotating reference frames, Derivation of equivalent circuits. Correlation of inductances. Run up transients, Dynamics under load change, speed reversal and braking.

Unbalanced and asymmetrical operation.Modeling and analysis of permanent magnet, switched reluctance and stepper motors. Development of Computer Software using latest simulation tools to predict the behavior of different machines.

EEV401 Special Module in Communication Engineering
1 credit (1-0-0)
Pre-requisites: EEL306 and EC 90
Details will be decided by the course coordinator.

EEV402 Special Module in Power Systems, Machines and Power Electronics
1 credit (1-0-0)
Pre-requisites: EEL203 & EEL303 & EEL209 and EC 90
Details will be decided by the course coordinator.

EEV403 Special Module in Electrical Machines
1 credit (1-0-0)
Pre-requisites: EEL203 and EC 90
Details will be decided by the course coordinator.

EEL404 Flexible AC Transmission System
3 credits (3-0-0)
Pre-requisites: EEL303
Overlap with:EEL894
Concepts of reactive power support and voltage stability. Compensation at a bus and over a line. The synchronous condenser, static var compensation, static phase shifter, thyristor controlled switched capacitor, STATCON's and DVR's, unified power flow controller, interphase power controller. Reactive power balance over a network and optimisation.

EEV404 Special Module in Control Engineering
1 credit (1-0-0)
Pre-requisites: EEL301 and EC 90
Details will be decided by the course coordinator.

EEL405 Power Engineering Instrumentation
3 credits (3-0-0)
Pre-requisites: EEL303
The concepts of accuracy and precision, Log errors and sources of measurement errors. Non idealities involved in Power instrumentation Instrument transformers, structures of PT's and CT's ratio and phase errors. Current probes and their efficiency. DC current measurements by Hall devices, saturable reactor set, UPS. Electromechanical meters for dc and ac measurements-moving coil and moving magnet structures. Analog circuits for power instrumentation, voltage followers, buffers, differential amplifiers, specific analog circuits for peak detection, rms detection, and average computation, common mode operation and noise analysis of OPAMP based circuits. Filter designs and concepts of operating bandwidth. Digital instrumentation in power application, A/D and D/A circuits and their operation, errors Basic concepts of digital filtering storage and related circuit design. Microprocessors in power instrumentation, configuration and software flowcharts for basic power measurement involving filtering, arithmetic operations and storage.

EEV405 Special Module in Electronics
1 credit (1-0-0)
Pre-requisites: EEL202 and EC 90
Details will be decided by the course coordinator.

EEV406 Special Module in Power Electronics and Drives
1 credit (1-0-0)
Pre-requisites: EEL209 and EC 90
Details will be decided by the course coordinator.

EEL407 Distribution System Planning and Automation
3 credits (3-0-0)
Pre-requisites: EEL303
Configuration of distribution systems load characteristics, distribution transformers, distribution substation design, feeder design, voltage regulation, protection in distribution systems, SCADA, distribution automation.

EEV407 Special Module in Power Systems
1 credit (1-0-0)
Pre-requisites: EEL303 and EC 90
Details will be decided by the course coordinator.

EEC410 Colloquium (EE)
3 credits (0-3-0)
Pre-requisites: registered for EET410
Students will deliver talks about their experience during practical training, and on topics of current interest.

EET410 Practical Training (EE)
Non credit
Pre-requisites: EC 90 at the end of 5th sem.
Fifty (50) working days or 400 hours of practical training in an industry.

EED411 Major Project Part 1 (EE)
3 credits (0-0-6)
Pre-requisites: EC 120
Formation of project team (up to two students and two faculty guides); formulation of work plan; completion of targeted work for the semester; and presentation of progress for award of grade. Topic could be from any area of electrical engineering. Completion of about a third of the total work for assessment and grading.

EED412 Major Project Part 2 (EE)
7 credits (0-0-14)
Pre-requisites: EED411
Continuation of planned tasks started in Project Part 1 to completion, thesis writing and presentation of complete work for award of grade. Completion of the planned work for assessment and grading.

EEC420 Colloquium (EP)
3 credits (0-3-0)
Pre-requisites: registered for EET420
Students will deliver talks about their experience during practical training, and on topics of current interest.

EEL420 Selected Topics in Electronics - II
3 credits (3-0-0)
Pre-requisites: EEL202 and EC90
Topics in electronics; details will be decided by the instructor.

EET420 Practical Training (EP)
Non credit
Pre-requisites: EC 90 at the end of 5th sem.
Fifty (50) working days or 400 hours of practical training in an industry.

EED421 Major Project Part 1 (EP)
3 credits (0-0-6)
Pre-requisites: EC 120
Formation of project team (up to two students and two faculty guides); formulation of work plan; completion of targeted work for the semester; and presentation of progress for award of grade. Topic should be in the area of electrical power. Completion of about a third of the total work for assessment and grading.

EEL421 Selected Topics in Power Electronics and Drives - II
3 credits (3-0-0)
Pre-requisites: EEL203 & EEL209 and EC90

Topics of current interest in power electronics and drives; details will be provided by the instructor.

EED422 Major Project Part 2 (EP)
7 credits (0-0-14)
Pre-requisites: EED421
Continuation of planned tasks started in Project Part 1 to completion, thesis writing and presentation of compelete workfor award of grade. Completion of the planned work for assessment and grading.

EEL422 Computers in Biomedicine
3 credits (3-0-0)
Pre-requisites: CSL201 and EC 90
Introduction to computer simulation in biological sciences. Simulation of normal and pathological states. Artificial intelligence and expert systems for medical applications, Algorithms for automated analysis of bioelectrical signals such as ECG and EEG. Pattern identification and tissue and cell typing. Fractal and chaotic dynamics in biological systems, 3D Medical Imaging, Telemedicine and Virtual reality, Computers in medical therapeutics; Drug Delivery System, Smart sensors and actuators, Bio-informatics.

EEL423 Demand Side Management
3 credits (3-0-0)
Pre-requisites: EEL303
The concepts of demand-side management (DSM) for electric utilities, DSM alternative and goals. End use equipment and control, utility equipment control, energy storage, dispersed generation, customer DSM promotions, performance improvement equipment and system benefit/cost analysis of DSM alternatives; issue in forecasting DSM program impacts. Implementation of DSM programme; pricing and incentives.

EEL424 Nuclear Power Generation
3 credits (3-0-0)
Pre-requisites: EEL303
Basics of nuclear fission, and characteristics of heavy isotopes. The concepts of beta-decay line, and suitability of nuclear fuels. Fission by fast and slow neutrons, criticality, and moderation. Types and basic structures of common reactor designs-BWR, HWR and PHWR, power output, size and radiation considerations, operation and control by solid and liquid moderators, neutron density and reactivity control. Point form differential equations for common nuclear reactors core models, moderator dynamics, and thermal circuits. Reactor - poisoning by Xenon and strontium, control of performance to avoid poisoning. Special features of alternators and boilers in nuclear plants. Control and safety standards of nuclear units.

EEL428 Substation Design
3 credits (3-0-0)
Pre-requisites: EEL303
Types of substations layout and bus bar arrangements Grounding; design and Practices, substation auxiliaries, Cable routing, data acquisition, substation Control, load shedding, implementation.

EEL430 Selected Topics in Communication Engineering - II
3 credits (3-0-0)
Pre-requisites: EEL306 and EC 90
Selected topics in communication engineering; details will be decided by the instructor.

EEL432 Satellite Communication
3 credits (3-0-0)
Pre-requisites: EEL306
Satellite systems basics, satellite channel, earth station and satellite equipment, different modulation and access techniques, examples of different satellite systems.

EEL433 Communication Engineering - II
3 credits (3-0-0)
Pre-requisites: EEL316

Communication Channels and Their Characteristics. Probability and Random Variables, Transformations of Random Variables. Stochastic Processes, WSS Processes, Power Spectral Density, Characterization of Noise, White Noise, Gaussian Noise. Representation of Bandpass Signals and Systems, Signal Space Representation. Optimum Receivers for the AWGN Channel. Performance of Optimum Receivers for Digital Modulation Schemes: Binary, M-ary Orthogonal, M-ary Biorthogonal, Simplex, MPAM, MPSK, DPSK, MQAM, MFSK. Channel Capacity and Random Selection of Codes. Block and Convolutional Channel Codes. Spread Spectrum Communications.

EEL435 Optical Communication
3 credits (3-0-0)
Pre-requisites: EEL306
Overlaps with: EEL712
Introduction to optical communication, review of optical sources, fiber and detector, optical signaling schemes viz., IM, PL, PCM, PCM/PL, digital PPM, PFM, PAM. Various receiver configurations - direct detection, homodyne and heterodyne receivers, Noise sources in optical communication - modal noise, speckle noise, shot noise, phase noise, thermal noise, Integrated and transimpedance amplifiers, optical line coding, performance evaluation of optical receivers for various modulation and demodulation schemes and their comparative study. Diversity receivers-phase and polarization diversities. Optical fiber link design, fiber optics networks, introduction to optical space communication.

EEL437 Selected Topics in Power Systems - II
3 credits (3-0-0)
Pre-requisites: EEL303 and EC 90
Topics will be decided by the instructor from among current areas of power systems.

EEL440 Selected Topics in Power, Machines and Power Electronics - II
3 credits (3-0-0)
Pre-requisites: EEL303, EEL209 and EC 90
Topics in power, machines and power electronics; details will be decided by the instructor.

EEL441 Industrial Electronics
4 credits (3-0-2)
Pre-requisites: EEL101 / EEL102 and EC 90
Power electronic components- thyristors, triacs, GTOs, MOSFETs and other bipolar devices and their switching properties. Introduction to thyristorised phase controlled rectifiers and dual converters. AC controllers and timers, dimmers, heating. SMPS and UPS systems. Introduction to AC controllers, inverters, choppers, cycloconverters. Introduction to converter fed AC and DC drives-their performance. Other applications of power electronics.

EEP443 FEM Analysis of Machines Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL203 and EC 90
Review of EM Theory. Basics of finite element analysis. Mesh formulations. Computer platforms and software. Typical case studies of solving electromagnetic, mechanical and thermal problems. Applications in Electromagnets, transformers, relays dc machines, synchronous machines, induction machines, permanent magnet machines, I-Phase machines, reluctance machines. Project exercises on the use of standard software.

EEP446 Electrical Machines and Industrial Drives Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL203 and EC 90
Experiments related to the course EEL446.

EEL450 Switchgear and Transients
3 credits (3-0-0)
Pre-requisites: EEL303
Switchgear; fault clearing processes and arcing phenomena, thermodynamic aspects of arc interruption, electrical aspects of arc

interruption; recovery and restriking voltage. Types of circuit breakers; testing of circuit breakers.

EEL451 Power Systems Protection
3 credits (3-0-0)
Pre-requisites: EEL303
Basic concepts of power system protection, types of relays, protection of generators, transformers, bus bars and transmission lines, distance and carrier current protection. Computer relaying. Induction motor protection. Theory of arc interruption, types of circuit breakers (air, air blast, oil, vacuum and SF6), circuit breaker rating and testing of circuit breakers.

EEL452 HVDC Transmission
3 credits (3-0-0)
Pre-requisites: EEL303
Comparison of HVAC and HVDC transmission, HVDC transmission schemes, Component description, converter: principles, characteristics, control circuits, HVDC system control, Protection, Harmonics and filters, AC-DC system interaction, AC-DC load flow.

EEP452 Machine Modelling and Simulation Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL203 and EC 90
Experiments related to modelling and analysis of electrical machines.

EEL453 Power System Dynamics and Control
3 credits (3-0-0)
Pre-requisites: EEL303
Introduction to power system stability problems, Models of: synchronous machines, excitation systems, prime mover and governor, loads, Transient stability analysis, Dynamic stability analysis, Dynamic Equivalents, Stabilizers, Levels of power system control, AGC, SCADA and Computer control.

EEL455 Power System Planning
3 credits (3-0-0)
Pre-requisites: EEL303
Load forecasting, generation system reliability, transmission system reliability and distribution system reliability. Generation system expansion planning, Transmission system expansion planning and distribution system expansion planning, Reactive power planning, Integrated power system planning.

EEL456 Power Engineering - II
4 credits (3-0-2)
Pre-requisites: EEL303
Integrated operation of power systems, advanced load flow modeling, advanced fault analysis, stability analysis, security analysis, optimal power flow, power system control.

EEL458 Power Systems Optimization
3 credits (3-0-0)
Pre-requisites: EEL303
Characteristics of generation units, economic dispatch of thermal plants, unit commitment hydro thermal coordination maintenance scheduling, emission minimization, optimal power flow, security constrained optimization.

EEL460 Selected Topics in Control Engineering-II
3 credits (3-0-0)
Pre-requisites: EEL301 and EC 90
Topics in control engineering; details will be decided by the instructor.

EEL462 Identification and Adaptive Control
3 credits (3-0-0)
Pre-requisites: EEL301
Review of stochastic process. Models and model classification.The identification problem, some fields of applications. Classical methods of identification of impulse response and transfer function models, model learning technique, linear least square estimator, Properties of ISE, generalized and weighted least square, Instrumental variable method. On line identification using recursive least squares, minimum variance

algorithm, stochastic approximation and maximum likelihood method. Simultaneous state and parameter estimation extended kalman filter, two stage identification methods. Nonlinear identification, Model reference adaptive control.

EEP467 Computer Control Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL301
Familiarisation with programmable logic controllers, Testing and debugging of PLC programming, Microcontroller based interfacing, Computer control of inverted pendulum, Exposure of software for mathematical modeling and analysis.

EEL470 Selected Topics in Computers - II
3 credits (3-0-0)
Pre-requisites: CSL201 and EC 90
Topics of current interest in the area of Computer Technology; details will be provided by the instructor.

EEL472 Parallel and Distributed Processing
3 credits (3-0-0)
Pre-requisites: EEL308
Overlaps with: CSL830, CSL847, MAL311, MAL465
Motivation for parallel and distributed processing.Classification of Parallel Architectures-SIMD/MIMD,control/data flow,distributed/shared memory architectures, Mapping algorithms onto regular arrays-data dependencies, linear, rectangular mesh and hexagonal arrays and algorithms for these architectures.SIMD algorithms-design considerations, masking,vector instructions and data structures.Memory allocation techniques.Interconnecting networks.Sorting and data broadcasting. Algorithms for shuffle/exchange networks.MIMD algorithms(shared memory)-synchronization,mutual exclusion, hot spots. Distributed Programming :message passing , RPC and rendezvous , paradigms for process interaction, implementations.

EEL473 Computer Communication
3 credits (3-0-0)
Pre-requisites: EEL306
Overlaps with: CSL 374
Introduction; Mathematical theory of Networks : birth-death proceses, M/M/m, M/G/1, simulation techniques for LANs; Local Area Networks, Metropolitan Area Networks, Access Techniques, Wide Area Network, Routing algorithms. Case studies in network design.

EEL481 Testing and Commissioning of Electrical Equipment
3 credits (3-0-0)
Pre-requisites: EEL303
Testing of Transformers, dc machines, Induction machines synchronous machines and other Electric apparatus. Study of testing standard (BIS and EMC) etc. on electrical equipment Type tests and routine tests. Tests before commissioning and after commissioning of electrical equipments. Various testing standards.

EEL482 Mechatronics
3 credits (3-0-0)
Pre-requisites: EEL201 & EEL203 & EEL301
Overlaps with: MEL411, MEL432
Mechatronics: definitions and terminology, its elements such as mechanics, electronics, microelectronics, power electronics and information technology. Mechanical elements with integrated electronics suspension systems, vibration dampers, clutches, bearing mechanical or magnetic, gears etc. Machines with integrated electronics, electric drives, pneumatic and hydraulic drives, water steam or gas turbines, combustion engines, etc. Generators, pumps, compressors, machines tools, robots, printing machines, vehicles: automobiles, ships and aircraft. Precision machines with integrated electronics devices for telecommunication, consumer electronics, data processing devices, sensors, actuators, optical devices and medical devices, Power electronics converters.

EEL483 Hydro Power Generation
3 credits (3-0-0)
Pre-requisites: EEL303
Types of Hydro plants subsystems of hydro plant, turbines, hydro alternates hydro plant. Auxiliaries, control of hydro power, micro hydel systems, special problems in hydro plants.

EEP483 Neural Computing Applications to Power Systems Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL303
Experimental work to complement EEL487 Intelligent Algorithms for Power Systems.

EEL486 Illumination and Heating
3 credits (3-0-0)
Pre-requisites: EEL101 / EEL102 and EC 90
Laws of illumination; Types of lamps and fixtures; Energy conservation measures; Electric heating; Electric welding.

EEL487 Intelligent Algorithms for Power Systems
3 credits (3-0-0)
Pre-requisites: EEL303
Introduction of Artificial Neural Networks (ANN), Multilayer feed forward networks, back propagation training algorithm, Radial basis function and recurrent networks. ANN based algorithms for: load flow analysis, economic load dispatch, load forecasting, transient stability, and power system stabilizers. Introduction to genetic algorithms.

EEP487 Power Quality Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL303
Experiments on power quality.

EEP488 Power Electronics and Simulation Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL209 and EC 90
Performance study with parameter testing for various power electronic converter and inverter circuits using simulation packages like PSPICE, PSIM, SIMULINK/MATLAB and advanced SIMULATORS.

EEP493 CAD of Electric Machines Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL203 and EC 90
Experiments related to EEL359 Electric Machine Design and CAD of Electric Machines.

EEP495 Distribution System Design Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL303
Distribution substation design; distribution feeder design; protection. Co-ordination of distribution system, load flow, load shedding strategies.

EEP496 Power System Dynamics and Control Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL303
Swing equation solution of SMIB system. Transient stability simulation of SMIB with excitation. Transient stability simulation of multimachine system. Small signal stability analysis. Power system control.

EEL499 Selected Topics in Electrical Machines
3 credits (3-0-0)
Pre-requisites: EEL203 and EC 90
Topics of curent interest related to electrical machines; details will be provided by the instructor.

EEL601 Computer Architecture
3 credits (3-0-0)
High Performance Processor. Architecture. Motivation for Parallel Processing. Classification of Parallel Architectures: SIMD/MIMD, Control/Data Flow, Distributed/Shared Memory Architectures. Mapping Algorithms onto Regular Arrays : Data Dependencies, Linear, Rectangular Mesh and Hexagonal Arrays and Algorithms for these architectures. SIMD Algorithms : Design Considerations, Masking, Vector Instruction and Data Structures. Memory Allocation Techniques. Interconnection Networks. Sorting and Data Broadcasting. Massively Parallel SIMD Computing. MIMD Algorithms (Shared Memory) : Synchronization, Mutual Exclusion, Hot Spots. Interconnection Networks. Algorithms for SM/SIMD Machines. Performance Issues. MIMD Algorithms (Distributed Memory) : Synchronous and Asynchronous Operation. Message Routing Schemes. Interconnection Networks. Packet and Circuit Switching. Network Architectures. Distributed Algorithms.

EEL602 Operating Systems
4 credits (3-0-2)
Process management, Concurrent processes, mutual exclusion, synchronization, and scheduling. Memory management, concept of locality of reference, virtual memory, cache management, memory allocation algorithms. Resource management, Deadlock and its prevention. Fairness and priority. Protection. File management and I/O management. Introduction to real time systems, Elements of distributed operating systems.

EEL641 Electrical Equipments in Power Plants
3 credits (3-0-0)
Review of Electromechanical energy conversion, synchronous generator: constructional features, excitation systems, factors affecting emf generation, armature windings, armature reaction, synchronous reactance, voltage regulation, effect of saliency, grid connected operation, cooling system, capability chart, basic concepts of stability.

3-phase induction motors : constructional features, rotating magnetic field, torque-equation, equivalent circuit, starting, speed control, braking modes of operation, solid state control of induction motors; abnormal operation of induction motors.

DC supply system in power plants, circuit breakers, condition monitoring of power plant equipment.

EEP691 Basic Electrical Engineering Lab
1 credit (0-0-2)
Basic experiments related to basic electrical networks, electrical machines, power systems and power electronics.

EED701 Minor Project (Computer Technology)
2 credits (0-0-4)

EEP701 Digital System Lab
2 credits (0-0-4)
Students will design, implement and experiment with digital systems. This will include ASIC design, FPGA based design and micro-controller/processor/DSP based embedded system design and relevant hardware and software development and experimental evaluation and verification.

EEL702 Computer System Software
4 credits (3-0-2)
Pre-requisites: CSL201 & EEL308
Overlaps with: CSL728
Introduction to Object Oriented Programming and Object Oriented Design. Use of UML in Software design. System software design issues. Language Translators, Assemblers, Linkers and Loaders. Run-time environment management. Lab exercises related to these topics.

EEP702 Software Laboratory
2 credits (0-0-4)
Students are expected to work under Windows and/or LINUX/UNIX environments on experiments related to the following topics: advanced data structures and algorithms, compilers, GUI, component-based software design, distributed and web based applications, database applications

EEL703 Computer Networks

3 credits (3-0-0)
Pre-requisites: EEL306
Overlaps with: CSL374, CSL858

Review of data communication techniques. Data transmission, line coding, error control coding. Data switching, circuit switching, message and packet switching. Network model ISO-OSI model, primitives and services. Elements of queuing. Data link control Simplex, pipelined and sliding window protocols, simplex performance analysis. X 25 data link layer. Random access techniques. Pure, slotted and finite population ALOHAs. Stability in ALHOAs. Routing and congestion control static, adaptive, centralized and distributed routing procedures, congestion control. Local Area Networks LAN topologies and protocols, IEEE 802.x protocols, implementation and performance issues. High speed LANs. Transport layer. Quality of service transport classes. Design issues, buffer management, synchronization. Session and presentation layer, Synchronization issues, formatting, data compression, data security.

EEP703 Computer Networks Lab

2 credits (0-0-4)

Simulation and Hardware Experiments on different aspects of Computer Networks. Like simple queues, queues with feedback, network of queues, discrete event simulation techniques, etc

EEL704 Robotics and Automation

3 credits (3-0-0)
Pre-requisites: EEL301

Basic component of Robotic systems. Kinematics of manipulators, Selection of Coordinate frames, Transformations. Solution of kinematics and manipulator dynamics. Newton-Euler dynamic formulations. Path planning. Position, velocity and force control, Computed Torque control. Linear and Nonlinear controller design of robot. Introduction to robot vision. Application of computer controlled robot in manufacturing and programmable automation.

EEV704 Special Module in Computers

1 credit (1-0-0)
Pre-requisites: CSL201 and EC 90

Details will be decided by the course coordinator.

EEL705 Embedded Systems and Applications

3 credits (3-0-0)
Pre-requisites: EEL308
Overlaps with: CSP413, MEL432, EEL375

Introduction to embedded system : Single purpose hardware and software. Architectural Issues : CISC, RISC, DSP Architectures. Component Interfacing : Interrupt, DMA, I/O Bus Structure, I/O devices. Software for Embedded Systems : Program Design and Optimisation techniques, O.S for Embedded Systems, Real-time Issues. Designing Embedded Systems : Design Issues, Hardware-Software Co-design, Use of UML. Embedded Control Applications : Open Loop and Closed Loop Control, Software Coding of PID Controller, applications – washing machine, automobiles. Networked Embedded Systems : Distributed Embedded Architectures, Protocol Design issues, wireless network. Embedded Multimedia and Telecommunication Applications: Digital Camera, Digital TV, Set-top Box, Voice and Video telephony.

EEL706 Soft Computing

3 credits (3-0-0)
Pre-requisites: MAL220 / MAL250
Overlaps with: MAL717, MAL720, EEL781

Introduction to Soft Computing: Rationale and Basics of Learning: Neural Networks: Multi-layer Feed-forward Networks, Recurrent Networks, Self-organising Networks; Fuzzy Logic: Basics, inferencing scheme, Neuro-Fuzzy systems; Evolutionary Algorithms: GA and Optimisation, Evolutionary Systems, Genetic Programming; Introduction to Rough Sets, Rough-Fuzzy representations, Belief Networks; Principles of SVM; Applications.

EEL707 Multimedia Systems

4 credits (3-0-2)
Pre-requisites: EEL205 & EEL358

Multimedia Data Types: Image, audio, video, animation; Compression Technology, System Design: Architecture and Operating Systems, Multimedia Delivery, Content management and retrieval.

EEL708 Information Retrieval

3 credits (3-0-0)
Pre-requisites: CSL201

Introduction – What is IR; Applications and significance; retrieval evaluation; Query Modeling and Query Languages; Indexing and Searching Text; Multimedia IR: Models, indexing , searching; User Interfaces and Visualisation; Distributed IR; Web Search Engines; Digital Libraries.

EEL709 Pattern Recognition

3 credits (3-0-0)
Pre-requisites: MAL250

Introduction – What is Pattern Recognition? Applications and Relation with other fields like Data Mining, Information Retrieval, etc.; Linear Discriminant Functions and its Applications; Bayesian Decision Theory; Maximum-Likelihood and Bayesian Parameter Estimation; Component Analysis, Expectation Maximisation, Hidden Markov Model; Non-parametric Techniques; Nearest Neighbour, K-NN; Non-metric Methods; Decision Trees, ID3, Grammar based Methods; Neural Network Based Approaches; Introduction to Fuzzy Logic Based Techniques; Support Vector Machine; Applications.

EEL710 Coding Theory

3 credits (3-0-0)
Pre-requisites: EEL306

Measure of information; Source coding; Communication channel models; Channel Capacity and coding; Block codes; Cyclic codes; BCH codes; Reed Solomon codes; Convolutional codes; Trellis coded modulation; Introduction to cryptography.

EEL711 Signal Theory

3 credits (3-0-0)
Pre-requisites: EEL306

Deterministic and random signals; Discrete random variables (Bernoulli, binomial, Poisson, geometric, negative binomial, etc.) and their properties like PDF, CDF, MGF; Continuous random variables: Gaussian, multivariate Gaussian; whitening of the Gaussian random vector; complex Gaussian random vector, circularity; Rayleigh and Rician; exponential; chi-squared; gamma; Signal spaces: convergence and continuity; linear spaces, inner product spaces; basis, Gram-Schmidt orthogonalization; Stochastic convergence, law of large numbers, central limit theorem. Random processes: stationarity; mean, correlation, and covariance functions, WSS random process; autocorrelation and cross-correlation functions; transmission of a random process through a linear filter; power spectral density; white random process; Gaussian process; Poisson process.

EEL712 Optical Communication Systems

3 credits (3-0-0)

Introduction to optical communications, Optical signaling schemes viz., IM, PL, PCM, PCM/PL, digital PPM, PRM, PFM etc., video signal, electro-optic modulators. Various receiver configurations, noise sources in optical communication, direct detection receiver, optimum gain in APD, signal-to-noise ratio (SNR) calculations, Optimization of SNR, optical preamplifier design, Optical line coding schemes, performance evaluation of various optical receivers and their comparative study, Applications of optical amplifier in the system. Optical fiber link design-power budget, time budget and maximum link length calculation, hybrid fiber co-axial/microwave links, fiber-in-the loop (FITL)- FTTH/FFTB, FTTC. WDM Systems. Energy efficient machines. Special induction generators for renewable energy-Wind, bio and small hydro systems.

EEL713 Microwave Theory and Circuits

3 credits (3-0-0)
Pre-requisites: EEL207

Review of EM theory: Maxwell's equations, plane waves in dielectric and conducting media, energy and power.Transmission lines and waveguides: closed and dielectric guides, planar transmission lines and optical fibre.Network analysis: scattering matrix other parameters, signal flow graphs and network representation. Impedance matching

and tuning.Analysis of planar transmission lines.Analysis of design of passive components.

EEL714 Information Theory
3 credits (3-0-0)
Pre-requisites: EEL205
Entropy, relative entropy, and mutual information. Asymptotic equipartition property. Entropy rates of a stochastic process, Markov chains. Data compression: Kraft inequality, Huffman codes. Channel capacity: symmetric channels, channel coding theorem, Fano's inequality, feedback capacity. Differential entropy. The Gaussian channel: bandlimited channels, channels with coloured Gaussian noise, Gaussian channels with feedback. Rate distortion theory: rate distortion function, strongly typical sequences, computation of channel capacity. Network information theory: Gaussian multiple user channels, the multiple access channel, encoding of correlated sources, the braodcast channel, the relay channel, source coding and rate distortion with side information, multiterminal networks.

EEL715 Image Processing
4 credits (3-0-2)
Pre-requisites: EEL205 and EC 90
Overlaps with: MAL715, CSL783
Introduction to 2-D Signals and Systems. Image Digitization. Image Transforms. Image Data Compression: Transform Domain Coding , Predictive Coding, JPEG. Image Enhancement: Image Restoration: Inverse Filtering, Algebraic Approach to Restoration, Wiener (LMS) approach, Constrained Least Squares Restoration, Interactive and other methods for restoration. Image Reconstruction: The Filtered Back-Projection Algorithm, Algebraic Renconstruction Method. Image Segmentation: Detection of Discontinuities, Edge Linking and Boundary Detection, Thresholding, Region-Oriented Segmentation. Selected Topics of Current Interest (for example multi-resolution analysis, morphological processing etc.).

EEL716 Telecommunication Switching and Transmission
3 credits (3-0-0)
Pre-requisites: EEL306
Basic line circuits, long haul circuits, signaling, switching exchanges, analysis of telecom switching networks, teletraffic engineering, management protocols, multi-service telecom protocols and networks.

EEL717 Signals & Communications
3 credits (3-0-0)
Representation of one- and two-dimensional deterministic signals, transmission of signals through linear networks, convolution theorem, probabilistic concepts and random signals, density and distribution functions, statistical averages, transformation, random processes, noise, representation of narrowband noise, review of linear and exponential modulations, sampling theorem, pulse modulation systems, PCM and DM, noise performance of analog modulation schemes.

EEP717 Communication Laboratory I
2 credits (0-0-4)
Experiments related to Communication.

EEL718 Statistical Signal Processing
3 credits (3-0-0)
Pre-requisites: MAL250 & EEL205
To provide an introduction to fundamentals of statistical characterization and analysis of signals, ideas of estimation, optimal linear filtering, geometric ideas, autocorrelation matrices and their properties, eigen-analysis, linear prediction, KL-expansion, factorization of autocorrelation matrices, Kalman filtering, least-squares filtering, adaptive filtering theory, LMS, RLS, and other algorithms, Singular Value Decomposition SVD, fundamentals of array signal processing.

EEP719 Communication Laboratory II
2 credits (0-0-4)
Experiments related to Microwaves.

EEP719 Communication Engineering Laboratory - II
1.5 credits (0-0-3)
Pre-requisites: EEL713

Experiments on microwave measurement techniques, antennas and design of microwave circuits.

EES720 Independent Study (Control & Auomation)
3 credits (0-3-0)

EEL721 Linear System Theory
3 credits (3-0-0)
Review of matrices and linear vector space including semigroup, group, rings and fields, state variable modelling of continuous and discrete time systems, linearization of state equations, solution of state equations of linear time-invariant and time-varying systems. Controllability and observability of dynamical systems. Minimal realization of linear systems and canonical forms. Liapunov's stability theory for linear dynamical systems.

EEL723 Microprocessor Based Industrial Control
3 credits (3-0-0)
Process Control Computer Systems : Minis, micros, classification by hardware features and software facilities, performance evaluation techniques.

Characteristics of Digital Processors : Organisation, instruction set, characteristics for process control, input/output arrangements, addressing techniques, memory systems.

Process Control System Software : Review of availability of process control languages, application packages, operating system for real-time process control.

System Selection Criteria : Specification, environment, hardware and software requirements. Maintenance, procurement procedures, cost/performance/availability ratios.

Development Tools : Development systems for micros, software tools, logic analyser, cross assemblers and compilers, simulators, emulators, in-house vs. turn-key trade off.

EEP725 Control Laboratory
3 credits (0-0-6)

EEL731 Digital Signal Processing
3 credits (3-0-0)
Discrete time signals and systems. Z-transforms. Structures for digital filters. Design procedures for FIR and IIR Filters. Frequency Transformations. Linear phase design. Introduction to DFT. Errors in digital filtering. Hardware implementation considerations.

EEL732 Microelectronics
3 credits (3-0-0)
Brief recapitulation : Band theory, F-D statistics. Recombination effects and bipolar junction devices. MOS Devices : MOS capacitance—ideal characteristics. Interface effects and characterisation. MOSFET principles and charateristics. Various MOSFET structures, viz. DMOS, VMOS etc. and some typical applications. Parasitic device effects in MOSFET and bipolar circuits.

Other devices : High frequency transistors. Metal Semiconductor contacts (Schottky diodes) and MESFET.

Device Modelling : Bipolar devices Gummel Poon model and RC distributed model.

MOS devices - Long channel modes, short channel structures and scaled down device models, sub-threshold conduction.

EEL734 MOS VLSI
3 credits (3-0-0)
The basic MOS inverter, transfer characteristics, logic threshold. NAND and NOR logic. Transit times and inverter pair delay. Depletion and enhancement loads. Technological options in MOS processing. CMOS. Design considerations in combinational logic, shift register arrays. Register to register transfers. MOS memories and programmable logic arrays. Non-volatile memories with MOS technology. Short channel structures. Scaled down MOS performance. Other MOS LSI considerations.

EEP735 I.E.C. Laboratory I
3 credits (0-0-6)
Design and development of electronic circuits using analog and digital ICs (Application Lab).

EEL736 Medical Electronics
3 credits (3-0-0)
Pre-requisites: EEL204
Basic principles of bio medical, instrumentation and techniques. Problems of interfacing biomedical, electrical and electronic equipments with living systems, measuring instruments for bio-signals e.g. ECG, EMG, EEG and evoked responses. Biomedical transducers for pressure, flow and temperature. Biomagnetic measurement and imaging. Cardiac output measurement techniques. Dignostic and therapeutic instruments. Prosthetic devices like pacemaker, hearing-aid and myoelectric arm. Functional electrical stimulation and algorithms for extremity control. Biotelemetry of biological signals, biosensors. Neonatal monitoring. Special aspects such as safety of medical electronic equipment. Telemedicine, biotechnology and nanotechnology.

EEP736 Physical Design Lab
3 credits (0-0-6)

EEL741 Modelling and Analysis of Electrical Machines
3 credits (3-0-0)
Pre-requisites: EEL203
Energy state functions, Modelling of electromechanical systems Matrix method and use of generalised circuit theory of machines. Different methods of transformation, phase variable instantaneous symmetrical component techniques, Development of basic performance equation and analysis of different rotating machines such as D. C., synchronous and induction machines, Dynamics and transients in electric machines. Switching transients and surges, Transient and short circuit studies on alternators Run-up reswitching and other transients in induction machines relevant computer techniques for machine analysis. Modelling of special electrical machines.

EEL742 Physical Phenomena in Machines
3 credits (3-0-0)
Engineering and physical aspects of rotating machines. Modern machine windings. Winding analysis and mmf waveforms. Space and time harmonics. Saturation. Unbalanced magnetic pull and magnetic noise in industrial machines. Heating/Cooling. Unbalanced and asymmetrical operation of induction motors. Special phenomena in electrical machines such as capacitor self excitation of induction machines and its applications. Use of electromagnetic field theory, performance of permanent magnet machines. Magnetic levitation Superconductors and applications. Permanent magnet and Switched Reluctance Motors.

EEL743 Power Electronics Devices and D.C. Converters
3 credits (3-0-0)
Review of power switching devices, i.e., Thyristors, GTO, MOSFETS, BJT, IGBT and MCTS. Trigger techniques, optical isolators, protection circuits, isolation transformers. Natural and forced commutation of SCRS, phase-controlled rectifier configurations. Control of output voltage by sequence and sector control. Reduction of harmonic using multiple-pulse control. Design of rectifier circuits. Comparative aspects of design using converter transformers-forced and sell turn off devices. choppersstep down and step up configurations. Design of chopper circuits. Reduction of harmonics. Introduction to multiphase choppers. Analysis of rectifier and chopper circuits. Unity p.f.rectifiers.

EEL744 A.C. Controller
3 credits (3-0-0)
Single phase and three-phase back Controllers. Triggering techniques for power factor and harmonic controls. Design and analysis of phase control circuits. Solid state transfer switches.

Concept of three-phase to single phase and single phase to three-phase cyclo-converter.envisaged.

Symmetrical and asymmetrical control. Harmonic analysis of the output voltage. Effect of source inductance. Line commutated inverter. Single phase and three-phase inverters, configurations of VSI & CSI. Concept of PWM techniques single and multiple pulse form, periodic and DC level modulation strategies. Reduction of harmonics. Software and hardware methods of generating firing pulses. Approach to basic design of inverters. VSCF concept as applied to inverters. STATCON, SVC, UPS, SMPS.

EEL745 Electrical Drives System
3 credits (3-0-0)
Basic Concepts Characteristics and operating modes of drive motors. Starting, braking and speed control of motors. 4 quadrant drives. Types of loads. Torque and associated controls used in process industries. Applications of solid state controllers such as choppers, rectifiers, inverters and cycloconverters in drive systems, and their performance characteristics. Modern trends in industrial drives and control. Case studies relating to steel mills, paper mills, textile mills, machine tools etc. A.C. motor drives in transportation system and traction. Duty cycle. Heating/cooling and insulation in motors. Choice of motors and rating. Electromagnetic Control of Motors.

EEL746 Non-conventional Energy Sources and Energy Converters
3 credits (3-0-0)
Review of various energy sources. Importance of unconventional sources such as solar, biogas, wind, tidal etc. Study of typical energy converters such as high performance motors, special generators driven by biogas engines, wind turbines etc. Mini-hydro generators.

Modern state-of-the art and futuristic systems in this area.

EEL747 Electrical Systems for Construction Industries
4 credits (3-0-2)
Elements of Distribution System : Distribution transformer circuit breakers, Cables, Fuses and protection schemes, Rectifiers, Battery chargers and inverters.

Machines and Drives : D.C. Motors, 3-phase induction motors and FKW motors starting, speed control and braking, Application to air conditioning, lifts, cranes, water pumps.

Illumination: Types of illumination, illumination laws, lamps & fixtures.

Electrical Energy Conservation: Modern compact fluorescent lamps, energy audit methods of saving electricity in drives, lighting, air conditioning, pumps and distributions systems metering, KW, KWh and KVAR meters stand by power generation : DG sets, UPS, maintenance and protection of D.G. sets and UPS.

EEL748 Power Quality
3 credits (3-0-0)
Pre-requisites: EEL303
Overview and definition of power quality (PQ) Sources of pollution, international power quality standards, and regulations, Power quality problems: rapid voltage fluctuations voltage unbalance, voltage dips and voltage swells, short duration outages, Power system harmonics: harmonic analysis, harmonic sources- the static converters, transformer magnetization and non-linearities, rotating machines, arc furnaces, fluorescent lighting. Harmonic effects-within the power system, interference with communication Harmonic measurements. Harmonic elimination-harmonic filters.

EEL749 Special Electromechanical Devices and Systems
3 credits (3-0-0)
Pre-requisites: EEL331
Introduction to Special Electrical Machines and Magnetic Devices, Permanent Magnet Machines, Permanent Magnet Brushless DC Machines, Stepper Motors, Hysteresis Motors, Switched Reluctance Motors, Hybrid Motors, Linear Machines, Magnetic Devices, Applications in Robotics, Industry Automation, Electric Vehicles, Aerospace and Defense Systems, etc, Super conducting Machines and Other Advanced machines, Case Studies, Computer Aided Simulation and Design of Special Electrical Machines.

EED750 Minor Project (EI)
3 credits (0-0-6)
Pre-requisites: EC 120

A semester-long project usually involving design and implementation under the guidance of a faculty member.

EEP752 Software Laboratory
2 credits (0-0-4)
Pre-requisites: CSL201
Exercises on system and application software development. Emphasis on issues involved in object oriented design and development (UML tools), Compiler design and middleware based distributed applications development.

EEL754 Computer Graphics
4 credits (3-0-2)
Pre-requisites: CSL201
Overlaps with: MAL754, CSL781
Elements of a Graphics System; Computer Graphics Hardware; Geometric primitive generation algorithms; Modelling and Viewing transformations; Curve and surface generation : Hermite, Bezier, B-splines; Solid-modelling techniques; Colour Spaces; Rendering : hidden surface removal, ray tracing, texture mapping, radiosity; Image based rendering.

EEP757 Embedded Telecommunication Systems Laboratory
3 credits (0-1-4)
Real-time operation systems, object-oriented design for exbedded systems-UML, Petrinet based program development, real-time protocol stackdesign, real-time programming, lightweight wireless protocols/ Bluetooth.

EEL758 Intelligent and Knowledge Based Systems
3 credits (3-0-0)
Pre-requisites: CSL201
Overlaps with: CSL333
Problem solving: State space representation, problem reduction, constraint satisfaction networks. Heuristics. Knowledge Representation, Predicate calculus, resolution-refutation, Prolog. Rule based systems: forward and backward chaining. Handling of uncertainty: probabilistic techniques, fuzzy logic. Reasoning with incomplete information :non monotonic reasoning. Elements of temporal logic. Structured Knowledge Representation schemes :Semantic Networks, Frames, Inheritence and default reasoning. Description Logic. Expert Systems: Architecture of the expert systems. Expert system shells. Knowledge acquisition. Consistency of the knowledge base. Planning. Case studies. Distributed AI and agent based systems.

EEL760 Antenna Theory and Techniques
3 credits (3-0-0)
Review of the theory of electromagnetic radiation. Introduction to various antenna typeswire, loop and helix antennas, analysis using assumed current distribution. Aperture antennas : slot, waveguide, horn, reflector and printed antennas. Analysis using field equivalence principle and Fourier transform methods. Linear arrays. Broadband antennas. Antenna measurements.

EEL761 Electronics & Instrumentation
3 credits (3-0-0)
Review of RC coupled amplifier, principles of feedback, feedback amplifiers and oscillators.

Operational amplifier and its characteristics, inverting and non-inverting amplifiers, instrumentation amplifer, active filters - low pass, high pass, band pass and all pass, universal active filter, oscillators, analog multiplexer, sample and hold circuit, Schmitt trigger, window detector. A to D and D to A converters, data acquisition systems, 555 timer and its applications, phase lock loops, Lock-in-amplifiers.

Review of flip flops, shift registers, counters, introduction to digital filters - IIR and FIR. Review of optical components - LED, LD, PIN and APD. Design of LED and LD transmitters and receivers; optical isolator, OTDR measurements.

Transducers and recorders in instrumentation.

EEL762 Digital Communications
3 credits (3-0-0)

Elements of information theory. Source coding theorem, Huffman coding, channel coding theorem, channel capacity theorem. Sampling process : Baseband and bandpass sampling theorems, reconstruction from samples. Practical aspects of sampling and signal recovery. TDM. Waveform coding. Techniques : PCM. Channel noise and error probability. DPCM and DM. Coding speech at low bit rates. Prediction and adaptive filters. Baseband shaping for data transmission. PAM signals and their power spectra. Nyquist criterion. ISI and eye pattern. Equalization. Digital modulation techniques : Binary and M-ary modulation techniques. Coherent and non-coherent detection. Bit vs. symbol error probability and bandwidth efficiency. Error control coding: Rationale for coding. Linear block codes, cyclic codes and convolutional codes. Viterbi decoding algorithm and trellis codes. Spread-spectrum modulation : Pseudonoise sequences. Direct-sequence and frequency-Hop spread spectrum, Signal-space dimensionality and processing gain.

Data networks : Communication networks. Circuit switching. Store-and-forward switching.

Layered architecture. Packet networks and multiple-access communication.

EEL763 Monolithic Microwave Integrated Circuits & Technology
3 credits (3-0-0)
History of Monolithic Microwave Integrated circuits. Monolithic circuit components Planar Transmission Lines, Lumped and Distributed Passive Elements, GaAs MESFET. Other active devices. Metal semi-conductor functions and their characterisation. Physical and Modelling of GaAs MESFET & HEMT.
Material and fabrication techniques of GaAs MESFET. Properties of GaAs.Electron beam and X-ray lithography. Plasma assisted deposition. Molecular beam epitaxy & MOCVD. Ion milling. S-parameter measurements and their use in GaAs MESFET. S-parameter measurements: General Concept.

Measurement of S-parameters of Active Devices.On wafer S-parameters of Active Devices. On wafer S-parameter measurements; utilisation of S-parameters in circuit Design.

GaAs Mesfet Circuit Design.

Amplifiers (Narrow band/Broad band) Oscillators, Misers, Active & Passive Phase shifters. Monolithic Microwave Integrated circuit process. Optical Control of MMIC's.

EEL764 Sonar Signal Processing
3 credits (3-0-0)
Range Doppler resolution. Spatial processors. Incoherent temporal processors. Coherent processors including deltic correlators. Doppler filtering. Fast Fourier transform processors. Matched filtering hyperbolic FM systems. Target identification.

EEL765 Sonar System Engineering
3 credits (3-0-0)
Propagation, the sea surface reflection and scattering from boundaries, effects of an inhomogeneous medium. Description of sources of noise. Reverberation. Probability correlation analysis. Spectral analysis.

Review of active/passive sonar system concepts. Basic design considerations. Review of spatial and temporal processors for search and track applications for active/passive sonars. Sonar displays. Physics of CRT displays. Psycho-physical aspects. Display format and detection criteria. Modern software format display. Miscellaneous sonar concepts including frequency scanning side scan, parametric array, coastal surveillance systems.

EEL766 Numerical Techniques in Electromagnetics
3 credits (3-0-0)
Review of analytical methods: Separation of variables conformal transformation: Green's function. Finite difference method: Iterative solution: relaxation and acceleration processes: different boundary conditions.

Variational method: Derivation of variational expression; Eulerlagrange equation: Rayleigh-Ritz method.

Finite element method: Discretization of solution region: shape

functions: element matrices and global matrix; method of sulution Method of moments; Basis functions; weighted residuals; method of least squares; numerical integration.

EEL767 Telecommunication Systems
3 credits (3-0-0)
Fundamentals of signals, signal transmission and media, modulation techniques, equalization, amplification, crosstalk, attenuation, switching principles, telephony, signaling, transmission systems-DSL, optical radio.

EEL768 Detection and Estimation Theory
3 credits (3-0-0)
Pre-requisites: EEL306
Detection theory: hypothesis testing, Bayes, minimax, and Neyman-Pearson criteria, signaling in additive Gaussian noise, receiver operating characteristic. M-ary hypothesis testing, MAP and ML decision rules. Estimation of random parameters, MMS and MAP estimates. Estimation of nonrandom parameters, Cramer-Rao inequality, consistent estimate. Bounds on estimation errors, composite hypotheses. Elements of sequential and non-parametric detection. Wiener-Hopf and Kalman filtering.

EEL769 Digital Communication and Information Systems
3 credits (3-0-0)
Review of Fourier Transforms, Random Processes, Probability density function, Gaussian, density function, Rayleigh probability density, Correlation between random variables, Autocorrelation, Power spectral density of random sequences, Noise, Some sources of noise, Frequency-domain representation of noise, Spectral Components of noise, Noise bandwidth, Quadrature components of noise, Representation of noise using orthonormal components, Sampling Theorem, Quantization, Pulse Code Modulation, Digital Modulation Schemes, PSK, QPSK, FSK, QASK, MPSK, Noise Performance Analysis of the digital modulation schemes. Information Theory, Concept of information, Entropy, information rate, Coding to increase average information per bit, Shannon's theorem, Capacity of Gaussain Channel, Bandwidth-S/N tradeoff, Discrete Memoryless channel capacity, Error Correcting Codes, Parity Check, Block Codes, Cyclic Redundancy Check, Coding strength, Bit Error Rate Calculations.

EEL771 Random Processes in Control and Estimation
3 credits (3-0-0)
Introduction to random variables and random processes. Wiener's theory of optimization. Application of Wiener's theory in the compensator design for feedback control systems. Gauss Markov model for vector random processes. Kalman filtering and prediction for discrete time and continuous time systems. Minimum variance control.

EEL772 Optimal Control Theory
3 credits (3-0-0)
Pre-requisites: EEL325
Maximization of functionals of a single and several functions using calculus of variations, Constrained extremals, Necessary conditions for optimal control, Linear regulator problems, Pontryagin's minimum principles and state inequality constraintsMinimum time problems, Minimum control effort problems, Singular intervals in optimal control problems, The principle of optimality, Application of the principle of optimality to decision making, Dynamic programming applied to routing problems, Computational steps for solving optimal control problems using dynamic programming, Discrete linear regulator problem, Hamilton -Jacobi -Bellman Equation, Numerical Techniques to determine optimal trajectories, Optimal control of distributed parameter systems.

EEP773 Telecommunication Software Laboratory
3 credits (0-1-4)
CASE tools, object-oriented program development, use of Telecommunication network simulator, implementation using C/C++/ Java, network management software design, V.5 test and simulation.

EEL774 Parameter Estimation and System Identification
3 credits (3-0-0)
Introduction and overview of Systems Identification, Adaptive Control

and applications. Parameter Estimation: Least Square, Generalized and Recursive Least Square, Estimator properties including error bounds and convergence, MES, ML and MAP estimators, Nonlinear Least Squares. Model Structures and Predictors. Recursive Identification of Linear dynamic systems: RLS, ELS, IV, RML, Stochastic Approximation, Extended Kalman Filter, generalized prediction error framework and its application to ARMA and state models, covergence analysis, Time varying parameters. Nonlinear System Identification.

EEP775 Telecommunication Networks Lab-1
3 credits (0-1-4)
Use of laboratory and Tele-communication field test instruments such as : oscilloscopes, oscillators, RMS meters, transmission impairment measuring systems, return loss meters, etc. Enables students to study voice and data switching functions and to measure transmission and traffic characteristics on models of the major business communication systems and carrier transmission facilities (controlled LAN environments, Ethernet, E1, T1/T3, Frame Relay lines). Experimental procedures include the use of frequency and time division multiplex systems and the modulation techniques employed by in such systems and the observation of noise and distortion effects.

EEP776 Wireless Communication Laboratory
3 credits (0-1-4)
Characterization of fading effects, Delay Spread Measurement, Fading Counter-measures using Antenna diversity and Frequency diversity, Demonstration of Handover, Transmission of Text over RS-232 Wireless Communication Link, Antenna Half Power Beamwidth measurements, VSWR and Impedance measurement of Antennas, Polarization of Antennas, Cross Polar Discrimination and Polarization Diversity, Basic MIMO systems.

EEL781 Neural Networks
3 credits (3-0-0)
Pre-requisites: EEL205
Overlaps with: MAL720
Introduction to Biological Neural Networks; Basic anatomy and physiology of a nerve cell; mathematical models of a biological neuron; networks of neurons; a simple model of a neuron and its application to a classification problem; linear separability and linear dichotomies; nonlinearly separable problems; learning with layered networks; backpropagation; recurrent neural networks; the Hopfield network; application to optimization tasks; unsupervised learning – both co-operative and competitive; Oja and Sanger's rules; Principal Component Analysis; Kohonen's Self Organizing Feature Map; applications of unsupervised learning; Reinforcement Learning; Support Vector Machines; Hardware Realization of Neural Systems; Current Trends and Future Directions.

EEL782 Analog ICs
3 credits (3-0-0)
Review of bipolar and unipolar transistor models. Theory and design of operational amplifiers. Definition and measurement of performance characteristics. Linear and non-linear applications. D/A and A/D converters. MOS operational amplifiers, timers, Function generators. Multipliers.

EEL783 Filter Design
3 credits (3-0-0)
Approximation theory of magnitude and/or delay. Practical design considerations. Use of computers in filter design. Active filter design using op-amps; various design methods; effect of op-amp non-idealities. Elements of switched capacitor, CCD and SAW filters.

EEL784 I.C. Technology
3 credits (3-0-0)
Basic I.C. processing steps, oxidation, diffusion, Ficks laws, sheet resistivity. Ion implantation. Epitaxy : Basics of vacuum deposition. Chemical vapour deposition: high and low temperature/pressure depositions. Etching techniques. Standard bipolar NMOS and CMOS process sequences. Techniques for process evaluation analysis. In-process measurements. Novel structures in bipolar and MOS, VMOS etc. Introduction to process modelling, SUPREM.

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EEP785 I.E.C. Laboratory II
3 credits (0-0-6)
Introduction to processing of ICs.

EEL786 Mixed Signal Circuit Design
3 credits (3-0-0)
BiCMOS: Devices and Technology. Basic Analog and Digital Subcircuits. Current Mode Signal Processing: Current Mode circuits, Continuous Time and Sampled Data Signal Processing. ADC and DAC's: Nyquist and Oversampled Converters. Analog VLSI Interconnects: PLL.

EEL787 Memory Design and Testing
3 credits (3-0-0)
Review of MOS Structure, Scaled Down MOSFET and CMOS Processing. Processing for Memories: Multipoly Floating Gate and Control Gate, Trench Capacitors and thin oxide. Inverter Design: Choice of W/L and Noise Margin Calculation, Cascode and Differential Inverters. SRAM and DRAM Cell Design: Basic Cell Structures, modelling and Design Equations. Sense Amplifiers: Necessity for Sense Amplifier, Voltage and Current Sense Amplifers, Reference Voltage Generation, Influence of Sense Amplifier Performance on cell architecture. Peripheral Circuits. Memory Testing: Modelling, Introduction to Functional Testing and Built in Self Test.

EEP788 IC Processing Lab
3 credits (0-0-6)

EEL789 Optoelectronic Instrumentation
3 credits (3-0-0)
Introduction to test and measuring instruments, instrumentation amplifier, analog signal processing: active filter, A/D, D/A converters, sample & hold, multiplexer, peak detector, zero crossing detector etc., digital design: PALs, FPGA, signal analyser: superheterodyne spectrum analyzer, DFT and FFT analyzer, digital filters and computer interface, microcontrollers: introduction to microcontroller and applications such as 8031, Optoelectronic circuits : circuit design for LD transmitter and PIN receiver, OTDR, optical spectrum analyzer, sensors : fiber optic and radiation sensors, their noise and error analysis, applications in physical sensors, chopper stablised amplifier.

EED790 Minor Project
3 credits (0-0-6)

EEL790 Selected Topics in Information and Communication Technology - II
3 credits (3-0-0)
Pre-requisites: CSL201 & EEL205 and EC 90
Topics of interest and recent developments in information and communication technology.

EEP790 Advanced Electrical Laboratory
3 credits (0-1-4)
Simulation techniques and Computer program development for Power System Studies like Load flow ,Short circuit and Stability analysis. Application of commercially available software packages like Matlab, EMTDC, P-Spice for Power system studies.

EEL791 Power System Analysis
3 credits (3-0-0)
Algorithms for formation of bus admittance and impedance matrices. Power flow solutions : Gauss Seidel, Newton Raphson, Fast decoupled power flow. Short circuit studies. Sparsity exploitation in power system studies. Static equivalents for power systems. Concepts of security states and security analysis in power systems. State estimation in power systems, Voltage stability analysis.

EEP791 Power System Lab.I
2 credits (0-0-4)

EEL792 Power System Protection
3 credits (3-0-0)
Basic Principles - CTs, Pts. Static relays. Modern circuit breakers Protection of power transformers, alternators, transmission lines, cables, reactors and capacitors. Protection of motors, rectifiers and thyristors. HVDC protection. Relay Coordination, Numerical relaying algorithms, Traveling wave relays, adaptive relaying.

EEL793 Power System Transients
3 credits (3-0-0)
Origin and nature of transients and surges. Surge parameters of plant. Equivalent circuit representations. Lumped and distributed circuit transients.

Line energisation and de-energisation transients. Earth and earthwire effects. Current chopping in circuit breakers. Short line fault condition and its relation to circuit breaker duty. Trapped charge effects. Effect of source and source representation in short line fault studies. Control of transients. Lightning phenomena. Influence of tower footing resistance and earth resistance. Travelling waves in distributed parameter multiconductor lines, parameters as a function of frequency.

Simulation of surge diverters in transient analysis. Influence of pole-opening and pole reclosing. Fourier integral and Z transform methods in power system transients. Bergeron methods of analysis and the use of the EMTP package.

Insulation Co-ordination : Overvoltage limiting devices, dielectric properties, breakdown of gaseous insulation, tracking and erosion of insulation, high current arcs, metallic contacts.

EEL794 High Voltage Direct Current Transmission
3 credits (3-0-0)
General aspects and comparison with AC transmission. HVDC thyristors. Converter and inverter operation. Control of HVDC clink. Interaction between AC and DC system. Harmonic generation and their elimination. Protections for HVDC system. Modelling of HVDC link for AC-DC power flow. AC-DC system power flow solution techniques.

EEL796 Power System Control and Instrumentation
3 credits (3-0-0)
Control of voltage, frequency and tie-line power flows, Q-v and P-f control loops. Mechanism of real and reactive power control. Net interchange tie-line bias control. Optimal, sub-optimal and decentralised controllers. Discrete-mode AGC. Time-error and inadvertent interchange correction techniques. On-line computer control. Distributed digital control. Data acquisition systems. Emergency control, preventive control, system wide optimization, SCADA.

EEL797 Power System Dynamics
3 credits (3-0-0)
Dynamic models of synchronous machines, excitation system, turbines, governors, loads. Modelling of single-machine-infinite bus system. Mathematical modelling of multimachine system. Dynamic and transient stability analysis of single machine and multi-machine systems. Power system stabilizer design for multimachine systems. Dynamic equi-valencing. Voltage stability Techniques for the improvement of stability. Direct method of transient stability analysis: Transient energy function approach.

EEP798 Power System Lab. II
2 credits (0-0-4)

EEL799 Power System Reliability
3 credits (3-0-0)
Basic Probability Theory : Review of probability concepts. Probability distributions. Application of binomial distribution to engineering problems. Probability distribution in reliability evaluation. Network modelling and evaluation of simple and complex systems. System reliability evaluation using probability distributions. Frequency and duration techniques.

Generation System Reliability Evaluation : Concept of LOLP and E(DNS) Evaluation of these indices for isolated systems. Generation system. Reliability analysis using the frequency and duration techniques.

Transmission System Reliability Evaluation: Evaluation of the LOLP and E(DNS) indices for an isolated transmission system.

Distribution System Reliability Evaluation: Reliability analysis of radial systems with perfect and imperfect switching.

EES800 Independent Study (Computer Technology)
3 credits (0-3-0)

EED801 Major Project Part-1 (Computer Technology)
6 credits (0-0-12)

EED802 Major Project Part-2 (Computer Technology)
12 credits (0-0-24)

EEL802 Testing and Fault Tolerance
3 credits (3-0-0)
Physical Faults and their Modelling; Stuck-at Faults, Bridging Faults; Fault Collapsing; Fault Simulation : Deductive, Parallel, and Concurrent Fault Simulation; Critical :Path Tracing; ATPG for Combinational Circuits : D-Algorithm, Boolean Differences, Podem; Random, Deterministic and Weighted Random Test Pattern Generation; Aliasing and its Effect on Fault Coverage; PLA Testing, Cross Point Fault Model and Test Generation; Memory Testing Permanent Intermittent and Pattern Sensitive Faults, Marching Tests; Delay Faults; ATPG for Sequential Circuits : Time Frame Expansion; Controllability and Observability Scan Design, BILBO, Boundary Scan for Board Level Testing; BIST and Totally Self checking Circuits; System level Diagnosis; introduction; Concept of Redundancy, Spatial Redundancy, Time Redundancy, Error Correction Codes; Reconfiguration Techniques; Yield Modelling, Reliability and effective area utilization.

EEL804 Scientific Visualization
3 credits (3-0-0)
Pre-requisites: EEL754/EEL707
Role of visualization in scientific research. History. Computational cycle. Visual metaphors. Visualization pipeline. Data: Acquisition from numerical simulations and measurements. Selection techniques for data preparation. Volume visualization I: marching cubes; ray casting, multimodal rendering. Applications in biology and molecular visualization. Volume visualization II: splatting, Fourier and wavelet volume rendering. Applications in medical imaging. Vector field visualization: experimental methods, surface particles, flow field topology, probing. Applications in flow visualization. Information Visualization. Applications in bioinformatics.

EEL806 Computer Vision
4 credits (3-0-2)
Pre-requisites: EEL205 & EC120
What is vision ; Overview of Applications; Camera: Physics of Image Formation, Projective Model of Camera, Camera Calibration; Multiple-view Geometry and Reconstruction; Shape from X (defocus, shading, texture); Motion Analysis and Tracking; Object Recognition and Image Understanding.

EES810 Independent Study (Communications Engineering)
3 credits (0-3-0)

EEL811 Miscellaneous Underwater Systems
3 credits (3-0-0)
Echo sounder. Underwater communication. Underwater measuring instruments/calibration.Remote controlled submersibles. Acoustic holography. Low light television. Sonobuoys and underwater weapon control

EEL812 Millimetre Wave Integrated Circuits
3 credits (3-0-0)
Analysis of basic transmission lines for millimetre wave frequencies.

Integrated finline, image guide and its variants, non-radiative guide, H-guide and groove guide. Millimetre wave devices for generation and detection. Transitions, bends and discontinuities. Measurement techniques. Design of millimetre wave devicescouplers, power dividers, filters, oscillators, mixers, switches, phase shifters and amplifiers.

EEL813 Selected Topics I
3 credits (3-0-0)

EEL814 Selected Topics II
3 credits (3-0-0)

EEL817 Access Networks
3 credits (3-0-0)
Pre-requisites: EEL306 and EC 120

The access loop, wired and wireless access, radio access, optical access networks, PONs, access standards, V5.x standards,service provisioning and inter-networking.

EEL818 Telecommunication Technologies
3 credits (0-1-4)
Data Networks, ISDN, SS7, Access-WILL/RILL, DECT, FITL, WAN-Frame Relay, ATM, Telecommunication Management network (TMN), Teletraffic Theory and Network analysis, Network planning and design.

EED820 Minor Project (Control and Automation)

EEL823 Discrete Time Systems
3 credits (3-0-0)
Introduction to discrete time systems. Time domain representation. Z-transformation. Analysis of discrete time systems; time domain approach and Z-domain approach. State variable representation, analytical design of discrete system, engineering characteristics of computer control systems, elements of hybrid computer, digital and hybrid simulation of sampled data systems.

EEL824 Nonlinear Systems
3 credits (3-0-0)
Classification of non-linear phenomena. Linear and piecewise linear approximations. Phase plane, describing function and quasilinearization techinques. Various notions of stability. Stability techniques of Lyapunov and Popov. Nonlinear controller design using feedback linearization and back stepping method. Introduction to variable structure control systems.

EEL829 Selected Topics in Advanced Control & System Theory-I
3 credits (3-0-0)

EED830 Minor Project (Integrated Electronics & Circuits)
3 credits (0-0-6)

EEL831 Digital Signal Processing-II
3 credits (3-0-0)
Pre-requisite : Digital Signal Processing I
Methods for fast computation of DFT including FFT, NTT and WTFA. Noise analysis of digital filters. Power spectrum estimation. Multi-rate digital filtering: Introduction to multidimensional DSP. Examples of applications of DSP in communications. Radar and Sonar.

EEV831 Special Module in Nano Electronics
1 credit (1-0-0)
Pre-requisite: EEL732 and EEL784 or EEL218 and EEL329
Special module that focuses on special topics. Development and Research problems of importance in the area of Nano Electronics.

EEL832 Computer Aided VLSI Design
3 credits (3-0-0)
Hardware description Languages; Verifying behaviour prior to system construction simulation and logic verification; Logic synthesis; PLA based synthesis and multilevel logic synthesis; Logic optimization; Logic Simulation: Compiled and Event Simulators; Relative Advantages and Disadvantages; Layout Algorithms Circuit partitioning, placement, and routing algorithms; Design rule verification; Circuit Compaction; Circuit extraction and post-layout simulation; Automatic Test Program Generation; Combinational testing : D Algorithm and PODEM algorithm; Scan-based testing of sequential circuits.

EEV832 Special Module in Analog and Mixed Signal IC Design
1 credit (1-0-0)
Pre-requisites : EEL732 and EEL786 or EEL219 and EEL329
Special module that focuses on special topics, Development and Research problems of importance in the area of Analog and Mixed Signal IC Design.

EEL833 Selected Topics in I.E.C.
3 credits (3-0-0)

EEV833 Special Module in Low Power IC Design
1 credit (1-0-0)

Pre-requisites : EEL734, EEL782 or EEL329
Special module that focuses on special topics, Development and Research problems of importance in the area of Low Power IC Design.

EEL834 VLSI Design
3 credits (3-0-0)
Relationship between design of ICs, technology and device models.

NMOS, CMOS, BiCMOS Process sequences and silicon foundry-concepts. Symbolic representations.

Array and other design approaches. Topics in design-yield and redundancy, Low Power design. Testability and fault tolerance.

Cell library formation. Design automation. Hardware description languages, Current Topics.

EEV834 Special Module in VLSI Testing
1 credit (1-0-0)
Pre-requisites : EEL734, EEL782 or EEL329
Special module that focuses on special topics, Development and Research problems of importance in the area of VLSI Testing.

EEP835 I.E.C. Project Laboratory
3 credits (0-0-6)

EEV835 Special Module in Machine Learning
1 credit (1-0-0)
Special module that focuses on special topics, Development and Research problems of importance in the area of Machine Learning.

EEV836 Special Module in Applied Mathematics
1 credit (1-0-0)
Instructor or Supervisor's Recommendation
Special module that focuses on special topics, Development and Research problems of importance in Applied Mathematics.

EES837 Independent Study (Integrated Electronics & Circuits)
3 credits (0-3-0)

EEL838 CMOS RF IC Design
3 credits (3-0-0)
Pre-requisites : EEL734 and EEL782
Historical Aspects - From Maxwell to current wireless standards: The Bridge between communication systems designer and RF IC Designer: a) Comn. System Characterization, b) RF System Characterization; Transceiver Architectures - Motivation for the individual Blocks; Lumped, passive RLC, RF properties of MOS, Turned Amplifiers; LNAs: Noise sources, Cascades and LNA Design; Mixers-passive and active mixers; Oscillators; Analysis Fundamentals, Inductors, LC Oscillators and VCOs; Frequency synthesizers: Principles, Ineger N vs Fractional PLL, Design Concepts.

EEV839 Selected Topics in IEC II
3 credits (3-0-0)
Pre-requisites : EEL734, EEL782
Selected topics related or having a bearing on electronics, circuits, their analysis, design, or application.

EED841 Minor Project
3 credits (0-0-6)

EEL841 Solid State Controllers of Drives
3 credits (3-0-0)
ROM based control of converters, such as rectifiers, choppers, inverters, cyclocon-verters. Use of PLL for speed control. Basic microprocessor system for speed control of drives. Field oriented control and programmable controllers. VSI and CSI converter with PWM technique for implementation of the field oriented control. Energy saving drive system, transfer function of converter controlled drive and analysis.

Switched Reluctance Motor Drive, Permanent Magnet Brushless Motor Drives, Synchronous Reluctance Motor Drives, Sensorless Control, Direct Torque Control, Direct and Indirect Vector Control, CLM Drives, Power Quality Improvements in Drives.

EEP841 Electrical Machines Laboratory
1.5 credits (0-0-3)

EES841 Independent Study (Power Electronics, Electrical Machines & Drives)
3 credits (0-3-0)

EET841 Industrial Training and Seminar
3 credits(3-0-0)

EED842 Major Project Part-1 (Power Electronics, Electrical Machines & Drives)
6 credits (0-0-12)

EEP842 Power Electronics Laboratory
1.5 credits (0-0-3)
Advanced experiments in electrical machines and power electronics

EED843 Major Project Part-2 (Power Electronics , Electrical Machines & Drives)
12 credits (0-0-24)

EEL843 Computer Aided Simulation & Design of Power Electronics Systems
3 credits (3-0-0)

EEP843 Electric Drives Laboratory
1.5 credits (0-0-3)
Advanced experiments on drive systems and their control, converter fed d.c. drives. Inverter fed a.c. drives. Computer control of drives.

EEL844 Advanced or Selected Topics in Power Electronics
3 credits (3-0-0)
Advanced topics in power electronics. Analysis and design of power electronic circuits.

EEP844 Microprocessor and Microcomputer Laboratories
1.5 credits (0-0-3)
Experiments in familiarization of microprocessors and microcomputers. Use of personal computers (PC) programming techniques. Software development on PC for typical drive problems. Machine interfacing with PC.

EEL846 Computer Aided Design of Electrical Machines
3 credits (3-0-0)
Basic design methodology and engineering considerations. Properties of electric, magnetic and insulating materials. Choice of materials, frames etc. Computerisation of design procedures. Optimisation techniques and their application to design problems. Design of large and h.p. motors. Database and knowledge based expert systems. Development of PC based software.

EEL847 Selected Topics in Machines & Drives
3 credits (3-0-0)

EED851 Major Project Part 1 (EI)
6 credits (0-0-12)
Pre-requisites: EC 165
This project spans also the course EED852. Topics should be from topics related to information and communication technology. The problem specification and the milestones to be achieved in solving the problem are to be clearly specified. Progress up to the end of the semester is to be presented for assessment and grade.

EEL851 Special Topics in Computers - I
3 credits (3-0-0)
Pre-requisites: CSL201 and EC 120

Topics of current interest related to computers; details will be provided by the instructor.

EED852 Major Project Part 2 (EI)
14 credits (0-0-28)
Pre-requisites: EED851
Continuation and completion of the work started in Project Part 1. Presentation at the end of the semester for award of grade.

EEL852 Special Topics in Computers - II
3 credits (3-0-0)
Pre-requisites: CSL201 and EC 120
Topics of current interest related to computers; details will be provided by the instructor.

EED853 Major Project Part 1 (EI)
4 credits (0-0-8)
Pre-requisites: EC 165
This course forms the first part of the two semester long major project. Work includes significant research and development in the area of information technology/communication technology under the guidance of faculty. Tasks include problem definition, preparation of work plan, literature review and initiation of work.

EEL853 Agent Technology
3 credits (3-0-0)
Pre-requisites: CSL201 and EC 120
Introduction: What are agents? Motivating Applications. Agent Architecture. Multi-agent Systems and Agent Societies. Distributed Problem Solving and Planning. Search Algorithms. Distributed Rational Decision Making. Probabilistic Reasoning. Implementing Agent Systems. Development Environments. Programming issues. Mobility and Security. Applications. Information Retrieval, E-Commerce, Industrial Control, Telecommunication System.

EED854 Major Project Part 2 (EI)
16 credits (0-0-32)
Pre-requisites: EED853
This course is the second part of the two semester long major project. Work includes significant research and development in the area of information technology/communication technology under the guidance of faculty. Tasks include completion of planned work, report writing and presentation

EEL854 Protocol Engineering
4 credits (3-0-2)
Pre-requisites: EEL703
Principles, stages, specification formalisms (UML, SDL, ASN.1) of telecom protocol design, protocol software development process, computer aided protocol engineering, verification and testing of protocols, object oriented techniques in protocol development.

EEL855 Internet Technologies
4 credits (3-0-2)
Pre-requisites: EEL703
Introduction to the Internet, comparison of Internet architectures, QoS issues, network applications, encryption, e-commerce, Web enabled systems, virtual reality, multimedia over the Internet.

EEL857 Network Security
4 credits (3-0-2)
Pre-requisites: EEL703
Practical topics in network security, mechanisms for secure networks, policy, intrusion detection, cryptographic protocols, inter-networking security mechanisms, private and public key encryption, IPSEC-Internet Protocol security architecture.

EEL858 Mobile Computing
3 credits (3-0-0)
Pre-requisites: EEL703
Overview of mobile computing, introduction to SS7 and GSM, Wireless Networking Protocol: mobile IP, Adhoc Networks, Adhoc Routing, Wireless Protocols- Wireless TCP, Data Broadcasting, Mobile data management, Location Dependency/Awareness, Disconnected or

Weak-connected operations, Adaptations, Mobile Applications and services, User Interface Issues, Security Issues.

EEP858 Telecom Networks Laboratory-II
3 credits (0-1-4)
Specification and implementation of the alternating-bit protocol in SDL ATM-Signaling Protocaols Hand-over in GSM radio mobile network, Data transmission with GSM in the non-transparent mode, Protocol analysis of data transmission via Ethernet LAN, Development of voice based services for intelligent networks, Planning and evaluation of DECT systems.

EEL859 Network Management
4 credits (3-0-2)
Pre-requisites: EEL703
Network planning, network initialization and configuration management, fault management, usage accounting, and security. The course will also include discussion of some current network and management products. It will also cover the development of network management systems and discuss the role played by network management protocols and products.

EED860 Minor Project (Communications Engineering)
3 credits (0-0-6)

EEL860 Wireless Communications
3 credits (3-0-0)
Cellular Concept. Mobile Radio Propagation. Cochannel Interference. Modulation Techniques. Diversity. Channel Coding. Multiple Access. Cellular Coverage Planning. Wireless Networking. Wireless Systems and Standards.

EED861 Major Project Part-1 (Communications Engineering)
6 credits (0-0-12)

EEL861 Selected Topics in Communication Engineering - I
3 credits (3-0-0)
Pre-requisites: EEL306 and EC 120
Topics of current interest in communication engineering; details will be provided by the instructor.

EED862 Major Project Part-2 (Communications Engineering)
12 credits (0-0-24)

EEL862 Selected Topics in Communication Engineering - II
3 credits (3-0-0)
Pre-requisites: EEL306 and EC 120
Topics of current interest in communication engineering; details will be provided by the instructor.

EEL863 Selected Topics in Communication Engineering - III
3 credits (3-0-0)
Pre-requisites: EEL306 and EC 120
Topics of current interest in communication engineering; details will be provided by the instructor.

EEL864 Modern Antennas and Arrays
3 credits (3-0-0)
Printed antennas. Arrays : pattern synthesis, planar arrays, ph ased arrays. Diffraction theory : paraboloidal reflector antenna, different feed configurations, shaped beam antennas. Millimetre wave antennas. Dielectric rod, lens, Fresnel-zone antenna, quasi-optical antennas. Antennas for biomedical application.

EEL865 Microwave Propagation and Systems
3 credits (3-0-0)
Frequency bands and allocations. Earth and its effects on propagation. Atmosphere and its effects on propagation. Attenuation of millimetre waves. Line-of-sight communication links: system configuration, multiplexing, link design. Troposcatter propagation and links: Fading and diversity reception, path profile and path loss, link design, signal design for fading channels.

EEL866 Microwave Solid State Devices and Circuits
3 credits (3-0-0)
Two terminal devices and circuits : Junction diodesPIN, Schottky, Varactor, tunnel diodes. Design and analysis of switches, limiters, phase shifters, modulators, harmonic generators and parametric amplifiers. Transferred Electron Devices—Gunn, LSA. Avalanche Transit Time Devices—Impatt, Trapatt and their circuits. Bipolars, JFET and MESFET. Design of oscillators and amplifiers.

EEL867 Fading Channels
3 credits (3-0-0)
Fading channel models and characterization: Scatter model. Scattering function. Classification of channels (dispersive only in time, only in frequency, doubly dispersive). Modulation and demodulation : Optimum receiver principles, structure of modulators and demodulators. Combining techniques. General principles of linear combining, selection combining, maximal ratio combining and equal gain combining. Decision oriented diversity, optimum combining. Coding for fading channels. Trivial repetitive coding, Interleaved coding, dual-k convolutional codes and trellis codes for fading channels. Performance evaluation. Random coding bound for coded systems, probability of error, bandwidth and complexity. Performance of linear combining systems. Examples of fading channels : Discussion on mobile communication channels and troposcatter channels.

EEL869 Optical Data Processing
3 credits (3-0-0)
Review of Fourier optics, coherent and incoherent imaging transfer functions, equivalence of optical and electrical systems, spatial filtering, holographic data processing, optical memories, application to synthetic aperture radar and biological signal processing. Hybrid opto-digital signal processing.

EEV871 Selected Topics in Communication Engineering-IV
1 credits (1-0-0)

EEV872 Selected Topics in Communication Engineering-V
1 credits (1-0-0)

EEP874 Project Laboratory
3 credits (0-1-6)

EED875 Major Project Part-1 (Control & Automation)
6 credits (0-0-12)

EED876 Major Project Part-2 (Control & Automation)
12 credits (0-0-24)

EEL878 Artificial Intelligence in Control Applications
3 credits (3-0-0)
An overview of the field of Artificial Intelligence. Neural Networks : Fundamentals, Back propagation model, Other models, control Applications. Genetic Algorithms and Evolutionary Computing : Optimization Examples. Fuzzy Systems : Fundamentals; Fuzzy Control; Hybrid Systems. Rough Sets : Basics; Knowledge Extraction from Data; Control Applications. Chaos; Applications.

EEL879 Selected Topics in Advanced Control & Systems Theory-II
3 credits (3-0-0)

EEL881 Issues in Deep Submicro CMOS IC Design
3 credits (3-0-0)

EEP881 Network Software Laboratory
3 credits (0-1-4)
Network simulation tools, characterization of networks, test procedures for network software, real-time operating systems, object-oriented design for networks, optimization tools, visualization techniques.

EEL882 Introduction to Telecommunication Systems
3 credits (3-0-0)
Basics of data communication, telephone systems, modulation and demodulation, multiple channel communication, introduction to communication channels, introduction to data networks and their applications.

EEL885 EHV AC Transmission
3 credits (3-0-0)
Introduction of EHV AC transmission. Tower configurations. Thermal ratings of lines and cables, transformer technology, circuit breakers. Voltage gradients of conductors. Corona effects, power loss and audible noise, radio interference. Electrostatic field of transmission lines. Lightning and lightning protection. Insulation characteristics of long air gaps. Design of EHV lines based upon steady-state limits, transient overvoltages, and voltage stability. Series and shunt compensation. Reactive power control apparatus.

EED888 Major Project Part-1 (Integrated Electronics & Circuits)
6 credits (0-0-12)

EED889 Major Project Part-2 (Integrated Electronics & Circuits)
12 credits (0-0-24)

EEL890 Photonic Switching and Networking
3 credits (3-0-0)
Photonic Switching: Switching architectures-single and multistage switching, space switching, time switching, combinations of space and time switching, interconnection networks; Networks: Introduction to computer data networks, ISO-OSI models, SDH, SONET; Fiber-optic LAN architectures and protocols- ring, star and bus architectures, DQDB, FDDI; High speed bus protocols- RATO-net, WDM networks- LAMBDA-net, coherent star, PASS-net, shuffle-net.

EED890 Major Project Part-1 (Power Systems)
6 credits (0-0-12)

EEL891 Selected Topics in Power System
3 credits (3-0-0)

EEL892 Power System Communication
3 credits (3-0-0)
Introduction. Communication links required for telemetry, telecontrol and teleprotection. Analog and Digital Communication-Speed and bandwidth requirements-Noise in power systems. Communication links PLCC, microwave, telephone line, satellite, fibre optic. Requirements of various communication equipments used in power systems. Computer networking in power system.

EES893 Independent Study (Power Systems)
3 credits (0-3-0)

EEL894 Flexible A.C. Transmission Systems
3 credits (3-0-0)
The phenomenon of voltage collapse; the basic theory of line compensation.

Static excitation systems; static VAR compensators; static phase shifters; thyristor controlled series capacitors.

Co-ordination of FACTS devices with HVDC links.

The FACTS optimisation problem Transient and dynamic stability enhancement using FACTS components.

Advanced FACTS devices-the STATCON and the unified power flow controller.

EED895 Major Project (M.S. Research)
40 credits (0-0-80)

EEL895 Broadband Communication and Information Systems

3 credits (3-0-0)

Fundamentals of telecom systems, Principles of communication and signaling, Fundamentals of transmission; mathematical models for networks, Tele-traffic engineering: Telecom Management Networks, Protocols, Architectures for Broadband Networks, ATM, SDH/SONET; Access and Hybrid Networks; All optical networks.

EEL896 Power System Optimization

3 credits (3-0-0)

Economic load dispatch in thermal and hydro-thermal system; reactive power optimization; optimal power flow. Linear programming and non-linear programming techniques to optimal power flow problems. Security constrained optimization. Unit commitment and maintenance scheduling, Interchange evaluation, Minimum emission dispatch.

EEL897 Load Forecasting and Load Management

3 credits (3-0-0)

Load Forecasting : Classification and characteristics of loads. Approaches to load forecasting. Forecasting methodology. Energy forecasting. Peak demand forecasting. Non-weather sensitive forecast. Weather sensitive forecast. Total forecast. Annual and monthly peak demand forecasts. Applications of state estimation to load forecasting.

Load Management : Introduction to load management. Electric energy production and delivery system structure (EEPDS). Design alternatives for EEPD systems. Communication/Control technologies for load management. Tariff structure and load management. Some principles of microeconomics and energy pricing strategies. Assessing the impacts of load management.

EED898 Major Project Part-2 (Power Systems)

12 credits (0-0-24)

EEL899 Distribution Automation

3 credits (3-0-0)

Introduction to distribution automation, configuration of distribution system. Nature of loads and load forecasting. Layout of substations and feeders. Design considerations. Distribution system load flow. Optimum siting and sizing of substations, optimum capacitor placement. Distribution system monitoring and control : SCADA, Remote metering and load control strategies, Optimum feeder switching for loss minimization and load control. Distribution system restoration. Distribution system protection and switchgear. Power quality issues.

Department of Humanities and Social Sciences

HUN100 Introduction to Humanities and Social Sciences
2 credit (0-0-4)
This introductory course will expose students to the basic concepts, debates, issues, ideas, and the problems of methodology in the different disciplines of Humanities and Social Sciences like Economics, English, Philosophy, Psychology, and Sociology. An objective of the course will be to improve English language proficiency of the students.

HUL101 English in Practice
3 credits (2-0-2)
Verb structures and patterns, avoiding common errors, vocabulary building, spelling patterns, developing writing skills (composition, letter writing) etc. developing listening skills.

HUP102 Psychology Laboratory
1 credit (0-0-2)
To familiarize students with psychological concepts through practical training in a laboratory through experiments pertaining to cognitive psychology, environmental psychology and physiological psychology.

HUL211 Introduction to Economics
4 credits (3-1-0)
Pre-requisites: HUN100
Current economic problems. Alternative economic systems. An overview of the economy. The market mechanism. National product and income. Consumption, savings and investment. Determination of national income. Aggregate demand and supply. Fiscal policy. The nature of money and monetary policy. Inflation and unemployment. Basic concepts of price theory. Determination of price by supply and demand. Elasticity of demand and supply. Theory of production. Theory of costs. Pricing in competitive and monopoly markets. The gains from international trade. Theory of exchange rates. Balance of payments. Economic growth, and development. Inequality and poverty.

HUL212 Microeconomics
4 credits (3-1-0)
Pre-requisites: HUN100
Micro versus macroeconomics. Theory of consumer behavior and demand. Consumer preferences. Indifference curve. Consumer equilibrium. Demand function. Income and substitution effects. The Slutsky equation. Market demand. Elasticities. Average and marginal revenue. Revealed preference theory of firm. Production functions. Law of variable proportions. Laws of return to scale. Isoquants. Input substitution. Equilibrium of the firm. Expansion path. Cost function. Theory of costs. Short Run and Long run costs. Shape of LAC. Economies and diseconomies of scale. Market equilibrium under perfect competition. equilibrium under alternative forms of market. Monopoly: pure and discriminating. Monopolistic competition. Oligopoly.

HUL213 Macroeconomics
4 credits (3-1-0)
Pre-requisites: HUN100
Major economic problems. National income accounting. Expenditure and income approaches to GNP. Measuring inflation and unemployment. Determination of the equilibrium level of income. Consumption function. Investment demand. Aggregate demand and equilibrium output. The multiplier process. Government sector. Fiscal policy. Tax receipts and Transfer payments. Foreign spending. Money, interest and income. Functions of money. Definition of money. Reserve Bank of India and Commercial Banks. Creation of money. The instruments of monetary control. The demand for money. Investment expenditure and rate of interest. The IS curve. Money market and the LM curve. Liquidity trap. The IS-LM model. Derivation of the aggregate demand curve. Monetary and fiscal polices. Keynesian versus monetarist views. The aggregate supply function: Keynesian and classical. Inflation and unemployment. Stagflation. The Phillips curve. The long-run Phillips curve. Inflation expectations. The rational expectations.

HUL214 International Economics
4 credits (3-1-0)
Pre-requisites: HUN100
Trade determination theories. Absolute and comparative advantage. Hackscher-Ohlin theorem and factor price equalizations theorem. New theories of trade. Economic growth and trade. Effects and sources of growth. Rybczynski theorem. Technical progress. Gains from trade and trade policy. Tariffs and quotas. Metzier paradox. Stopler-Samuelson theorem. ERP. Domestic distortions. Infant industry argument. Foreign direct investments. Multinational corporation. International monetary economics. Balance of payments. Exchange rates-fixed versus flexible. Devaluation. Elasticities approach. Absorption approach. Monetary approach. Internal and external balance.

HUL215 Econometric Methods
4 credits (3-1-0)
Pre-requisites: HUN100
Definition, scope and methodology of econometric research. Estimation and testing of hypotheses. Simple linear regression. OLS and its properties. Gauss-Markov theorem. Statistical tests of significance. Multiple regressions. Statistical tests. Heteroskedasticity. Autocorrelation. Multicollinearity. Distributed lagged models. Pooling of time series and cross-section data. Simultaneous equation systems. Identification problem. Estimation methods. ILS, 2SLS. Qualitative and limited dependent variables. Maximum likelihood methods. Forecasting.

HUL216 Indian Economic Problems and Policies
3 credits (2-1-0)
Pre-requisites: HUN100
Performance of the Indian Economy since 1951. Agricultural growth in India. Inter-regional variation in growth of output and productivity. Institutional changes. Technological changes. Farm price policy. Food situation. Recent trends in industrial growth. Industrial and licensing policy. Growth of private sector. Problems of public sector units. Industrial sickness. Policy changes for industrial growth. Economic reforms and liberalization. Population growth. Unemployment and underemployment in India. Main trends in imports and exports. Balance of payments position in recent years. Foreign capital. Indian planning: strategy and objectives. India's five-year plans. Regional planning. Saving and capital formation. Poverty in India. Income inequalities in India. Environmental problems.

HUL231 An Introduction to Literature
4 credits (3-1-0)
Pre-requisites: HUN100
What is literature? This is the central question that the course will address through representational readings from different genres. The focus will be less on any given genre and more on how it becomes possible for the student to reconstruct something called 'literature' through the variety of genres to which he or she is exposed. The course does not presuppose any knowledge of literature though students will be expected to have a strong command of the English language. The actual texts chosen to illustrate the different forms of literature will not be restricted to any particular culture but will be open ended to include any text that will help the class to answer the question of what constitutes the essence of literary representation.

HUL232 Modern Indian Fiction in Translation
4 credits (3-1-0)
Pre-requisites: HUN100
To study the need, the scope and the processes of literary translation, with particular reference to the multilingual nature of Indian society and the predicaments of the bilingual writers in India. Students will be encouraged to work with at least some texts of their own choice and to present their work in an acceptable format. A preliminary list of the possible texts will be circulated. This list will be open-ended as it will grow and evolve according to the preferences and the inclinations of the people who are actually doing the course.

HUL233 American Literature
4 credits (3-1-0)
Pre-requisites: HUN100
This course aims to acquaint students with a broad spectrum of issues in the culture of the United States that are reflected in its literature. It will include texts written by both white and colored peoples of the United States including slavery and immigration narratives. Selections of texts include those pertaining to the culture of New England Puritanism, The American Renaissance, Modernism, Postmodernism, etc. It will also look at the relationship between the categories of race,

class and gender as critical tools and examine how these tools force us to revaluate the relationship between culture and literature. It will also address the perennial question of the American Dream and the representation questions that this notion gave rise to.

HUL234 Language and Communication
4 credits (3-1-0)
Pre-requisites: HUN100
This course builds the skill sets needed to understand the basics of both language and communication. It is also interested in exploring the relationship between the two categories (language and communication) in order to work out how they relate to each other. It will include introductory concepts in semantics, semiotics, syntax, lexicography, and discourse analysis. It will also include an analysis of philosophical problems of reference, representation, rhetoric, sense, speech acts, and textuality. Students will have to submit a term paper and make an oral presentation on any aspect of language and/or communication that they wish to explore at length. Workshops are also included to help students internalize the concepts of communication to which they have been introduced.

HUL235 Technical Communication
4 credits (3-1-0)
Pre-requisites: HUN100
This course is designed to sensitize students of technology to the importance of communication. The topics covered include the basic principles and models of communication, stylistic considerations in technical writing, types and formats of technical documents, the process of writing technical reports, graphical representation of technical data, technical presentations including the use of media to support technical presentations and collaborative writing. Students will be expected to prepare a technical report and make a short oral presentation.

HUL236 An Introduction to Drama
4 credits (3-1-0)
Pre-requisites: HUN100
This course will introduce students to problems of both dramatic and theatrical representation. It will include readings from both ancient and modern drama and engage with some of the leading theorists of drama from Aristotle to Brecht. Students will be exposed to the generic differences between the different forms of drama like tragedy, comedy, melodrama, farce, etc. Students will be encouraged to stage scenes from well-known plays as a part of their assessment.

HUL237 Contemporary Fiction
3 credits (2-1-0)
Pre-requisites: HUN100
This course aims to acquaint students with fiction written after the modernist era. Much of this fiction is an attempt to shake off the excessive sense of despair that characterized the modernists. It is also preoccupied with the aftermath of World War II, the cold war, the great ideological debates between capitalism and communism, and the return to realist modes of narration despite the persistence of modernist aesthetics. Representative texts will be examined at length to understand and work through the issues listed above.

HUL238 Modern Fiction
4 credits (3-1-0)
Pre-requisites: HUN100
This course is quite demanding in that it expects students to have not only an excellent command of the English language but a preoccupation with the nature of language per se. Since the very essence of modernist aesthetics is based upon a preoccupation with the combinatorial possibilities of language as opposed to referential or instrumental forms of linguistic expression, only students with an excessive capacity for both existential and linguistic self-reflexivity will enjoy the study of modern fiction. Amongst the writers who will be read include Hardy, Joyce, Lawrence and Nabokov though others may also be included if time permits.

HUL239 Indian Writing in English
4 credits (3-1-0)
Pre-requisites: HUN100
This course aims to introduce the students to the problems of identity as they emerge in Indian English literature during the nation's struggle for freedom and thereafter. The breakdown of the joint family in the wake of independence and its far-reaching consequences. The age-old conflict between arranged marriages/marital bliss and romantic love as a major preoccupation of the Indian writer. The problem of guilt in man torn between a sense of duty toward family and his need to break away from it for self - fulfillment. The impact of the West on Indian society and mind, and its various manifestations in Indian fiction in English as it exists now in courses of study.

HUL240 Indian English Poetry
4 credits (3-1-0)
Pre-requisites: HUN100
The aim of this course will be to read the poems of Indian English Writers (pre and post Independence), with specific reference to the articulation of their identity. Some of the perspectives from which the poems will be discussed include the notion of home (childhood, family and ancestors); land (history, geography, community and contemporary politics); language (the dialogue between the different languages in the creative repertoire of the poets); and culture (ritual, traditions, legends and myths). The course will also look at the differences between the resident and expatriate poets vis-a-vis the conflicts and resolutions as expressed in their poems. An attempt will be made to make this list as culturally and linguistically representative as possible. Students will be expected to choose one poet and make a presentation and write an assignment.

HUL241 Workshop in Creative Writing
4 credits (3-1-0)
Pre-requisites: HUN100
Introduces the concept of creative writing through an analysis of the techniques of writing and stylistics along with explorations in the problem of literary creativity. It also introduces contemporary writing that is relevant to the areas being discussed in the workshop. Students are invited to write in a genre of their choice. Selected readings in the theory and practice of creative writing will be used to brainstorm on what is involved in acquiring a style of writing.

HUL251 Introduction to Logic
4 credits (3-1-0)
Pre-requisites: HUN100
Informal logic: The student is acquainted with the fundamentals of informal logic needed in verbal analysis. Fallacious reasoning and its forms are analyzed and the student comes to recognize the many informal fallacies that are due to the equivocation of language or to a lack of relevance between premises and the conclusion of an argument. Logical systems: Students conceptualize the difference between inductive and deductive argument forms and systems and perform inductive and deductive inferences. They study the formal rules and principles demonstrated in the deductive system of Aristotelian logic. Symbolic logic: The ability to translate ordinary language into symbolic form is acquired and the student constructs arguments in symbolic expression. Philosophy of logic and the role of logic in science: The procedure of scientific explanation is investigated and its methodologies examined.

HUL252 Introduction to Classical Indian Philosophy
4 credits (3-1-0)
Pre-requisites: HUN100
There is no one system, which can be called Indian philosophy. Diversity and healthy dialogue between even antagonistic systems characterizes the classical philosophical scene in India. The course will begin by exploring the worldview implicit in the Vedas, the Upanishads, and the orthodox systems and then move on to the rejection of this entire system in Buddhism and materialism. Instead of presenting the course material in a historical fashion, the focus will be on analyzing the fundamental questions of classical Indian philosophy.

HUL253 Moral Literacy and Moral Choices
4 credits (3-1-0)
Pre-requisites: HUN100
This is primarily a course in applied ethics. It will focus primarily on questions like: What is the meaning of right action? Can ethical assertions be true or false? Is morality relative to society? Or can we say that acts have universal moral content? The course discussions will help to

demonstrate that morality is not always self-evident and that rational morality must come in place of taboo based moralities.

HUL254 Art and Technology
4 credits (3-1-0)
Pre-requisites: HUN100
This course will study the nature of the art object comprising both the cognitive and the aesthetic. It will be attempt to work out a relation between truth, morality and beauty and differentiate between the beautiful and the sublime. It will also focus on the element of creativity in art, science and technology by examining the differences between the genius and the expert. It will examine the aesthetics of engineering design and the effect of mechanical and electronic reproduction on the nature of the work of art. Finally, it will consider the relationship between media entertainment and information technology by differentiating between media as message and mass deception. Critical strategies to understand the role of power and ideology in information societies will be examined.

HUL255 History of Natural Science: Copernicus to Einstein
4 credits (3-1-0)
Pre-requisites: HUN100
This course will discuss the history of science in the period from the sixteenth century to the twentieth century. The primary focus will be on astronomy, physics, chemistry, and cosmology. Among the issues that are relevant include the non-scientific or metaphysical basis in the construction and maintenance of any scientific paradigm. There will also be discussions on changes in scientific methodology over this period. The major goals of this course are to get a good understanding of some of the topics in the history of science, and to improve our skills in reading, thinking, speaking and writing critically about topics in the history of science.

HUL256 Critical Thinking
3 credits (2-1-0)
Pre-requisites: HUN100
This course is an intorduction to Philosophy. It will discuss the fundamental questions involved in the study of logic, metaphysics and ethics, It comprises a study of the different theories of truth, the problem of God's existence, the debate between determinism etc.

HUL257 Introduction to Philosophy of Science
4 credits (3-1-0)
Pre-requisites: HUN100
The logical nature and reconstruction of scientific explanation and the laws of nature. The nature of scientific evidence. The differences between verification and falsification as forms of scientific validation. The influence of society on the nature of scientific work.

HUL261 Psychological Basis of Behavior
4 credits (3-1-0)
Pre-requisites: HUN100
Psychology as a science and its methods. Fields of psychology. Principles of learning. Remembering and forgetting. Thinking: the thinking process, concepts, problem solving, decision-making, creative thinking. Motivation :Theories of motivation, various types of motives, frustration and conflict. Perception: attention process, form perception, constancy of perception, depth perception, movement perception, the plasticity of perception, factors affecting perception. Personality. Various approaches to personality.

HUL262 Environmental Psychology
4 credits (3-1-0)
Pre-requisites: HUN100
The nature and history of environmental psychology. Environmental perception. Environmental cognition. Environmental attitudes. Performance in learning. Work environments. Coping with environmental stress. Coping with crowding. Privacy and territoriality. Personal space affiliation and support in the urban/rural environment. Environment and behavior: a unifying framework.

HUL263 Organizational Psychology
4 credits (3-1-0)
Pre-requisites: HUN100
Introduction to organizational psychology, its field, methods of study,

organizational psychology as an applied behavioral science. Group behavior and individual adjustment. Levels of communication. Types of organizations. Theories of leadership. Motivation and productivity. Tests for selection. Training for employee's growth and development. Effective organizations.

HUL264 Managerial Behavior: Psycho-social Dimensions
4 credits (3-1-0)
Pre-requisites: HUN100
The psychosocial dimensions of work in organizations: introduction and background. Major approaches to organization analysis, an organizational behavior approach. The early practice of management. Theories of organization. Organizational processes and functions. The structural variables, context and environment of work organization, socio-cultural environment, its impact on organizations. Social dimensions of organizational behavior: formal/informal organizations. Group dynamics and teams. Motivational processes and theories. Communication technology and interpersonal processes. Leadership processes and styles. Decision-making. Behavior oriented decision-making techniques. Creativity and group decision making.

HUL265 Personality and Society
3 credits (2-1-0)
Pre-requisites: HUN100
Coping with stress, Approaches to the study of personality. Freud's psychoanalytic theory. Jung's analytic theory. Adler's individual psychology, Roger's person centered approach, Lewin's field theory, and Skinner's operant reinforcement theory. Models of healthy personality, the notion of the mature person, the self-actualizing person, etc. Yoga and personality. The problem and value of psychological growth. Psychotherapeutic techniques and Eastern psychology.

HUL266 Industrial Safety: Psychological Dimensions
4 credits (3-1-0)
Pre-requisites: HUN100
Theories/models of accident causation, psychological factors related to cause and effect of accident. Human errors, human factors in the workplace. Safety and health at work. Managing and motivating safety behavior and performance, prevention and control of industrial hazards. Maintaining industrial hygiene. Occupational health management. Employee participation. Training and development of employees. Technology and development. Social responsibilities of administrators, system designers, managers. Issues related to waste management and accidents.

HUL267 Positive Psychology
4 credits (3-1-0)
Pre-requisites: HUN100
Positive Psychology: Introductroy and Historical Overview, Positive Prevention and Positive Therapy; Identifying Strengths: Positive Directions in Diagnosis and Intervention; Emotion focused Approaches: Subjective well-being, The concept of flow, Self-esteem, Positive affectivity, Emotional intelligence and Emotional creativity; Cognitive focused Approaches: The role of Personal Control in Adaptive functioning, Well-being, Optimism and Wisdom; Self-based Approaches: Authenticity, Uniqueness seeking; Interpersonal Approaches: Empathy, Altruism, Moral Motivation and Forgiveness; Biological Approaches: Role of Neuro-Psychology and Biopsychology in Positive Psychology; Specific Coping Approaches: Meditation, Yoga and Spirituality.

HUL271 Sociology: The Science of Praxis
4 credits (3-1-0)
Pre-requisites: HUN100
The rational organization of knowledge and the emergence of sociology as a scientific discipline. Industrial society in Western Europe. Industrialism and its scientific programme. Key thinkers and key perspectives. Science, reform and revolutionary social change. The critics of modernity. Implications of these thinkers for social science and society today.

HUL272 Introduction to the Sociology of India
4 credits (3-1-0)
Pre-requisites: HUN100

This course focuses on understanding the various constructions of Indian society from colonial to contemporary times. The structural and cultural dimensions of Indian society are explored through the study of village, region nation and civilization. Castes and tribes, kinship and family systems, the diversity of religious traditions and organizational forms are explored together with contemporary issues of secularism communalism, religious conversions and caste-based affirmative action. Institutions such as 'purdah' and 'dowry' allow the understanding of the social construction of gender in Indian society.

HUL273 Science, Technology and Society
4 credits (3-1-0)
Pre-requisites: HUN100
The socio-cultural context of the rise of modern science and technology. The West European case since Copernicus (1473-1543). Transfer of science and technology in the colonial and post-colonial period of Asia and other developing countries. Science and technology for world transformation. From dependency to creative autonomy issues of scientific culture and technological civilization. science and technology in modern India. The colonial experiences. Post-Independence development. Criteria for choice of development alternatives for India.

HUL274 Re-thinking the Indian Tradition
4 credits (3-1-0)
Pre-requisites: HUN100
The examination of sources, the structure, the texts and exemplars of the Indian tradition provide the theoretical framework for the discussion of contemporary political and social issues. These are economic development and social justice religion and the nation, communalism and secularism, caste class and gender equity and so on. The political misuse of tradition in programs of reform and revival both in the past and in modern times will be highlighted to underline the need for rethinking tradition in an academically serious manner.

HUL275 Environment, Development and Society
4 credits (3-1-0)
Pre-requisites: HUN100
Comparative perspective on the nature-culture-technology relationship as embodied in human habitats. Nature as sustenance and as 'symbol'; religion, folklore, and ecology. Indigenous systems of natural resource management, the role of development and technological innovation as sources of change, conflicts over the use of natural resources, ethnicity, class and gender. State of environmental resources - land, water, forests, air. Development projects and their environmental implications - Narmada Dam, Green Revolution, Social Forestry, Biotechnology issues feature among the case studies. Environmental protest movements, major environmental accords (North-South perspectives). Engineering and environmental ethics.

HUL276 Sociology of Knowledge
4 credits (3-1-0)
Pre-requisites: HUN100
The de-mystification of science as a privileged form of knowledge since Copernicus. Re-examining the laboratory, the factory and the nation-state, structures linked to the West-European model of science. Examining systems deemed ethno-science or folk-lore, to set up a dialogue with institutionalized science. Comparing science with religion as forms of knowledge having competing power over human belief and action. Examining Traditional Knowledge (TK) systems and their relevance for global economy.

HUL281 Mind, Machines and Language
4 credits (3-1-0)
Pre-requisites: HUN100
What is the role of language in the cognitive sciences? What are the implications of conceiving the mind as a machine (computer)? Can theories about language acquisition help us to understand the ways in which humans perceive the world? Finally, how are the three categories (mind, machine and language) related to each other? These are a few of the fundamental questions that will be posed in this course. It will benefit any student who wishes to think systematically the cognitive structures that he or she inhabits but otherwise takes for granted.

HUL282 System and Structure: An Introduction to Communication Theory
4 credits (3-1-0)
Pre-requisites: HUN100
This course is an introduction to theories of communication for which there is not sufficient time in the other communication courses, which are mainly applied in their orientation. This is an interdisciplinary course. It will examine how the notion of communication is used in different disciplines in the humanities and the social sciences. It will intersect with problems of organizational structure, linguistic structure, interpersonal structure and the problem of what is involved in changing a structure. This course will include no components of remedial English, business correspondence or skill building activities. Only those really interested in theoretical questions should enroll.

HUL283 Industrial Organizations
4 credits (3-1-0)
Pre-requisites: HUN100
Individuals, organization and their interaction. The development of individual organization relationships: Choice. Adaptation development processes. Influence on work behavior: structural factors. Structure and context in organizational design. Design of work. Influence on work behavior: organizational practices and social processes. Evaluating and rewarding work effectiveness. Social influences on members and work effectiveness. Improving organizational effectiveness: methods and goals of organizational change. Organizational renewal process.

HUL284 Participative Management
4 credits (3-1-0)
Pre-requisites: HUN100
Participative management: historical development, philosophy, theoretical framework. Psychosocial factors in participative management as an industrial relations system. Technology for participative management systems. Participative management in India: its successes and failures. Implementation strategy in the Indian context. Participative management and job design. Participative management as a strategy for quality of work life.

HUL285 Social Responsibilities of Scientists and Technologists
4 credits (3-1-0)
Pre-requisites: HUN100
The concept of social responsibilities and its relevance. The development of the field. The systems approach and multidisciplinary nature of the issue systems, methodology and planning for social responsibilities. The social sub-system and science and technology. The human sub-system and science and technology. Other methodological aspects. Ethics issues in science and technology.

HUL286 Social Science Approaches to Development
3 credits (2-1-0)
Pre-requisites: HUN100
Historical genesis and theories of development and underdevelopment. Comparative paths of development. Soviet Union, Japan, China. India's path of planning and socialism: development experience in the post independence period. Explanations of the poor achievements of India's economy in meeting basic needs for several decades after independence. Social indicators of development, problems of poverty and inequality. Economic reforms and liberalization. Panchayati Raj and decentralization. Role of religion, caste and family in development. Interrogation of the accepted paradigm of development from the point of view of gender, environment and poverty issues. Appropriate technology and development.

HUL287 Industry and Work Culture under Globalization
4 credits (3-1-0)
Pre-requisites: HUN100
The course will focus on the sociological dimensions of industry under globalization. Changing nature of industrial organization (changes in

production processes-horizontal and vertical integration), emergence of new industries, changing rhythms and forms of work, the work culture and the decline of organized industry; the growing importance of the informal sector and the implication of these changes for family and society will be discussed. The transnational nature of much of contemporary industry-new phenomena such as out sourcing, call centers etc, Industry and global governance (WTO) the new international division of labor. Education and industry linkages, rise of the consumer society and its sociological implications for industry.

HUL288 Science and Humanism: Towards a Unified World View
4 credits (3-1-0)
Pre-requisites: HUN100
Introduction and orientation to the development of science up to the 19th century and the concomitant worldview. Traditional conflict between science and religion - its causes and consequences. Role of science as a promoter of human values. Humanism and its true basis. New paradigm emerging from the 20th century Developments in science and the implications of the complementarity of science and humanism-the need for inner development. Education, development, and planning with the new unified worldview.

HUL289 Macro Perspective on Science, Technology and Human Development
4 credits (3-1-0)
Pre-requisites: HUN100
The dynamics of scientific discovery, technological innovation and its application to the human scene. Case histories of some recent developments in physical and biological sciences and their impact on communications, health care, education and defence, interlinking issues such as protection of the environment and avoidance of potential catastrophes arising out of side effects, techniques of conflict analysis and resolutions of Indian thinkers to the development and application of these techniques, the respective roles of the individual and the social organizations in anticipating and solving problems as well as in optimizing the application of science and technology towards human development.

HUL290 Technology and Culture
4 credits (3-1-0)
Pre-requisites: HUN100
To examine the relationship between technology and culture through a consideration of modern/current developments in various specific areas: e.g. Biotechnology and Medicine, IT, AI & Robotics, Fashion Technology, Magic Technology, Communications, Defense and Space Research.

To focus on the roles played by the IITs themselves in creating 'knowledge societies' - that is, in influencing, formulating and envisioning the links between technological 'solutions' and socio-cultural 'problems' especially in the Indian context. Here we will discuss, for example: Patent Laws, Gender Issues, Environmental Ethics, Design(er) and Person(al) Technological Aesthetics, Technologies for the Disabled, Educational Technologies.

HUL291 Electronic Governance
4 credits (3-1-0)
Pre-requisites: HUN100
Information and communication technology for development; historical evolution; theoretical assumptions or foundations; criticisms – policy rhetoric; implementation – telecenters, public-private partnership; critical success factors; barriers – legislature, technology, people; evaluation; India specific case studies.

HUL 301 The Sociology of Religion
4 credits (3-1-0)
Pre-requisites: HUL271
This course will introduce students to sociological approaches to the study of religion in cotemporary society. Religion will be understood in terms of its social and cultural structure; in addition the course will also encourage a critical perspective on religion and society – its interface with society, polity and the economy. Religious conflict and change, syncretism, popular religion, revivalism and fundamentalism will also be considered.

HUL 307 Fantasy Literature
4 credits (3-1-0)
Pre-requisites: HUL231
Major Themes of Fantasy; Archetypes and Myths; Motifs – journeys, theology, devices and aides; creation of alternate worlds; treatment of time and space; close reading of individual texts.

HUL 308 Theatre of the Absurd
4 credits (3-1-0)
Pre-requisites: HUL231
Socio-political background of the theatre of the Absurd, its basis in Existentialist philosophy. The reactions against the conventions of realist theater that dominated this theatre. The pre-occupations of major playwrights with issues of language and the difficulty of communication, the isolation that human beings tend to feel from each other and themes of violence.

HUL 401 Political Ecology of Water
4 credits (3-1-0)
Pre-requisites: HUL271 and any 300 level courses in Sociology
Understanding Political Ecology; Water as resource and as in integral part of Indian culture; Indigenous water conservation strategies; Pollution of groundwater; Water related natural disasters and their management; Dams and Hydroelectric Project   related controversies in India; Environmental Movements in India – case studies; community Control of Water; local and state level disputes; and Water Policy (India).

HUL701 Sociological Theory Developments and Trends
3 credits (2-1-0)
Classical Theories Positivism, evolutionism and Marxism, structuralism and functionalism in sociology and social anthropology. Exchange theory. Symbolic interactionism, conflict theory, neo-Marxism; post-modernism. The purpose of the course is two-fold : first, to introduce the student to the field of social theories; and second, to present him with some perspectives whereby he may develop a better understanding of both his social environment and theoretical understanding.

HUL706 Language, Society and Culture
3 credits (2-1-0)
Psycho-linguistics and sociolinguistics; culture and identity studies; studies in expressive culture: idea-systems, myths and archtypes.

HUL707 Social Psychology
3 credits (2-1-0)
Schools of social psychology with special reference to personality and social structure. The problems and methods of social psychology. The association motive. Interpersonal attraction. Learning in social context. Social motives and attitudes. Social influence. Dissonance. Consonance and balance. Social status: Its effect on social motives and behaviour, social roles. Personality and social phenomenon. Cultural influences on personality and social behaviour. Social perception communication. Group process. Group task performance : Problem solving co-operation and competition. Leaders and leadership. Power and politics in organisations. Psychological processes in organizations. Aggression and its management.

HUL709 Social Research Methods
3 credits (2-1-0)
Scientific approach to social research. Concepts and indices. Analytical and formal aspects. Hypothesis formulation and testing strategies. Design of applied empirical research. Measurement and interpretation of social data. Social statistics. Sampling designs, report writing.

HUL710 Personality Structure and Dynamics
3 credits (2-1-0)
The topics for discussion will be : Coping with stress. Model of success and failure in adjustment. Approaches to the study of personality. Freud's classical psychoanalytic theory, Jung's analytic theory, Adler's individual psychology, Roger's person- centred approach. Lwein's field theory, Skinner's operant reinforcement theory. Erikson's theory : Psychohistorian perspective of man. Models of healthy personality; mature person: Allport's model.

Self-actualising person : Maslow's model. Here-and-now person : Perl's model. Roger's theory : on becoming a person.

HUL711 Psychological Testing & Behavioral Assessment
3 credits (2-1-0)
The concept of Behavioral Assessment: Uses and Varieties of Psychological Tests, Why Control the use of Psychological Tests?Test Administration, Examiner and Situational Variables and Effects of Training on Test Performance.

Technical and Methodological Principles: Test Construction, Norms and The Meaning of Test Scores, Reliability and its Types, Validity and its Basic Concepts and Item Analysis.

Other Techniques of Behavioral Assessment: Interview, Questionnaire and Schedule, Content Analysis, Observation as a tool of data collection, Rating Scales, Survey and Projective Tecniques. Brief Review of some Selected Psychological Tests and Concluding Comments.

Ethical and Social Considerations in Testing: Ethical Issues in Behavioral Asssessment. User Qualifications and Professional Competence, Responsibility of Test Publishers, Protection of Privacy, Confidentiality and Communicating Test Results.

HUP722 Seminar (Case Material-based) Minor Project
3 credits (0-0-6)
(In lieu of any one of the courses.)

HUL736 Planning and Economic Development
3 credits (0-0-6)
Economic growth. Economic development. Historic growth and contemporary development. Lessons and controversies. Characteristics of developing countries. Obstacles to development. Structural changes in the process of economic development. Relationship between agriculture and industry. Strategies of economic development. Balanced/ Unbalanced growth. International trade and economic development. Population. Planning for economic development. Use of input-output model and linear programming techniques in planning. Indian plan experience. Strategy of Indian planning. Indian plan models.

HUL738 International Economics
3 credits (2-1-0)
The theory of International Trade. Impact of dynamic factors in International Trade. Free Trade, Protection. Economic integration and developing countries. The balance of payments. International capital movements. Rate of exchange. Relationship between Trade, Foreign Aid and Economic Development. Role of multinational corporations in developing countries. The IMF and the International Monetary System. Trade problems of developing countries. The new International Economic order. The structure and trends of India's foreign trade. India's balance of payments. India's trade policy. Indian and international financial institutions.

HUL745 Psychological Factors in Work Design
3 credits (2-1-0)
Approaches to work design. Historical perspective. Human information processing, Natural and man-made environment effect, psychology of work. The living environments, physical features, psychological dimensions of work. Job enrichment, quality of working life. Future of work designs.

HUL748 Community Psychology
3 credits (2-1-0)
Concept of community and their implications for community psychology. Community processes and orientations toward change. Examinations of the models; the mental health model; the organizational model; the social action model; the ecological model. Implications for a psychology of the community : the study of community life, interaction strategies; implications for manpower and training; family therapy and the community; crisis intervention; advocacy and community psychology.

HUL754 Science, Technology and Society
3 credits (2-1-0)
An interdisciplinary exploration of the mutual interaction of science, technology and society, with insights drawn from sociology of sciences, history of science and technology, and the changing formations of the modern society.

HUL755 Econometrics and Economic Forecasting
3 credits (2-1-0)
Nature of econometrics, specification of econometric model. Least-squares estimators. Properties of the least-squares estimators. Statistical inference in regression model. Dummy variables. Multi-collinearity. Specification error. Maximum likelihood estimators. Generalized least squares. Heteroscedasticity. Auto-correlation. Pooling of time-series and cross-section data. Distributed legs. Simultaneous-equation system. Identification problem. Procedures for estimating a single equation in a systems of equations. Estimation of equation systems. Forecasting. Moving average models. Autoregressive models. Simulation models.

HUL759 Urban Social Systems
3 credits (2-1-0)
This course intends to impart a comprehensive and systematic understanding of urban social systems. Students completing this course will have a detailed knowledge of urban-growth and urban behaviour analysis, and urban- planning through a feedback analysis approach. Following will be the main course contents:

Nature, types and growth of cities, Some important aspects of urban-systems: migration; neighbourhood; social groups; and voluntary associations. Trend of urbanisation. Urban influences on rural areas. A profile of urban India and its problems. Solution of the problems through various approaches. Urban planning.

HUL760 Industry and Society
3 credits (2-1-0)
The basic aim of this course is to introduce students from various backgrounds scientists, technologists to the study and understanding of modern industrial societies. the course material will focus on the following topics.

Nature and type of industrial society. Workers in modern industrial societies: the work situation; alienation; and embourgeoisement. White collar worker. Trade-unionisation. Industrial democracy. Labour-management relations in Indian industries.

HUL761 Sociology of India
3 credits (2-1-0)
Approaches and Concepts: Institutions, Caste and Kinship; Religion; Marriage and Family. Agrarian social structure : Land reforms; Dimensions of social change; Sanskritisation and modernization. A profile of modern India.

HUL762 Industrial Economics
3 credits (2-1-0)
Basic concepts : Plants, firm and industry. Market structure. Economics of scale and optimum firm size. Pricing under alternative market structures. Market power and concentration. Integration, diversification and merger. Behavioural and managerial theories of the firm, gorwth of the firm. Industrial productivity and its measurement. Industrial location. Input-output analysis. Project appraisal and capital budgeting. Industrialisation and economic development. Problems of industrialisation in India. Role of public and private sectors. Growth of small-scale industries and their problems. Government regulation of industry. Balanced regional development.

HUL810 Communication Skills
3 credits (3-0-0) (Audit)
Introduction to major grammatical models. Phonological and syntactical structure of present-day English. Langauge of science and technology. Aspects of style. Some common errors.

Technical presentations design and delivery.

Audio Visuals in communication.

Collecting materials for research.

Organization of research paper/dissertation.

HUL812 Grammar and Rhetoric
3 credits (3-0-0)
Two complementary aspects of studies in linguistics and literary theory are brought together in this course; grammatical paradigms for the study

of sentential and supra-sentential structures, including those of narrative and argument; theories of rhetoric; pursuasion, use and meaning; rhetorical functions such as those performed by tropes like metaphor, irony, simile, metonymy, etc. debates on the universal psychological as well empirical standing of such figurative language; its place in the lexicon etc. The course will be useful to those students of literature who require some knowledge of technicalities of grammar and to those students of linguistics who feel that the analysis of language extends beyond the study of sentence 'structure' to social 'meaning'.

HUL823 Contemporary Critical Theory
3 credits (2-1-0)
Recent developments in linguistics, philosophy and the social sciences; interdisciplinary cross-talk in these areas, concerning the status of canonical literary as well as marginal texts; feminist, post-modernist, post-colonial, subaltern, orientalist, new historicist, liberal Marxist and critical practice. The aim of the course is to familiarise students with some of the vocabulary of theoretical inquiry today, so that they are enabled in their own research to question the verities which their disciplines seem to offer.

HUL840 Philosophy of Social Sciences
3 credits (3-0-0)
Some of the key issues which arise in social sciences will be discussed in this course. These are : (1) What is 'out there' in the social universe ? (2) What are the most fundamental properties of the social world? (3) What kind(s) of analysis of these properties is (are) possible and/ or appropriate ? (4) What are the natures of theory, law, and explanation ? (5) Problems of reductionism. (6) Problems of free will versus determinism, purposeful behaviour, interpretations of actions. (7) Philosophical issues specific to various social sciences, e.g., philosophical bases of various economic theories, or of theories of psychology, or issues regarding the assumptions concerning human nature made by various social science disciplines.

HUL841 Philosophy of Science
3 credits (3-0-0)
The major issues to be discussed in this course include : (a) scientific explanation; (b) theories of confirmation of a scientific hypothesis; (c) theoretical-observational terms/distinction; (d) problem of induction; and (e) the problems of theory choice. A survey of the historical development of the twentieth-century philosophy of science will be provided. Some historical episodes in science will be employed to gain a better understanding of the issues to be discussed.

HUL843 The Philosophy of Language
3 credits (3-0-0)
The twentieth century is one which has been said to mark a 'linguistic turn' in philosophy. This course will examine the basic sense/reference, truth/falsity, denotative/ connotative, meaning/use, analytic/synthetic, argument/predicate, intension/extension dichotomies as they are explored in post-Fregean analytic philosophy.

Five or six distinct strains of philosophical opinion are salient for this course. They are (A) the logical positivism associated, with Ayer et. al. (B) Witgenstein's 'picture' and 'game' theories of meaning; (C) the speech-act theory of Austin and Searle; (D) the Gricean maxims of conversational cooperation and non-natural meaning; (E) the 'pragmatism' of Quine on webs of meaning, Davidson on truth and interpretation and Rorty on philosophy as conversation and social conduct; (F) the writings of continental 'non-analytic' philosophers such as Derrida and Habermas who hold opposed positions on the nature of language. The views of Kripke, Dummett and Dennett among philosophers and Chomsky, Katz and Fodor among linguists will also be discussed.

The course may have a seminar format in which particular topics are considered in depth and short papers are prepared by students.

HUL845 Environmental Ethics
3 credits (3-0-0)
Objectives: To acquaint the student with (a) philosophical concepts underlying thinking about the environmental crisis and (b) the models of human-nature relationship found in some of the classical philosophical systems of India.

Contents: (a) What is 'environment'? (b) Conceptual basis for the split between 'nature' and 'culture' (c) Philosophical theories about the environment: Utilitarianism: Deep Ecology: Ecofeminism. (d) Non-humans as recipients of moral consideration (e) Environment and Gender (f) Enviroment and Development (g) The Third World perspective (h) Revisioning Ethics, Metaphysics and Epistemology in the light of the above debates.

HUL846 Philosophy and Film
3 credits (3-0-0)
Nature of cinematic representation: Illusion, image, reality. Perception of image: Analytical, cognitive and phenomenological theories, Interpretation of film: meaning, authorship, Intention, Image and emotional response.

Film Theories: Classical theories: Eisenstein, Arnheim, Bazin, Pudovkin, Contemporary theories: Semiotics, Psychoanalysis, Marxism, Post-structuralism, Feminism, Auteur theory.

Aesthetics of Film: Cinema as art, entertainment and technology, Cimema's relationship with literature and other arts, Cinema and Digital Art, Aesthetics of interactive cinema, Aesthetics of special effects.

HUL873 Sociology of Science
3 credits (3-0-0)
The relationship between the sub-culture of science and the wider culture of knowledge which surrounds it. The nature of scientific knowledge and the general characteristics of scientific research which make such knowledge possible. Whether present framework of organizing knowledge is itself an object of sociological investigation? Comparison of methods of acquiring and of validating knowledge claims across cultures. Investigation through case studies of the various cognitive frameworks. Transfer of scientific and other expertise to wider sub-culture. Nature of scientific community, and of communication within a community and inter-community through networking.

HUL881 Elements of the Narrative Art
3 credits (3-0-0)
It is a course more broad-based than the theory of fiction. The following topics will be studied : Narrative theory and types of narrative; point of view; plot; characterization; setting; time and place the language of narrative; figures of speech.

HUL882 The European Renaissance, Selfhood and Survival
3 credits (3-0-0)
This course will cover drama, prose, and poetry from one of the richest periods of European Literature : the Renaissance. It will relate the production of a work of art to Renaissance history and cultural politics. Tests by Pico, More, Machiavelli, Sidney, Spenser and Shakespeare and others will be examined from the point-of-view of selfhood and survival.

HUL883 Critical Theory: Plato to Derrida
3 credits (3-0-0)
This course will explore western critical theory from antiquity to the present and measure its efficacy when applied to a literary text. Ideas of nimesis, fiction truth, art and society, art and gender will be studied with regard to different "schools" of critical theory : Platonic, Aristotelian, Renaissance, Romantic, Formalist, Structuralist, Poststructuralist, Deconstructionist and Feminist. Since the material is vast, only three or four topics will be studied in a semester.

HUL884 Indian Writing in English
3 credits (3-0-0)
The course focuses on the dominant themes like India's struggle for freedom, partition and communal harmony/ discord, Issues of pluralism and the related problems as reflected in Indian Writing in English. It also aims at a close study of problems of modernization, diaspora and India's quest for identity, Rushdie and Post Rushdie. The students should be prepared to do intense study of the texts and wherever possible a comparative study of the literary representations with the visual and electronic media will also be undertaken. All the genres of literature will be made part of the study.

HUL885 American Fiction I
3 credits (3-0-0)

It is primarily a survey course covering American fiction before World War I. Its aim is to acquaint students with some of the major novelists of the period. Selected texts of some of the following will be studied Hawthorne, Melville, Poe, Drieser, Edith Wherton, Willa Cather, Henry James, Ellen Glasgow.

HUL886 American Fiction II
3 credits (3-0-0)
This is a survey course covering American fiction of the post- World War–I period. Some of the major novelists of the period will be studied, including Hemingway, Scott Fitzgerald, Steinbeck, Richard Wright, Ralph Ellison, Saul Bellow, Bernard Malamud, John Barth, John Updike.

HUV886 Special Module in Cognitive Psychology
2 credits (1-0-2)
The course will focus on current relevant and emerging issues, and experiments in the field of cognitive psychology.

HUL888 Applied Linguistics
3 credits (3-0-0)
Notions of applied linguistics; psycholinguistics; socio- linguistics; language learning; language teaching; contrastive analysis; error analysis; pedagogic grammars; applied lexicology; communicative teaching; discourse analysis; stylistic and literature.

HUL889 British Fiction – A Stylistics Approach
3 credits (3-0-0)
Language in prose and poetry; stylistics; deviance; prominence, foregrounding; literary relevance; stylistic variants; language and the fictional world; the rhetoric of text; discourse situation; conversation, speech and thought.

HUL891 Globalization and Transnationalism
3 credits (2-1-0)
Globalization & Globalism, Nationalism & Transnationalism, Dicopora, Glocality. Globalisation and Transnational movements of people, ideas & technology, culture, capital and goods. Relationship between locality, national boundaries and transnationalism- personal and collective identity. Transnational migration and global politics of gender and work in a global world- Dicopora. Religion and Ethnicity in a global world. The State and Democracy in a globalised world.

Department of Management Studies

SML100 Introduction to Entrepreneurial Ventures
4 credits (3-1-0)
Nature, Need, Scope and Characteristics of Entrepreneurship. Indian Economic and Industrial Heritage and Entrepreneurial Development. Current economic and Industrial environment with special reference to Entrepreneurial Ventures.

Choice of Technology.

The need, scope and approaches for Project Formulation, Biography of Indian Entrepreneurs.

Elements of Production Process. Production Planning. Leadership. Group Dynamics. Time Management. Elements of Technical Entrepreneurship. Understanding Human Behavior.

Achievement Motivation. Creativity- coping with uncertainties. Attitude towards Wealth and Work. Samll-Medium-Large scale enterprise linkage.

SML101 Management Concepts and Techniques - An Introduction
4 credits (3-1-0)
Introduction to Management Theory; the system approach to management. Systems methodology. Management style. Managers and their external environment. Introduction to planning: Nature and scope of planning, Type of planning, Long and short-term plans. Decision-making. Systems approach to decision-making.

Organizing: Basic departmentation. Line and staff authority relationships. Functions of leadership, Nature of leadership, Control: The system and process of control, Control techniques, Control of overall perfomance.

Introduction to functional areas of management: Operation Management, Financial Management, Marketing Management, Human Resources Management and Organization Management.

SML301 Entrepreneurial Operations
4 credits (3-1-0)
Pre-requisites : EC 60
Entrepreneurship in India; The Operating cycle; Market Segmentation; Market Research; Test Marketing; Essentials of Costing & Pricing; Working Capital Management; Break even Analysis; Product Development; Production Planning and Control; Materials Management; Selection and Recruitment; Group Dynamics; Delegation; Industrial Policy; Project Identification; Techno Economic Feasibility Report.

SML302 Entrepreneurship Management
4 credits (3-1-0)
Pre-requisites : EC 60
Self employment need and mode. Structural base of Indian economic life. Industrial sector in the national developmental life. Indices of technical entrepreneuship. Opportunity identification and opportunity generation for technical entrepreneurship. Problem solving, decision-making, conflict and change in a new industrial enterprise. Systems consideration in an entrepreneurial venture. Management reporting and information systems of a new business enterprise. Preparing for an entrepreneurial career. Issues in resource management. Managing innovations. IPRs & SMEs.

SML303 Cost Analysis and Control
4 credits (3-1-0)
Pre-requisites: EC 60
Meaning, nature and managerial need of cost analysis. Cost concepts and cost classification relating to income determination, profit planning, control and decision-making.

Elements of costs-material, labour and overheads. Allocation, absorption and apportionment of overheads; methods of allocation of overheads.

Cost accounting systems-process and job (contract, unit and operating). Costing for joint products and by-products. Full costing system. Variable costing, differential costing and decision-making. Budget and budgetary control; preparation of operating budgets, fixed and flexible budgets, cash budget. Cost-volume-profit relationship and profit planning. Standard costing and variance analysis.

SML304 Introduction to Marketing Management
4 credits (3-1-0)
Pre-requisites: EC 60
Marketing Orientation; Consumer Behaviour; Segmentation; Forecasting product life cycle; Product decision; Pricing decision; Promotion; Distribution; Sales management; Marketing Information Systems; Market Planning and Control; Market Research; Cases and Exercises.

SML305 Organization of Engineering Systems and Human Resources Management
4 credits (3-1-0)
Pre-requisites: EC 60
Understanding organization. Concerns of organizing engineering business and systems: Structure, processes, design issues in running engineering organization, operating organization. Cybernetics, and socio-technical systems, issues of efficiency and excellence: Man-machine relationship, concerns of recruitment, selection, skill formation and redeployment, developing teams and leadership. Understanding motivation and human resources planning. Indian Industrial law; Managing industrial relations.

SML306 Manufacturing Systems Management
4 credits (3-1-0)
Pre-requisites: EC 60
Overlaps with : MEL421, MEL322
Essentials of Manufacturing Management, Manufacuring Systems Classification, Operations Capacity Planning; Facilities Design-Location, Layout & materials handling; Assembly line Balancing; Organizing Conversion System; Productivity Improvement Techniques; Scheduling Production & Service. Systems, Production Planning & Inventory Control, Material Requirements Planning; Quality Management; Advanced Manufacturing System-Introduction to FMS, JIT; CIM, WCM; Maintenance Management, Applications of Operations Research Techniques to Manufacturing Systems Management. Case Studies.

SML307 Information Systems for Managerial Decision-making
4 credits (3-1-0)
Pre-requisites : EC 60
Role of Information in Managerial decision-making; Information Needs for various Levels of Managerial Decision makers; Computer Based Information Systems-Office Automation Systems; Transaction Processing Systems; Functional Information Systems, Information Systems Planning, Design & Implementation; Structured Systems Analysis & Design; Object oriented Design; Evaluation of an Information Systems; Introduction to Decision Support Systems; User Involvement & End User Computing. Case Studies.

SML401 Managerial Accounting and Financial Management
4 credits (3-1-0)
Pre-requisites : EC 90
Overlaps with: SML303, SML770
Accounting principles underlying preparation of financial statements, Managerial uses of financial data. Ratio analysis and interpretation of financial statements. Cost Concepts. Cost volume-profit relationship and profit planning. Break even analysis. Incremental analysis and managerial decisions. Budgetary control system and preparation of various types of budgets. Time value of money. Cost of capital and capital budgeting. Determinants of working capital and its measurements. Cash management. Receivables management.

Introduction to International Finance; Risk Management in International Operations.

SML402 Industrial Marketing Management
4 credits (3-1-0)
Pre-requisites : EC 90
Fundamentals of Industrial Marketing: Industrial Buyer Behaviour Models: Decision-making Units; Technology and Marketing; System Selling; Role of Service; Intangibles in Industrial Marketing, Derived Demand Methodologies; Globalization; Contract Review; Selling; Strategies for Diversification; Market Planning and Direct Restructuring; Marketing Strategy; Case Studies.

SML700 Fundamentals of Management of Technology

3 credits (3-0-0)

*Pre-requisites: SML305 and SML401

Module I: Understanding technology: definition, Key concepts, role, importance, need. History of technological developments, Today's challenges. Issues of concern in Management of New Technology. Technology-Management integration, Life cycle approach to technology management. Technology innovation process. Managing and fostering the Innovation.

Module II: Technology forecasting and assessment. Technology flow and diffusion. Evaluating technology, technology planning and strategy, Strategic potential of new technology. Factors promoting technology acquisition. Flexibility in Technology Management. Technology transfer and absorption, Modes of global technology transfer. Technological Entrepreneurship.

Module III: Technology implementation. Integrating people and technology, human factors in technology operations. Organisation structure and technology. Investing for technological maintenance and growth. Concern of phasing out and upgradation. Market factors in technology operations, Science and Technology Policy, Technology support systems. Information networking for technological updatedness.

SML701 Strategic Technology Management

3 credits (2-0-2)

*Pre-requisites: SML305 and SML401

Module I: Emerging technology-strategy relationship in the large corporation from the perspective of individual firm, and entire industry. Global technology comparison, technological change, sources of technology, Technology Information. Criticality of technology for growth, core competencies, R&D productivity, Resource Leverage. World Class Organisation.

Module II: Corporate technology strategy, Generic competitive technology strategies. Corporate R&D, Strategic technology management process, relationship between technology strategy and corporate strategy. Strategic shifts and resource commitments, technology vision and goals, technology leadership. SWOT analysis for technology, Matching Business Portfolio and Technology Portfolio, Technology- Market matrix. Innovation and entry strategy, Flexibility in Technology strategy.

Module III: Business/technology alliances and networks. Technology forecasting and assessment. Technology strategy at business level. Strategic Technology Planning, Investment in Technology, Technology Strategy and functional strategy. Implementation and Control of technology strategy, Managing Corporate culture, structure, and interdepartmental linkages.

SML702 Management of Innovation and R&D

3 credits (3-0-0)

*Pre-requisites: SML305 and SML401

Module I: Technological innovation systems and processes. Understanding the process of technological innovation and the factors affecting successful innovation. Management problems from the product/service concept-stage to end-product/service marketing. Creativity and Innovation- Creativity process, Individual and group creativity, Critical functions in the innovation process, Evolving innovative culture, teams for innovation.

Module II: Product and technology life cycle, Management of R&D planning, organising, staffing, scheduling, Controlling, budgeting, Selection of R&D projects. Methodologies for evaluating the effectiveness of R&D, Research Productivity. Protection of Intellectual Property Rights. Evolving flexible organisation.

Module III: Issues relating to managing scientists and technologists as individual, in teams, and in large organisations. Human Resource Management in R&D and Innovation, training, motivation, communication, group dynamics. Information management for innovation and R&D- strategies, sources, channels, and flows. Standardisation and Quality management.

SML703 Management of Technology Transfer and Absorption

3 credits (2-0-2)

*Pre-requisites: SML305 and SML401

Module I: Transfer of technology from R&D to field and at international level. Commercialization of new technology and new venture management, prototyping, test marketing, pilot plant, project viability, Technology push and market full. Quality management, customer education and awareness. Assessment, justification and financing of new technology, source of funds, venture capital financing. New venture products and services.

Module II: Global transfer of technology, Technology transfer models: Active, passive. Multi channel approach: from hardware technical services acquisitions to strategic partnering and networking arrangements. Sourcing technology, technology negotiation, licensing agreement. Fee for technology transfer, royalty, equity participation. Modes: technological collaboration, joint venture, alliance, acquisition. International S&T cooperation: institutional framework, multilateral/ bilateral cooperation, pre-emptive R&D cooperation.

Module III: Absorbent Strategy: Japanese technology absorption, Technology Absorption: product and process technologies, Reverse engineering. Appropriate technology. Vendor development. Adaptation and assimilation of technology.

SML704 Science and Technology Policy Systems

3 credits (3-0-0)

Module I: Role of S&T in economic development, Modern analysis of growth and structural change, international economic relations, liberalisation, globalisation/ regionalisation, industrial/technological partnerships, S&T in Indian Economic Policy. Government policy and its impacts on technology development. Living with the new technology, social issues. International trends, Technology policy in USA, Japan, European Commission, and other select countries.

Module II: National technology Policies, Regulatory Policies: Industries Development and Regulation Act, MRTP, FERA, Intellectual Property Rights, Patents act, Environment Protection Act, R&D Cess Rules, Import Export Policy; Development Policies: Industrial Policy Resolution, Scientific Policy Resolution, Technology Policy Statement, New Technology Policy, Policy on Foreign Investments and Technology Imports. Role of UN and other International Agencies.

Module III: Support Systems: Technology infrastructure, technology parks, Technology development and utilization schemes by government and Financial Institutions, Venture capital financing, TIFAC, Technology mission, Standards, Support to Small scale sectors. Research laboratories, and institutions. S&T in five year plans, Fiscal incentives. Organization set up for Science and Technology. R&D in corporate sector.

SML710 Creative Problem Solving

3 credits (2-0-2)

Module I: Structure of managerial problems. Open and close ended problems, convergent and divergent thinking. The creativity process, Individual and group creativity, Idea generation methods: Brain storming, Nominal Group Technique, Idea Engineering, Check list, Attribute listing, Morphological analysis, Synectics, Mental Imaging, Critical Questioning. Total System Intervention, Flexible Systems Methodology.

Module II: Idea Structuring: Graphic tools, Programme Planning Linkages, Interpretive Structural Modelling, Relationship Analysis, Flexible Systems Management, SAP-LAP Analysis, Flexibility Influence Diagrams, Collaboration Digrams. Scenario Building: Harva method, Structural Analysis, Options Field/Profile Methodology.

Module III: Viable Systems Modelling. Fuzzy sets in multicriteria decision making, Analytic Hierarchy Process, Intelligent Management Systems, Creativity applications in TQM and Business Process Reengineering.

SML713 Information Systems Management

3 credits (2-0-2)

*Pre-requisites: SML305

Module I: Survey of Information systems and technology. Concepts of information; Information as a resource. Types of information systems-

management information systems, decision support systems, transaction processing systems, on-line systems, executive support systems, real-time systems, expert systems.

Module II: Information Systems planning, architecture, and prioritization, Flexibility in Information systems and MIS success, Quality and value of Information, User Involvement, MIS life cycle. Evaluation of Information Systems. Role of Top Management.

Module III: Organizing for managing information resources; data administration and information management, Data center administration. The application development backlog, Outsourcing, Information system security. Managing technology-driven change. End-user computing. Training for IS users and managers.

SML714 Organisational Dynamics and Environment
3 credits (3-0-0)
*Pre-requisites: SML305 and SML401
Module I: Organisational systems vix. a vis., the environment. The dialectics of agency and structure- extent of environmental and organizational control. External control of organization. Organizations and the new institutionalism. Systems for managing chaos and conflict.

Module II: Constituent systems for organizational functioning- planning, learning, organising, communication and control systems. Organizational systems and mechanisms related to technology. Systems for managing strategy, and structure related to new technology.

Module III: Systems for managing continuous and radical change for organizational renewal and transformation. Adaptiveness and flexibility in organisational systems. Systems for managing collective action within the organization. Feminism and organizational systems for managing gender diversity.

SML715 Quality and Environment Management Systems
3 credits (2-0-2)
*Pre-requisites: SML305 and SML401
Module I: Concept of Total Quality, Quality Management Systems as a means of achieving total quality. Linkage of Quality and Environment Management System. Strategic concern for Environment. Need and relevance of documentation and standardization of Management Systems. Various tools of documenting and recording the Management Systems, Various standards for Management Systems. Flexibility and change in Management Systems and documented procedures.

Module II: Quality Management Systems, IS0 9000, Quality Policy, Data, Records and Traceability. Documenting the Quality System: Quality Manual, Quality Audit, Design and Change Control, ISO 9000 Registration. Six Sigma. Awards and appreciation.

Module III: Need for proper Environment Management Systems and their economic implications. Environment Management Systems, Green Products and Strategies, Environment Assessment: Environment Protection Act, ISO 14000.

SML716 Fundamentals of Management Systems
3 credits (3-0-0)
*Pre-requisites: SML305 and SML401
Module I: Basics and Variants.The concept of a system, Systems Approach to management. Emerging paradigm, customer centred management systems, Flexible Management Systems.Management of Paradoxes. Management Systems in various countries: Western Management Systems, Japanese Management Systems, Chinese Management System,Indian Management Systems. Organisational Culture and Value System.

Module II: Management Systems in Operation: Strategic Planning Systems, Management Control Systems, Financial Information Systems, Marketing Management Systems, Logistics and Distribution Systems, Systems for Human Resources Planning and Performance Management.

Module III: Methodologies for Development and Improvement. Methodology for developing Management System. Optimization and

Learning Systems methodologies, Microworld, Continuous Improvement and Reengineering of Management Systems. Organizing to improve systems.

SML717 Business Systems Analysis and Design
3 credits (2-0-2)
*Pre-requisites: SML305 and SML401
*ModuleI:*System development methodologies; Requirements analysis and determination. Requirements engineering. Structured approaches to business systems analysis. User driven business analysis. Role of the consultant.

Module II: Requirements specification. Application prototyping. CASE methodologies and techniques; Systems design; Data-driven approaches (E-R Modelling). Process-driven approaches (Gane and Sarson and Yourdon techniques). Traditional work flow methods.

Module III: Object-oriented analysis and design. Verification and validation of business system design. Limits to analysis and design trade offs. IBM's Business Systems Planning approach. Business Systems Applications. Enterprise Resource Planning.

SML720 Business Environment and Corporate Strategy
3 credits (2-0-2)
*Pre-requisites: SML305
Module I: An overview of planning in India. Macro economic concepts: consumption, savings, investment. Objectives of economic policy. Nature of economic policies, Chronological survey of policy pronouncements and their impact on business: FEMA Completion policy. Industrial policy resolutions etc. Comparative economic systems. Dynamics of development Global business environment. Internal and External analysis.

Module II: Business and government relations and government influences in income planning, prices and production policies. Impact of tax and inflationary parameters on corporate policy planning, Problem of determining planning horizon. Effect of uncertainties. Liberalization: Industry Policy and Trade Policy Coping strategies by Indian business, company formation and company Law.

Module III: The nature of corporate strategy, Strategic Management in different contexts, Patterns of strategy development, explaining views on strategy development. Industry and Competitive Analysis, Generic Competitive Strategies, Offensive strategies, Defensive strategies, Vertical integration strategies, Flexibility in strategy. An overview of strategy formulation process, vision, mission, objectives.

SML 723 Telecommunications System Management
3 credits (3-0-0)
*Pre-requisites: SML305 and SML401
Module I : Telecom Technology Systems Evolution: Recent Developments in Telecom Industry, Regulation & Liberalization policy. Techno-managerial aspects of telecommunication, role of the telecommunication managers in a dynamic environment. The business of telecommunication; telecommunication as a facilitating infrastructure for economic development of the country, technical survey of the ways and means that voice, data and video traffic are moved long distances, data network, the telephone system.

Module II : Issues of the monopolization and deregulation of telecom, national telecom policy, various institutions/organizations like telecom regulatory authority etc; conveyance. Telecom service costing, economic evaluation of telecom projects, telecom project financing.

Module III : Telecom marketing, building brand equity for competitive advantage, Customer care, total service quality management, preparing for the new millennium managing change and people development.

SML726 Telecom Systems Analysis, Planning, and Design
3 credits (3-0-0)
*Pre-requisites: SML305 and SML401
Module I : An introduction to the basic system analysis tools, the procedures for conducting system analysis advanced software principles,

techniques and processes for designing and implementing complex telecommunication systems.

*Module II : *Planning and implementation of telecommunications systems from strategic planning through requirements, the initial analysis, the general feasibility study, structured analysis, detailed analysis, logical design, and implementation.

*Module III : *Current system documentation through use of classical and structural tools and techniques for describing flows, data flows, data structures, file designs, input and output designs, and program specifications. The student would gain practical experience through a project as part of a term paper.

SML728 International Telecommunication Management
3 credits (3-0-0)
*Pre-requisites: SML305 and SML401
Module I: Historical development and evolution of telecom, managerial issues and structure of industry; evolution and role of international institutions; global trends in liberalization and de-regulations, Patterns of Transaction in international telecom management; managing the market growth; developing, operating and monitoring regulation issues.

Module II: Role of telecommunications in socio-economic development; ICT & Social change, new technologies and services for international telecommunications; data services and business applications, Telecom prospectus of WTO & other international bodies.

Module III: Current issues and organisational growth; telecom implications for the industry,value added services and market drives; regional prospectvies on development of telecom; Human Resources Planning and Industrial relations in ITSM; skill formation for ITSM and learning renewal, future directions of growth.

SML730 Organisation Management
3 credits (3-0-0)
*Pre-requisite: SML401
Module I Scope of organizations: Nature and function of organisations; individual organization environment interface; longitudinal thinking. Organisation Management: Theory, practice and major schools of thought, application potentials and possibility.

Module II Organisational architecture: Systems perspective on organisations and contingency approach . The socio-technical systems approach. Theory of organizational structures; Nature and consequences of structure; organisation process; IT & organisations.

Module III Integrating the elements: Organisational culture; coping strategies- individual & organisational; Impact of environmental and cultural variables on organizational structure and style; organisation design; mechanisation, automation and computerisation; Organizational interdependence and organizational evaluation.

SML731 Human Resources Management
3 credits (3-0-0)
*Pre-requisites: SML401; Overlap with: SML305
Module I: Management of human resources- historical evolution of the field. Influences on the approach of management of human resources. Line and staff components of human resource management. Role of Human Resource management in a competitive business environment. Interpersonal dynamics.

Module II: Building a task-person fit. Determining Human Resource requirements. Recruitment and selection process. Training and Development. Team Building, Leadership. Appraising employee performance.

Module III: Wage and Salary Administration. Collective bargaining and industrial relations, Quality of worklife. Cost-Benefit analysis of HR functions. Safety, Health and employee assistance programmes. Global reference points of Human Resources Management.

SML734 Management of Small Scale Industrial Enterprises
3 credits (3-0-0)
*Pre-requisites: SML305 and SML401
Module I: MSME Act 2006; Nature of entrepreneurial management,

the new entrepreneur, his problems and prospects in the Indian environment. Practical aspects of setting up and running of industrial enterprises including formulation of projects and feasibility study for new projects.

Module II: Raising resources for new enterprises. Location, design, product and process. Choice of technique in small business. Survey needs for growth of the enterprise. Monitoring to avoid sickness. Development and diversification.

Module III: Integration with LSEs and MNCs. Informations network for new enterprises. Implication of WTO to SMEs. Globalisation & Competitiveness of SMEs. Entrepreneurship in the globalisation era.

SML740 Quantitative Methods in Management
3 credits (2-0-2)
Module I: Role of quantitative methods and operations research for managerial decision making and support. Role of mathematical models in problem formulation and solving. Structure of decisions, statistical decision theory; decision making under uncertainty, risk, certainty. Decision Trees; Fuzzy Decision Making. Game theoretic applications. Mathematical Programming models- formulation and applications. Linear Programming- graphical method, Simplex technique; transportation, assignment and transhipment problems. Mixed Integer Programming.

Module II: Non-Linear Programming, introduction to Quadratic Programming, Geometric Programming and Direct Search techniques. Multiple Criteria Decision making- Goal programming, TOPSIS and AHP.

Module III: Sequential decisions using Dynamic Programming. PERT and CPM. Queuing theory- M/M/1 and M/M/n model. Monte Carlo System Simulation concepts and applications. Brief introduction to Non-traditional optimization. Case Study applications and use of OR software packages.

SML745 Operations Management
3 credits (3-0-0)
*Pre-requisites: SML305
Module I: Managing operations; planning and design of production and operations systems. service characteristics. Facilities planning-location, layout and movement of materials. Line balancing. Analytical tools and techniques for facilities planning and design.

Module II: Production forecasting. Aggregate planning and operations scheduling, Production Planning and Control. Purchasing, Materials Management and Inventory control and JIT Material Requirements Planning. MRPII, ERP, Optimization techniques applications.

Module III: Work Study, Value Engineering, Total quality & statistical process control. Maintenance management and equipment policies. Network planning and control. Line of Balance, World class manufacturing and factories of the future, Case studies.

SML760 Marketing Management
3 credits (2-0-2)
*Pre-requisites: SML305

Module I: Introduction to Marketing function; genesis, the marketing concept. Marketing Management System: objectives, its interfaces with other functions in the organisation. Environment of Marketing-Political Environment Economic Environment, Market segmentation Consumer buying behaviour. Socio- cultural environment. Legal Environment. Ethical issues in marketing.

Module II: Marketing Strategy- Marketing planning and Marketing programming. The concept of marketing mix, Product policy; the concept of product life cycle. New product decisions. Test marketing- Pricing, Management of distribution: channels of distribution. Advertising and promotions. The concept of Unique Selling Proposition.

Module III: Implementation and Control. The marketing organization- alternative organization structures; the concept of product management. Administration of the marketing programme: sales forecasting; marketing and sales budgeting; sales management; management of sales force. Evaluation of marketing performance; sales analysis; control of marketing effort; marketing audit.

SML770 Managerial Accounting and Financial Management

3 credits (2-0-2)
Pre-requisites: SML305 Overlap with: SML401

Module I: Accounting principles underlying preparation of Financial Statements. Preparation of Financial Statements- a synoptic view. Managerial uses of financial data. Techniques of financial analysis- Ratio Analysis.Cash-Flow statement. Cases and Problems.

Module II: Cost concepts. Cost-Volume-Profit (CVP) relationship and Profit Planning. Budgeting. Full Costing and Variable Costing methods. Cost analysis for Decision- Making. Standard Costing and Variance Analysis. Cases and Problems.

Module III: Long-term Investment Decisions: Developing relevant data, Time Value of Money, Cost of Capital, Determination of Working Capital, Techniques of Capital Budgeting decisions, Capital rationing. Cases and Problems.

SML780 Managerial Economics
3 credits (2-0-2)
Module I: Role of economic analysis in managerial decisions. Basic concepts; Objectives of business firms and profit policies. Theories of profit; Demand analysis and demand management w.r.t. domestic and world markets. Determinants, estimation and managerial uses of elasticities of demand; Demand forecasting; Supply function and market equilibrium analysis; Cost concepts; cost function; Break-even Analysis; Equilibrium analysis of firm in an open economy.

Module II: Pricing and output under different market situations; Recent advances in pricing theory and practices. Production analysis and Input Demand Functions; Project appraisal techniques. Social cost benefit analysis; Investment decisions under risk and uncertainty.

Module III: National Income concepts and their interrelationships. Inflation analysis; (Indian) Monetary System and banking structure. Monetary policy analysis and its implications to industry. Issues of economic growth, development and planning. Managerial analysis of Indian Five Year Plans. Industrial development planning and strategy. Regulation of industry and business. Industrial sickness. Fiscal policy and its managerial implications. Business cycles and economic stabilisation. Balance of payments and Exchange Rate.

SMP783 Management Laboratory
3 credits (0-0-6)
Pre-requisites: SML305 and SML401
Module I: Introduction and overview of Management Laboratory- Interpretation of managerial process. Case development technology- Game development technology and simulation exercises- Data sources.

Module II: Research methodology in management and system sciences- Management systems instrument development technologies- Case analysis and report writing methodology.

Module III: Development of cases/games/simulation experiments. Seminars and group discussion.

SMP791 Computer Laboratory
1 credit (0-0-2)
Pre-requisites: SML305 and SML401
Introduction to Computers, DOS, WINDOWS. Working with Word Processing and Graphics Packages. Familiarity with Spread Sheet and Data base Packages. Appreciation to special packages for Management Research (SPSS, Dynamo, OR Packages, Expert Choice).

SMD792 Minor Project
3 credits (3-0-0)

SMV793 Statistics for Management
1 credit (1-0-0)
Pre-requisites: SML305 and SML401
Nature and role of statistics for management. Introduction to probability theory; Measures of central tendency and dispersion. Probability distributions; Sampling distributions. Estimation and hypothesis testing; t-tests; ANOVA; Chi-square tests; Non-parametric statistics; Correlation and regression analysis. Introduction to, and hands-on sessions on, packages for statistical modelling.

SMN794 Communication Skills
1.5 credits (1-0-1)
Pre-requisites: SML305 and SML401
Communication effectiveness, Formal and informal communication. Inter-personal skills and rapport. The art of listening. Role expectation/ role ambiguity and conflict. Organisational strategies for effective communication, Written communication. Presentations, use of audio visual aids. Managerial report writing.

SMN795 Systems Thinking
1 credit (1-0-0)
Pre-requisites: SML305 and SML401
Systems thinking in evolution of Management thought. Hard and Soft Systems thinking, Open Systems thinking. Socio-technical systems, Flexible Systems thinking,SAP-LAP framework Analytic and synthetic approaches. Basic systems concepts, principles, and metaphors. General system theory. Principles of cybernetics.

SML801 Technology Forecasting and Assessment
3 credits (2-0-2)
Module I: Forecasting as an input to technology planning, Futures Research, Elements of forecasting process. Types of forecasting methods. Quantitative methods of forecasting: time series models, growth curves, Precursor, Envelope curves, Experience curves, technical assessment.

Module II: Qualitative methods: Morphological analysis, Relevance trees, Delphi, Technological gap analysis, Analogy method, Organising for Technology Forecasting.

Module III: Technology assessment: Components, problem definition, Social description, Measure, Impact assessment. Strategies for assessment, Economic impact analysis. Assessment of risk and uncertainty. Safety and environment considerations.

SML802 Management of Intellectual Property Rights
3 credits (3-0-0)
Module I: Nature of Intellectual Property; Patents, Industrial Design, Trademark and Copyright; Process of patenting and development; technological research, innovation, patenting, development; International cooperation on Intellectual Property;International treaties on IPRs; Patenting under PCT. Procedure for grants of patents.

Module II: Scope of Patent Rights;Licensing and transfer of technology; Patent information and databases; Geographical Indications.

Module III: Administration of Patent System. New developments in IPR; IPR of biological systems,plant varieties, computer softwares etc. Traditional knowledge; Case Studies; IPR and IITs.

SML 804 Technical Entrepreneurship
3 credits (3-0-0)
Module I: Basis and challenges of entrepreneurship Technological entrepreneurship, Innovation and entrepreneurship in technology based organisations, High tech. entrepreneurship. Entrepreneurial characteristics. Concept of new ventures. Technology absorption, Appropriate technology. Networking with industries and institutions.

Module II: Starting a new technological venture and developing the business: Business idea, Business plan, Marketing plan, Financial plan, Organisational plan. Financing a new Venture: Sources of Capital, Venture Capital, Going public. Enterprenrurship & liberalization.

Module III: Managing the new technological venture: Developing systems in new venture, Managing doing early operations, Growth and expansion, ending the venture. Legal issues, Franchising and acquisition. Entrepreneurship, globalisation and Entrepreneurship.

SML811 Management Control Systems
3 credits (3-0-0)
Pre-requisites: SML713
Module I: Nature of Management Control Systems: planning and control process. Essentials of Management Control System. Behavioural aspects of Management Control-motivation and morale, goal congruency, and so on. Management Control Process: Programming, Budgetary Planning

and Procedures, Fixed and Flexible Budgeting, Zero Base Budgeting. Internal Audit and Internal Control. Standard Cost Accounting Systems as measures of operating performance.

Module II: Variance Analysis and reporting of financial performance: Material, Labour and Overhead Cost Variances, Revenue Variances, Profit Variances, Variance Reporting.

Module III: Management Control Structure: Responsibility Accounting System- Concept of Responsibility Centre, Expense Centre, Profit Centre, Investment Centre. Inter-Divisional Transfer Pricing System, Measurement of Division Performance.

SML812 Flexible Systems Management
3 credits (2-0-2)
Module I: Emerging management paradigms: Total Quality Management, Business Process Reengineering, Learning Organisation, World Class Organisation, Flexibility in Management. Concept of systemic flexibility. Liberalisation, Globalisation and change. New Organisation forms.

Module II: Concept and dimensions of Systemic flexibility. Managing paradoxes. Methodology and tools of flexible systems management. Underlying values, and guiding principles, Case Analysis using SAP-LAP framework. SAP-LAP models and linkages.

Module III: Flexibility in functional systems, Information Systems flexibility, manufacturing flexibility, organisational flexibility, financial flexibility, and strategic flexibility. Linkage of flexibility with organisational performance.

SML813 Systems Methodology for Management
3 credits (2-0-2)
Module I: Introduction to systems methodology, Flexible Systems Methodology, Need and applicability of Systems methodology for management. Nature of managerial problems. System Dynamics Methodology- Philosophy, Foundation, Steps, building blocks, feedback structures, principles of systems, learning organisation.

Module II: Validation, Simulation and testing of System Dynamics models, Policy analysis, Micro world and Management games, Managerial applications of Systems methodology.

Module III: Management of physical systems. Physical system theory: fundamental premises and postulates, modelling of basic processes, application to manufacturing, managerial, and socio-economic systems. Critical comparison and integration of Physical System Theory and System Dynamics. Flexibility in physical system theory.

SML815 Decision Support and Expert Systems
3 credits (2-0-2)
Pre-requisites: SML713
Module I: The management support framework for computers. Fundamentals of decision theory and decision modelling. Humans and information processors and information systems as decision systems. Human decision styles.

Module II: Models, heuristics, and simulation. Overview of DSS-database, modelbase, user interface. DSS development methodology and tools. Need for expertise in decision models and expert systems. Expert systems fundamentals. Knolwedge engineering, knowledge representation and inferencing. Building expert systems.

Module III: Integrating expert systems and DSSs. Strategies for implementing and maintaining management support systems. Case studies, and laboratory and filed projects.

SML816 Total Quality Management
3 credits (2-0-2)
Pre-requisites: SML745
Module I: Introduction to TQM; Customer Orientation, Continuous Improvement, Quality, Productivity and Flexibility, Approaches and philosophies of TQM, Quality Awards, Strategic Quality Management,

TQM and corporate culture, Total Quality Control; Basic Analytical tools-Check Sheets; Histograms; Pareto charts, Cause and Effect diagrams; Flow charts.

Module II: Statistical Process Control; Advanced Analytical tools-Statistical Design of Experiments; Taguchi Approach; Cost of Quality; Reliability and failure analysis. FMECA, Quality Function Deployment, Benchmarking, Concurrent Engineering.

Module III: Quality Teams, Employee practices in TQM organisations: Leadership, delegation; empowerment and motivation; role of communication in Total Quality, Quality Circles; Total Employee Involvement; Problem Solving in TQM- Brain storming; Nominal Group Technique Team process; Kaizen and Innovation; Measurement and audit for TQM; Quality Information Systems, ISO 9000 series of Quality Standards; TQM Implementation; Reengineering and TQM.

SML817 Management of System Waste
3 credits (2-0-2)
Pre-requisites: SML715 and SML720
Module I: Introduction to waste and waste management. The concept of wastivity and its inter-relationship with Productivity Quality and Flexibility. Systems concept of waste, complementarily of waste and resource management. Functional elements of waste management. Waste management and cost reduction. Taxonomy of wastes, JIT, TQM and waste.

Module II: Management of waste in industrial and service sectors. Management of manpower waste and unemployment. Management of energy waste in the national economy. Energy recycling, Waste management and energy conservation. Total energy concept, overall energy wastivity.

Module III: Interfaces of waste management: environment control, nature conservation, resource development, Quality and Productivity Management, Business Process Reengineering. Role of legislation and government. Waste management and national planning.

SML818 Industrial Waste Management
3 credits (2-0-2)
Pre-requisites: SML715 and SML720
Module I: The concept of industrial system. Systems waste and waste management. Wastivity and productivity measurement. The categories of industrial systems waste. Stages and causes of waste generation in industrial systems. Waste reduction measures and systems in industry. Collection and disposal system of scrap, surplus and obsolete items. Recycling and processing of industrial waste. Industrial pollution and environment control.

Module II: Value engineering, design waste and cost reduction. Inspection rejects and quality management. Reliability, maintenance, breakdown and management of waste. Space waste and layout planning. Time management, manpower waste in industry, absenteeism. Capacity utilization. Waste heat recovery and energy waste in industry. Resource conversation/loss prevention in process industries. Data and information waste, management of hazardous waste. Waste treatment. Natural calamities. Accident prevention, industrial safety and waste management.

Module III: Waste management in Indian industries- present practices, potentials and perspectives. Management of waste in different industrial systems- steel, aluminum, power, automobile, transport and other service industries. Economic analysis and system models of industrial waste management systems. Analytical and Creative techniques to waste control.

SML819 Business Process Reengineering
3 credits (2-0-2)
Pre-requisites: SML720 and SML745
Module I: Nature, significance and rationale of Business Process Reengineering, Reengineering scenarios in major countries, Problems issues, scope and trends in BPR, Implementing BPR: Methodology and steps, IT enabled reengineering, mediation and collaboration.

Module II: The paradigm of Mass customization, managing organisational change, Transforming/ Reinventing the enterprise, Team building. Case studies of success as well as failure.

Module III: People view, empowering people, reengineering management. Issues of purpose, culture, process and performance, and people.

SML820 Global Business Environment
3 credits (3-0-0)
Pre-requisites: SML720
Module I : Global Scene.

Historical and economic background, firms and International Business. The global scene and the challenges ahead, challenges to free International Trade Political Risk, Protection, Accounting, Taxation and Legal practices. The International debt risks.

Module II: Regional Issues.

Global Monetary Institutions and Trade Agreements, Regional Trade Agreements and Facts. Socio-cultural context of Internatioal Business: European countries, U.S.A. developing of newly industrialized countries and Japan. Management of Multinational firms.

Module III: Globalization of Indian Economy.

Liberalization and globalization of Indian business. India's multinationals, Indian laws and policies relating to investment in India by international firms and outside India by Indian firms.

SML821 Strategic Management
3 credits (2-0-2)
Pre-requisites: SML720
Module I: Strategic Management Process.

The Strategic Management Process, Flexible system view of Strategic Management, Strategic Situation Analysis, The use of scenario, Structural analysis of the competitive environment, Competitive Advantage Profile, Industry foresight. Strategic Capability Analysis-Resource audit, value chain analysis, comparative analysis, financial analysis, SWOT analysis, core competencies, culture and stakeholder expectations, Global strategy.

Module II: Strategy Formulation.

Strategic Intent, Vision, Mission and objectives. Strategic architecture, crafting a strategy. Alaternate directions for strategy development. Alternate methods for strategy development: Portfolio analysis, screening strategic option; Analysing return risk and feasibility, selection of strategies. Strategies Alliances and Joint Ventures, Mergers & acquisition.

Module III: Strategy Implementation.

Implementing strategy:Corporate Restructuring, Budgets, Policies, Best practices, Support Systems, Rewards. Culture and Leadership, Functional strategies.

SML822 International Business
3 credit (2-0-2)
Pre-requisites: SML720
Module I: Key Issues in International Business.

Socio-cultural, economic and political forces facing business. International sourcing. Understanding the determinants of competitive advantage in international business at the national, industry and firm level. Global forces transforming international business. Multinational Corporation. Problems and Prospects in an International Environment, competitive and cooperative business strategy.

Module II: International Business Strategy of Indian Industry.

Competitive position of key Indian Industries. Entry strategies for Indian firms: Joint Ventures, strategic/technical alliances/collaboration. Strategies employed by Indian firms to develop and sustain international business.

Module III: Globalization Strategy.

Globalisation strategy, strategies of Multinational Corporation, implications for functional strategies: marketing, HR, planning, organisational structure, production, Global Information Systems,

Strategy Alternatives for Global Market entry and expansion, International negotiations.

SML823 Strategic Change and Flexibility
3 credit (2-0-2)
Pre-requisites: SML720

Module I: Patterns of Change and Flexibility.

Patterns of change, liberalization, globalization and privatization, changes in Social Political and Economic environment, Technological and organizational change. Changes in customer requirements. Impact of change of business and workforce. Need for flexibility, concept of Strategic Flexbility: Openness, Adaptiveness, Change, and Resilience. Understanding the process of strategic change. Managing chaos strategically. Regenerating strategies.

Module II: Revising Strategies Postures.

Corporate restructuring, Alliances, joint ventures, acquisitions and merges. Recorganising the firm, the impact of mergers and acquisitions on organizational performance. Management of continiuity and change, Blue Ocean strategy.

Module III: Energising Strategies Change.

Reengineering the corporation, identification of key business processes. Organization of the future. Implementing Strategic Change. Transforming the organizatin. Sustaining change. Consolidating gains and producing more change. Anchoring new approaches in the culture. Leading a high-commitment high-performance organization. Organization Vitalizations

SML824 Policy Dynamics and Learning Organization
3 credit (2-0-2)
Pre-requisites: SML720
Module I: Learning Organization.
Emergence of learning organization. Strategies for organization learning, using Feedback, shared vision, team work, personal mastery, mental models, systems thinking, role of leader, organizational dynamics. Soft Systems Methodology application to policy formulation. Flexibility in policy strategy. Strategy formulation in a learning organistion, clarifying vision and opportunities for change in a learning organization.

Module II: Micro World and Policy Dynamcis.

Systems-linked organization model. Micro world for policy learning. System Dynamics modeling applied to policy formulatins, conceptual model. The language of systems thinking links and qualitative system dynamics, Flexibility Influence Diagram, Collaboration Diagram, Archetypes, leverage points, Integrative simulation models.

Module III: Frontiers.
Role playing games and case studies to develop principles for successful management of complex strategies in a dynamic world. Strategic Management game for policy planning, Interactive Planning. Strategic issues such as business cycles, market growth and stagnation. And diffusion of new technologies. Knowledge management in learning organizations.

SML825 Strategies in Functional Management
3 credit (3-0-0)
Pre-requisites: SML720
Module I: Linkage of corporate and Buinsess strategy with various Functional strategies, Flexibility in Functional Strategies. Marketing Strategy, financial Strategy.

Module II: Manufacturing Strategy, IT Strategy, Human Resources Strategy.

Module III: Technology Strategy, Quality and Productivity Strategy, Environmental Strategy.

SML826 Business Ethics
3 credits (3-0-0)
Pre-requisites: SML720
Module I: Ethics in Business
Historical perspective, culture and ethics in India, codes and culture.

Economics and the Environment: green business, Ethics and Competition. The ethical code, social audit. A framework for analysis and action. The sphere of personal ethics: consequences, rights and duties, virtu and character. Role of objectiveity, practicability, judgement and balancing acts. The individual and the corporation.

Module II: Ehtical Responsibilities.
Ethical responsibilities of economic agents: role obligations, obligation to sharesholder, rights and, obligations to customers, obligations to pay taxes. Environmental protection. Corporate accountability, Ethical conflicts, concern for the locality, Attitude to labour.Ethics and Government policies and laws.

Module III : Ehtics in Functions.
Ethical responsibilities of organizations leader: power, leadership. Obstacles to ethical conduct. Pressures for conformity. Evaluation and rewards. Job pressures and issues. Organizational change. Ethics in use of Informatrion technology. Intellectural Property Rights. Ethics in Marketing. Ethics of advertising and sponsorship. Freedom Vs State Control. Acquisitons and Mergers, Multinational decision making: Reconciling International norms.

SML827 International Competitiveness
3 credits (3-0-0)
Module I: Introduction to Competitiveness
Background, Need, Basics, Myths; Global Perspectives, Context, Definitions, Benchmarking & Key Issues; Related concepts: Excellence, Value Creation; Competitiveness at Different Levels.

Module II: Evaluating & Planning for Competitiveness
Frameworks of Competitiveness & Strategy, Evaluating Competitiveness, Enhancing Competitiveness, Competitiveness Processes & Initiatives, Leadership Dimension, Cases.

Module III: Practitioners Perspectives
Business Models for Competitiveness, Functional (e.g. HR, Operational, Financial, Technological) Linkages, Partnerships/Cooperation for Competitiveness, Emerging Issues/ Practices.

SML828 Global Strategic Management
3 credits (2-0-2)
Pre-requisites: SML720
Module I: The Process of Globalization and Global Strategy.

Globalization of markets and competition, globalization and localization, Diagnosing Global Industry Potential, Designing a global strategy, Making Global strategies work, Global strategic alliances, M&A.

Module II: Regional Strategy and Entry Strategy.
Regional Strategy, Emerging Markets Assessing Country Attractiveness, Entry Strategies: Subsidiaries, acquisitions, joint ventures, Licensing, Franchising, Agents and Distributors.

Module III: Managing Globally and Future Challenges.
Designing a global organization, Global Marketing and Operations, Cross Cultural Management, Leadership and Global manager, Globalization and the Internet.

SML829 Current and Emerging Issues in Strategic Management
3 credits (3-0-0)
Pre-requisites: SML720
(Relevant current and Emerging Issues)

SML830 Organisational Structure and Processes
3 credits (3-0-0)
Pre-requisites: SML730 and SML731
Module I: Organisational structure- classical and neoclassical theories. Strategy and structure. Modern Organizational theory- systems view of organisation and integration. Micro, intermediate, macro environment. Participative structures.

Module II: Work culture and organization processes. Decision processes, balance and conflict processes. The process of role and status

development. Influence processes and technological processes. Capacity development in organizations.

Module III: Interface of structure and processes- structural functionalism; Allport and Event- Structure theory. Organizational Governance- organizations as a subject of political enquiry, Models of organizational governance. Making and breaking patterns.

SML831 Management of Change
3 credits (2-0-2)
Pre-requisites: SML730 and SML731
Module I: Process of change and organization theory and practice. Elements of change. Achieving Systematic change. Domains of systematic change-strategy, technology, structure and people. Planning for change.

Module II: Change and the use of power. Nature and sources of power. Leadership and change- Transactional vs. Transformational change. Change cycle including participative and coerced change.

Module III: Change through behaviour modification. Positive and negative reinforcement. Training for change. Managing conflict. Implementing change. Adjustment to change and organising for growth. Prerequisites and consequence of change. The change Dynamics.

SML832 Managing Innovation for Organisational Effectiveness
3 credits (3-0-0)
Pre-requisites: SML730 and SML731
Module I: Elements of creativity person, creative organization, nature of innovation. Assessing creativity. Tools and techniques for enhancing creativity. Innovation and risk.

Module II: Managing social equity and organisation efficiency paradox, blocks to creativity, methods to overcome the blocks. Introducing creativity in organisation. Structure and creativity. Work culture and innovation.

Module III: Practices of creativity and intervention strategies- organization excellence: Creteria and practice-innovation and quality, Innovation and BPR/appraisal system- interventions. Innovation and competitiveness.

SML833 Organisation Development
3 credits (3-0-0)
Pre-requisites: SML730 and SML731
Module I: Organisation Development- nature and scope. The generic and contextual element of developing organisation. Introduction to process change. Theories, strategies and techniques of organizational diagnosis for improving organisation's problem solving and renewal process, legacy factors and organizational growth.

Module II: Coping with environmental change. Socio-cultural dimensions of work and behaviour, Environmental analysis and impact. Diagnosis of the ongoing process from symptoms to causes. Organistion development and intervention strategies.

Module III: Personal change. Laboratory learning techniques. Managerial Grid. Sensitivity training. Transactional analysis. Inter-group and team building interventions. Management by objectives. Total system interventions-stabilising change.

SML835 Labour Legislation and Industrial Relations
3 credits (2-0-2)
Pre-requisites: SML730 and SML731
Module I: Introduction of industrial relation and a systematic view of personnel. Labour Relations. Introduction to Indian Trade Unionism. Industrial relations and conflict in industries. Introduction of Labour Regulation Act, Factories Act, Trade Union Act, and Safety Act.

Module II: Role of Industrial Legislation. Introduction of Industrial Dispute Act. Different jurisdiction of Labour Court. Issues in recognition of unions. Tribunal and national tribunal. Strategies for resolving Industrial Conflict, Collective bargaining. Works committee and joint consultative committee, Negotiation process.

Module III: Influence of Government regulations. Third party intervention in industrial disputes. Rules of grievances. Discipline in Industry. Contribution of tripartite bodies. Labour Welfare Participative Management. Workman's Compensation Act. Productivity in Industry. Healthy industrial relations and economic development.

SML839 Current and Emerging Issues in Organisation Management
3 credits (3-0-0)
Pre-requisites: SML730 and SML731
(Relevant current and Emerging Issues)

SML840 Manufacturing Strategy
3 credits (3-0-0)
Pre- requisites: SML745
Module I: Manufacturing and operations strategy-relevance and concepts. Strategic issues in manufacturing & operations, Capacity planning, International innovations in manufacturing. Choice of technology and manufacturing process in the prevailing environment.

Module II: Technology-manufacturing process interfaces with marketing, engineering, quality, purchasing, finance and accounting. Inter-relationship among manufacturing manager and their suppliers, customers, competitors, superiors and production workers.

Module III: Strategic implications of Experience Curve. Focused manufacturing-green, lean and mean. Strategic issues in project management and implementation of manufacturing policies. Perspectives of Manufacturing Strategy. Case Studies.

SML843 Supply Chain Logistics Management
3 credits (3-0-0)
Pre-requisites: SML745
Module I: Perspective of Supply Chain Logistics Management.
Logistics concept, role and scope; Logistics Environment- Integrating Logistics of Supply, Logistics of Production and Logistics of Distribution. Internal and external factors for logistics strategy, Operational Resources of logistics (personnel, warehouse means of transport, warehouse transport aids, organizeational aids, material stocks, and area/spare) Effective supply chain management, customer networking and manufacturing, Risk Pooling, Postponement, cross docking in supply chain.

Module II: Logistics Activity Mix.
JIT and Logistics, Synchronised manufacturing. Purchasing and Materials Management. Distributional logistical systems and facilities-single stage or multistage, warehouse(s), their number, location and allocation, Automated Warehousing, Materials Handling and Packaging. Simulation aided planning of conveyor and warehousing systems.

Module III: Supply Chain Logistics Mix Management.
Logistical Connnectivity: Transportation modes, rate structure, legal aspects; maintenance, spares and repairs; test and support equipment, Routing of freight flows. Management and Organization of the Logistics Systems; Organization, Information and cost control; Logistical information Systems, Computer aided logistics management. Case Studies.

SML844 Systems Reliability, Safety and Maintenance Management
3 credits (3-0-0)
Pre-requisites: SML745
Module I: Reliability, Safety, Risk Assessment Perspective.
Introduction to reliability, availability and safety engineering and management. Select statistical concepts and probability distributions. Optimization techniques for systems reliability, availability and safety. Reliability, availability, safety and maintainability. Risk assessment and management for reliability and safety.

Module II: Maintenance Planning and Control.
Maintenance management objectives and functions. Classification of Maintenance system. Maintenance Planning and Scheduling. Issues of

Relplacement versus reconditioning and imperfect repair maintenance models. Spare parts Inventory Planning and Control for single and multi-echelon systems. Diagnostic tools of failure analysis: Failure Mode Effect and Criticality Analysis, Fault Tree Analysis.

Module III: Information System for Reliability, Safety and Maintenance Management.
Organizational aspects and a computer aided management information system for reliability, safety and maintenance. Life cycle costing and cost management for maintenance. Human factors in maintenance, Maintenance Manpower Planning. Case Studies.

SML845 Total Project Systems Management
3 credits (2-0-2)
Module I: Project Systems Management: a life cycle approach, project characteristics; project life cycle phases: conception, definition, planning and organising, implementation and project clean up. Project feasibility analysis. The project manager: role and responsibilities, Team Building and Conflict Management. Tools and techniques for project management. Environmental impact analysis of a project.

Module II: Network techniques for project management-PERT, CPM and GERT. Accounting for risk, uncertainty and fuzziness. Time cost tradeoffs and crashing procedures. Multi project planning and scheduling with limited resources. Multi objective, fuzzy and stochastic based formulations in a project environment.

Module III: Funds planning, performance budgeting and control. Project materials management. Pricing, estimating, and Contract Administration and Management, Building and Bid evaluation and analysis. Project implementation and monitoring, Project management information and control systems. Project systems management performance indices. Software Packages application for Project Systems Management. Case studies.

SML846 Total Productivity Management
3 credits (3-0-0)
Pre-requisites: SML745
Module I: Total Productivity overview; meaning, relevance and scope for productivity and effectiveness. Productivity conceptualisation. Productivity mission, objectives, policies and strategies. Productivity environment. Corporate culture, management styles, employees participation, trade unions and role of governmental agencies. Productivity measurement, monitoring and management both at micro and macro levels. Corporate and annual productivity plans.

Module II: Benchmarking: Management issues, modelling, tools and techniques; indicators for evaluation of manufacturing, business or services organizational performance and its measurement.

Module III: Productivity Improvement Techniques: modifying organizational characteristics and work characteristics. Work study, Value Engineering, Waste Management. Human resource development strategies to increase productivity. Managing technological change. Interfaces of Productivity with Quality, Reliability and Safety. Management commitment and involvement for higher productivity. Case Studies.

SML847 Advanced Methods for Management Research
3 credits (2-0-2)
Pre-requisites: SMV793; or MAL140
Introduction to management research, types of management research, research designs, Portfolio of management research methodologies involving qualitative and quantitative tools, optimization approaches, Multi-criteria decision making tools, case studies, interpretative models, soft system methodology, simulation, etc. Design of a questionnaire-based survey instrument, development of data measurement, scale development, testing the validity and reliability of data, sampling techniques, descriptive statistical analysis, inferential analysis, sampling techniques, sampling distribution, hypothesis testing, ANOVA, factor analysis, correlation, regression : OLS, Logic, Tobit, Discriminant analysis, Co-integration, unit root testing, Granger, casuality, VAR, GARCH and its variants. Structural equation modelling and other related research tools. Portfolio of optimization tools such as linear programming, goal

programming, integer programming, Data Envelopment Analysis for designing a management research. Case study approach with SWOT, SAP-LAP, value chain, PEST, etc. AHP, ANP modeling of risk and uncertainty in management, real life case development with appropriate research design.

SML849 Current and Emerging Issues in Manufacturing Management
3 credits (3-0-0)
Pre-requisites: SML745
(Relevant current and Emerging Issues)

SML850 Management of Information Technology
3 credits (3-0-0)
Pre-requisites: SML713
Module I The Strategic Framework for IT Management.

Emerging information technologies: IT for competitive advantage; IT for internal effectiveness; IT for inter- organizational linkage;Module II Strategy Development and Planning Techniques.

Module II: IT Planning (CSFs, Scenario analysis, Linkage analysis, Enterprise modeling); Strategy formulation techniques; Nolan's stage model and revised models for Nolan's stages; IT investment decisions; methods for evaluating IT effectiveness; IT enabled business process redesign.

Module III : Strategic Issues Related to IT Management.

Relating IT to organizational leadership, culture, structure, policy and strategy; programmer productivity; Managing legacy systems; evaluating centralization- issues; IT-forecasting.

SML851 Database Design and Data Management
3 credits (2-0-2)
Pre-requisites: SML713
Module I: Introduction to Database Systems.

Evaluation of database technology; Limitations of file systems; Databae systems- hierarchical models (IMS architecture- DBD, PSB), network models (DBTG DDL and DBTG DML), and relational models normalization and relational calculus);

Module II: Database Design.

Database systems- hardware software, data people; database systems and their organizational development; Database development lifecycle; Logical database design; implementation design.

Module III: Strategic Issues Related to IT Management.

Database implementation; Knowledge base systems and natural languages; Database administration and control; Distributed database systems. Data mining , data warehousing.

SML852 Network System: Applications and Management
3 credits (3-0-0)
Pre-requisites: SML713
Module I: Networking fundamentals.

Communication fundamentals (transmission and transmission media; communication techniques; transmission efficiency) Wide area networks, local area networks, ISDNs; OSI architecture, IBM's SNA, Digitals DNA, Internetworking; network applications- EDI, Email, file transfer, conferencing, Enterprise networking.

Module II: Networking technologies and applications.

Design and development of enterprise network; Web-based application development, Desing of large-scale intranets, Network and systems management issues, Remote access to computer resources, Network and system security.

Module III: Managing networks.

Preparing for doing business on the internet; Choosing and costing networks and network services; network management requirements; network performance indicators; performance monitoring.

SML855 Electronic Commerce
3 credits (2-0-2)
Pre-requisites: SML713
Module I: Business Opportunities with or without Internet : Business revolution and e-commerce: issues of competitive advantage, physical distribution system and supply chain improvements, value chain analysis.

Networks and commercial transactions, The Internet environment, on-line commerce solutions.

Types of e-commerce: web store, auctions, discounting, advertising and promotions (case studies) etc., risks in internet commerce, jobs in cyberspace.

Business Models for e-commerce, on-line commerce options: customer choices and merchant choices, Advertising and marketing on internet. Consumer-oriented commerce. Network infrastructure for EC. Business of Internet commercialization.

*Module II: Technology of e-commerce***:** Technology Basics: all the nets (internet, intranets & extranets), telecommunication infrastructure of internet, protocols & convergence.

Business technologies for WWW: database integration, web databases and software developments.

Security technologies: encryption, cryptography, public key solutions, key distribution and certification, Electronic payment methods: technologies (EDI, EFT, EFTPOS etc.), secure transaction models, Protocols for the public and private information (Secure sockets layer (SSL) and Secure electronic transaction (SET)].

Electronic Payment Systems : First virtual internet payment system, cyber cash.

Digital Currencies : Basics, eCash, Smart cards.

Re-intermediation at work, intelligent agents, datamining tools.

Module III: Setting up a e-business (Legal Commercial Framework).

Strategy for setting up a web site, creating commercial web site, shopping agents.

Taxation implication of i-commerce : Income tax, sales tax, tax reforms and trade policy, Action and gambling on Internet. Ethics and legal issues : cyber laws. NP Future trends : Convergence of technologies, Virtual concepts, Government internet commerce.

SML856 Business Intelligence
3 credits (3-0-0)
Pre-requisites: SML713
Module I: Data Warehousing.

Problems of modern databases & the nature of BI Warehousing, Multidimensional Modeling, Online Analytical Processing (OLAP) Systems Interface of BI with organization capability Paperless office & Virtual Organization.

Module II: Data Mining.

Knowledge Discovery, Data Mining tools, Market Basket Analysis, Management Applications Customer Relations Management (CRM) Data Visualization and Multidimensionality Geographical Information Systems (GIS) and Business applications.

Module III: Other Decision Supporting Technologies.

Executive Support Systems, Knowledge Management Characteristics and Capabilities of DSS Collaborative Computing Technologies: Group Support Systems Intelligent Support Systems (Expert Systems, ANN, Genetic Algorithm etc.) and their Managerial Applications.

SML857 Database Management Information Systems
3 credits (3-0-0)
Pre-requisites: SML713
Module I: Introduction to database.

Role of information in an organization: Need for a data architecture, Need for Information Resource Management, Data concepts and data modeling, Entity- Relationship modeling, Relational Modeling including normalization, Maping Entity- Relationship Model to Relational Model.

Module II: Database Information Systems.

Structured Query Language, Data storage and file organization, Technology of DBMS, Concurrency control, Recovery management. Use of database and application development tools. Database security.

Module III: Emerging data management techniques.

Distributed database systems and object databases. Data warehousing and data mining; Executive information systems and decision support systems.

SML859 Current and Emerging Issues in Information Technology Management
3 credits (3-0-0)
Pre-requisites: SML713
(Relevant current and Emerging Issues)

SML861 Market Research
3 credits (2-0-2)
Pre-requisites: SML760; SML793
Module I: Research concepts; exploratory, descriptive and conclusive research. The market decision-making process and the need of different types of research. Types of marketing problems and type of marketing research activity. Sources of data; use and appraisal of existing information.

Module II: Information from respondents, sampling design, scaling techniques and questionnaire design, interviewing, mail surveys. Information from experiment, experimental design for marketing, Movtivational research, Advertising research, Analysis and reporting.

Module III: Marketing information systems, Structure and design, its role in planning and control; the place of marketing research.

SML862 Product Management
3 credits (3-0-0)
Pre-requisites: SML760
Module I: The product in corporate life, Corporate and product objective, product management role, responsibility, scope and functions, product strategy and policy, optimum product pattern/line range.

Module II: New product development and launching. Challenge of change-opportunity and risk-product innovation, modification, addition and elimination product proposals-sources, generation, processing and selection. Establishing techno-economic feasibility product testing and test marketing. Developing the strategy and the plan. Implementing the plan, coordination and control. Brand identity, Image, Equity, Brand Plan and Management, New Product Development Process. Brand and Product launch plan.

Module III: Organization for Product Management, Marketing manager-product manager-brand manager concept, approaches and organizational role, product manager-functions and tasks-tools and techniques. Brand extensions, acquisitions, Brand value, Consumer insight. Strategies brand management.

SML863 Advertising and Sales Promotion Management
3 credits (3-0-0)
Pre-requisites: SML760
Module I : Mass communication theory and practices, marketing and promotion mix- interrelationship and interdependence advertising. Sales Promotion, Publicity and Public Relations- Scope, Objectives, activities and creative role. Advertising, objectives tasks and process, market segmentation and target audience- Message and copy development. Mass media, selection, planning, budgeting and scheduling. Integrated programme and budget planning. Implementing the programme, coordination and control. Advertising Agencies in India, their services and terms, advertisement campaign development, Agency selection and appointment; Agency Organization and operation, Getting the best of the agency services. Analysis of effectiveness of advertisement and promotional compaign.

Module II : Why and when sales promotion support, Sales promotion activities; Consumer Oriented-Sales channel Oriented-Sales staff oriented, Planning, budgeting, implementing and controlling campaigns. Advertisement development brief.

Module III : Valuation and measurement of advertising and sales promotion effectiveness, Company organization for advertising: sales manager, Sales Promotion Manager, Market Development Manager-Role of Tasks, advertising ethics, economics and social relevance. The Public Relations Activities, Public relations and mass media. Media planning and budgeting control.

SML865 Sales Management
3 credits (2-0-2)
Pre-requisites: SML760
Module I : Organisational framework of the field sales force. Types and methods of field sales organisations-Career in Field Sales Management. Field Sales Manager- coordinating and controlling the Marketing mix, Tasks and responsibilities, team relations with Salesman and interaction and reporting relationship with Top Management. Operating environment for Field Sales Managers. Sales forecasting.

Module II: Sales Information and Planning, The qualities and role of a Field Sales Manager- Hierarchy of objectives and goals, concept of sales strategies and tactics; types of Planning. Marketing Intelligence and Sales Management. Relationship and contribution of Marketing Research to the sales development as decision making process. Designing and planning of sales territories, procedure for designing sales territories. Determining sales manpower requirements to establish sales territories- Recruiting salesman- selection process and system. Distribution and chamel selection & Management.

Module III: Operational Management, Staffing: Its advantages, responsibility for staffing, tools and methods of selection. Sales training: Its objectives, programme content, Methods of training, concepts of territorial management for field sales force. Measurement and control: General considerations governing evaluation and sales performance and control. Sales audit, Sales budgeting, Key account management, Route Planning and control. Sales Promotion Customer relationship management.

SML866 International Marketing
3 credits (3-0-0)
Pre-requisites: SML760
Module I : International marketing-its scope and tasks- world economy prospects and Challenges; India's external trade. Analysis of export performance. Why all organisations cannot go global Shipping terms and international trade terms. Information needs of exports.Costing and pricing in international trade. Advantages and disadvantages of globalisation.

Module II : Strategic export planning. Handling an export transaction. Export marketing Checklist; Selection of Markets: Choosing Markets; Export pricing; Management of export logistics. Documentation for export; processing of an export trade. Sales forcasting in international trade, Identifying geographical territories for expansion. Cultural factors affecting business in global market.

Module III : Export credit system preshipment and post- shipment, finance, medium and long term credit financing; ECGC; Transportation and shipment of cargo; Marine insurance of cargo; procedure for claiming rebate of excise duty. Import replenishment licensing

procedures. Generalized scheme of preferences. Sourcing and Transfer pricing mechanism. WTO related issues and IPR related issues impacting global trade.

SML867 Industrial Marketing Management
3 credits (3-0-0)
Pre-requisites: SML760
Module I: Industrial marketing and Environment. Application of industrial buyer behaviour theories. Marketing plan to implement the marketing concept.

Module II: The new product development process. Personal selling (negotiations, systems selling, targets setting, fact finding, training); sales communications.

Module III: Marketing Research for industrial product Marketing control (variance analysis audit). Industrial purchase behaviour and processes, new product launch. Forecasting methods.

SML869 Current and Emerging Issues in Marketing
3 credits (3-0-0)
Pre-requisites: SML720 and SML760
(Relevant current and Emerging Issues)

SML870 Advanced Financial Management
3 credits (2-0-2)
Pre-requisites: SML770
Module I: Aims and objectives of Financial Decisions. Integrated approach to Corporate Financial Decisions. Effect of Taxes on Financial Decisions. Capital Budgeting Decisions under conditions of Risk and Uncertainty. Unequal expected lives and investment outlays. Capital Asset Pricing Model: meaning, Systematic and Unsystematic risk, calculation of Beta, CAPM and Cost of Equity Capital. Business Valuation Cases and Problems.

Module II: Capital Structure Decisions: Operating and Financial Leverage, Optimum Capital Structure and Capital Structure Theories, EBIT/EPS Analysis, Designing Capital Structure in practice. Cases and Problems.

Module III: Divided Decisions: Dividend and Valuation- Walter's Model, Gordon's Model, Theory of Irrelevance of Dividends (MM Approach). Types and Determinants of Dividend Policy. Internal Financing and Dividend Policy. Stock Dividend (Bonus Shares) and Stock (Share) Splits. Lease Decisions: Fundamentals of Leasing, Types of Leases, Financial framework for evaluating Lease Versus Buy/Borrowing alternative. Mergers Acquisition and corporate restructuring Cases and Problems.

SML871 Accounting for Decision Making
3 credits (2-0-2)
Pre-requisites: SML770
Module I: *Accounting Framework for Preparation of Corporate* Financial Statements and Reports: Accounting Cycle and Statements of Financial Information. Accounting Standards. Corporate Financial Statements and Reports.

Module II: Conceptutal Framework for Decision Making and Pricing Decisions

Concept of cost relevancy. Full-Cost Fallacy and Loss Minimization criteria, Differential Costs versus Variable Costs, Opportunity Loss. Concept. Developing relevant data for decision-making. Techniques of decision-making Differential Costing and Incremental Analysis. Pricing Decisions: Full-Cost versus , Selling at below normal price, pricing special orders. Case and Problems.

Module III: Product Decisions.

Make or Buy, Sell Now or Process Further, Operate or Shut-Down, Addition/Discontinuation of Product Lines/Divisions/Departments: Product Mix Decisions with Input Constraints(s), with and without samples Constraints. Decisions Relating to Disposal of Inventories. Cases and Problems.

SML872 Working Capital Management
3 credits (3-0-0)
Pre-requisites: SML770
Module I: Nature and Financial of Working Capital.

Nature of Working Capita, Trade-off between Profitability and Risk, Determinants of Working Capital. Factoring as a Sources Finance. Forecasting Working Capital requirements. Sources of financing Working Capital. Factoring as a source of finance. Bank credit and working capital Finance. Approaches to determine Financing Mix. Working Capital Leverage. Cases and Practical Problems.

Module II: Current Assets Management.

Cash Management, Inventory Management, Receivables Management. Cases and Practical Problems.

Module III: Analysis aTools and New Development.

Operating Cycle, Ratio Analysis, Funds-flow Analysis and Cash -Flow Statement as tools of Working Capital Management. Recent changes and new developments.   Practical Problems.

SML873 Security Analysis and Portfolio Management
3 credit (3-0-0)
Pre-requisites: SML770
Module I: Investment Environment.

Saving and Financial flows, Financial Intermediation, Investment in Corporate Securities and other Investment Outlets, New Issue market and Secondary Markets. Sources of investment information. Theoretical framework for investment Decision. Regulatory Framework of Securities Markets in India.

Module II: Valuation of Securities.

Valuation of Variable Income Securities (Equity Shares): Theory of Valuation-Earnings and Dividend Model. Fundamental Analysis,Aggregate Economic Analysis, Industry Analysis, Company Analysis, Technical Analysis, Growth Shares, Under and Overvalued Shares. Analysis of Fixed Income Securities like Preference Shares, Debentures/Bonds and other Financial Instruments. Interest Rate structure and yield to Maturity Curve. Convertible Bonds: Warrants and Options.

*Module III: Portfolio Management.*General principles. Measures of Risk and Return, Required Rate of Return and CAPM, Markkowitz Portfolio Theory.   Efficient Capital Market Theory. Alternative Efficient Market Hypotheses. Constructing the Optimum Portfolio.

SML874 Indian Financial System
3 credits (3-0-0)
Pre-requisites: SML770
Module I: Overview of Indian Financial System.

Role of Financial Markets in capital formation and economic development; Indian Financial system- An overview. Commercial Banks and Industrial Finance- evolving role. Reserve Bank of India as a Regulator of Banking System and its other functions. Basel -I and Basel-II norms.

Module II: Financial Markets.
Money Market Organization in India-nature, constituents and instruments. Industries Securities Market in India: New Issue Market and Stock Exchange. Differences and similarities, functions, methods of New Issues, Regulatory Framework and SEBI.

Module III: Mutual Funds, Insurance and others.
Investment Policy and performance appraisal of Unit Trust of India, Insurance, IRDA. New Developments such as financial instruments, Private foreign investments, case studies and problems.

SML875 International Finacial Management
3 credits (3-0-0)
Pre-requisites: SML770

Module I: Foreign Exchange Market and Risk Management: Environment of International Financial Management: Balance of Payments. Means of International Payments, Foreign Exchange Market, Currency Futures and Options Markets, Foreign Exchange Risk Management, Political Risk, Interest Rate Risk.

Module II: Financing of International Operations : Determination of Exchange Rate, Exchange Market and Arbitrage, Exchange Rate Control, Financing of Exports and International Investments, International Monetary Systems, European Monetary System, International monetary and Financial Institutions.

Module III: Financial Management of MNCs: Capital Budgeting Decisions for Multinational Corporation, Financing Decisions- Cost of Capital and Financial Structure, Working Capital Management and Control, International Banking, International Transfer Pricing.

SML879 Current and Emerging Issues in Finance
3 credits (3-0-0)
Pre-requisites: SML720
(Relevant current and Emerging Issues)

SML881 Management of Public Sector Enterprises in India
3 credits (3-0-0)
Pre-requisites: SML780
Module I: Public enterprises, their status and role in developing societies. Central and State level PSUs. The role of public enterprise in the economic and industrial development of India. Structure and goals of public enterprise. Public enterprises. Government relationship. Issues of autonomy and accountability.

Module II: Political economy of public enterprises. Traditional economics Vs. Political economy. The nature of contending social forces. Planning and decision-making in public enterprises. Role of technology in public enterprises. Public enterprise-financial problems and issues of divestment and pricing in public enterprise.

Module III : Project management, monitoring and evaluation in public enterprises. Performance evaluation in public enterprises. Performance indices. Strategies for performance improvement. Concern of liberalisation and public sector undertakings.

SML887 Business Law
3 credits (2-0-2)
Pre-requisites: SML305
Module I: Nature of Business law, Sources of Business law and their classification. Mercantile law, Statue I Case law, Customs and Usage. Agreement and their legal obligations. Essential elements of a valid contract, Types of contact,Void and voidable contract. Unenforceable and illegal agreements. Offer and acceptance over the telephone.

Law of Arbitration-Definition of Arbitration, Effect of an arbitration. Arbitration without Intervention of Court. Powers and duties of Arbitrators.

Module II: Sale of Goods Act. Definition and essentials of a contract of sale, Distinction between sale and agreement to sell, sale and hire purchase, sale distinguished from contract for work and labour. Kinds of goods, perishable goods. Document to the title of goods. Rules regarding transfer of property, Transfer of Title on sale. Rules regarding delivery of goods. Buyers rights against seller, and unpaid seller's rights. Consumer protection act. Consumers rights, consumer's disputes redressal agencies, consumer protection council.

Module III: Negotiable Instrumentd act. Definition and characteristic of Negotiable instrument. Liabilities of Parties to Negotiable Instruments.

Brief exposure to Company law including incorporation of a company -

objects, registration, article of association, raising capital from public, company management and reconstruction, amalgamation and winding up.

SML 889 Current and Emerging Issues in Public Sector Management
3 credits (3-0-0)
Pre-requisites: SML881
(Relevant current and Emerging Issues)

SMN895 Management Research Methodology
1 credit (1-0-0).
Pre-requisites: SML760
Problem conceptualization and definition. Hypothesis formulation. Selection of Research Methods, Flexible Systems Methodology for preparing research design, Scaling, sampling methods, Managing oral evidence, Questionnaire design, validation and pretesting. Interview design, Case study, Field experiments, Quasi experiments. Qualitative research methods. Statistical techniques and implementation of research plan using statistical packages.

SMN896 Human Values in Management
1 credit (1-0-0)
Pre-requisites: SML731
Values-driven management, Value conceptualization and construction. A strategy and vision of value, creating a shared vision of value. Ingraining practical ideals. Human technology. Fundamental human pursuits. Importance of action and the technique of right action. Values for effective managers. Specific problem areas: stress, motivation, quality, and leadership, Quality of life. Enlightened and liberated organisation.

SML897 Consultancy Process and Skills
3 credits (3-0-0)
Pre-requisites: SML305 and SML401
Module I : Introduction to Consultancy-its evolution, growth & status, Types of Consulting Services, firms and role of consultants, client-consultant relationship. Marketing of Consultancy Services.

Module II:The Consulting Process-Entry, Diagnosis, Action Planning, Implementation and Termination/Closing;

Module III :Methods of selection of consultants, Costs and fee calculation, Preparation of Consultancy proposals and Agreements, Technical Report Writing and Presentation.

SML898 Consultancy Professional Practice
3 credits (3-0-0)
Pre-requisites: SML305 and SML401
Module I : Negotiation Skills, Professional Ethics and Code of Conduct. Managing a Consultancy firm-fundamentals of consulting firm management, consulting firms and IT in consulting firms, management of consulting assignments.

Module II : Consulting in variou areas of Management-Consulting in general and strategic management, consulting in financial management, consulting in marketing and distribution management, consulting in production and operation management, consulting in HRM, consulting in IT.

Module III : R&D-Consultancy relation-ship, Careers and Compensation in Consulting, Training and development of Consultants, Future Challenges and Opportunities in Consultancy.

SML899 Current and Emerging Issues in Consultancy Management
3 credits (3-0-0)
Pre-requisites: SML305 and SML401

* Pre-requisite for PG courses is applicable for B.Tech. student.

Department of Mathematics

MAL110 Mathematics - I
4 credits (3-1-0)
Overlaps with: MAL111, MAL115
Taylor's theorem and infinite series. Fundamental theorem of integral calculus. Applications of definite integral to area, arc length, surface area and volume. Differential calculus of functions of several variables with applications; Maxima and minima; Ordinary differential equations of first and higher order; Series solution for Legendre and Bessel equations. Laplace transform.

Rank and inverse of a matrix, consistency of linear system of equations; Eigen values, Eigen vectors and their applications to system of ordinary differential equations; Cayley-Hamilton theorem; Diagonalization of matrices.

MAL111 Introduction to Analysis and Differential Equations
4 credits (3-1-0)
Overlaps with: MAL110, MAL115
Product of sets; mappings and their compositions; denumerable sets' upper and lower bounds, supremum, infimum.

Metric spaces: Definition and examples, open and closed subsets; neighborhoods, interior, boundary, closure, diameter of a subset, boundedness, separability. Convergence and limit of a sequence, Cauchy sequence, complete spaces. Continuous functions, bounded functions, intermediate-value theorem. Compactness in metric spaces.

Differential, differentiability, Leibniz rule, Taylor theorem, indeterminate forms, Extrema of functions. Riemann integral: Properties, Fundamental theorem of integral calculus. Applications to arc length, volume and surface area; Improper integrals. Limit and continuity of functions of several variables. Partial derivative and total differential. Composite functions; equality of mixed derivatives; Taylor's theorem; extrema and saddle points; implicit functions, Jacobian.

Solution of dy/dx = f(x, y); linear differential operator L, higher order ordinary differential equation with constant coefficients: Wronskian, solution space; Euler's equation; boundary value problem; initial value problem – existence and uniqueness theorem.

MAL115 Multivariable Calculus and Matrix Theory
4 credits (3-1-0)
Overlaps with: MAL110, MAL111
The Riemann integral definition and properties. The fundamental theorem of integral calculus, applications and improper integrals; Gamma function. Existence properties, Sequence and series of functions, Power series, Properties of functions represented by power series, Fourier series.

Scalar and vector valued functions of several variables: limits, continuity, partial derivatives, differentiability, Jacobian, Implicit differentiation, gradient and directional derivative, Taylor's theorem in one and several variables, maxima and minima, constrained extrema and Lagrange multipliers.

Multiple integrals: definitions, properties, evaluation and applications of double integrals (in Cartesian and polar coordinates) and triple integrals (Cartesian, cylindrical and spherical coordinates), line integrals, Green's theorem; Proof, first and second forms, Applications, Surface integrals, Gauss theorem; proof and extensions; Volume integrals, Stokes' theorem; Proof and applications.

Row reduced Echelon matrices, rank of a matrix, systems of linear algebraic equations, Eigen values and Eigen vectors. Diagonalization of matrices, Hermetian, Unitary and Normal matrices, Bilinear and Quadratic forms.

MAL120 Mathematics - II
4 credits (3-1-0)
Overlaps with: MAL122, MAL124
Vector Field Theory: Vector calculus, arc length, directional derivative, gradient, curl, divergence, line and double integral, Green's theorem, surface integral, triple integral, Gauss and Stokes' theorems with applications.

Complex analysis: Limit and derivative of a function, analytic function, Cauchy-Riemann equations, elementary functions, line integral, Cauchy's integral theorem, Cauchy's integral formula, derivatives of analytic function, convergence of sequence and series, power series, Taylor series, Laurent series, zeros and singularities, residues and residue theorem, evaluation of real integrals, Conformal mapping, Linear fractional transformations, mapping by elementary functions.

Fourier series, Fourier integrals and Fourier transforms.

MAL122 Real and Complex Analysis
4 credits (3-1-0)
Overlaps with: MAL120, MAL124
Metric spaces: Definition and examples, open, closed and bounded sets; closure, interior and boundary, convergence and completeness; Bolzano-Weierstass theorem, completeness of R, Continuity and uniform continuity, connectedness, compactness and separability.

Limits, continuity and differentiability of functions of a single complex variable, analytic functions, the Cauchy-Riemann equations. Definition of integral, Proofs of Cauchy's integral theorem, Integral formula and derivatives of analytic functions, Morera's and Liouville's theorems, Maximum modulus principle, Taylor's and Laurent series. Isolated singular points. Cauchy residue theorem: proof and evaluation of real integrals. Conformal and bilinear mappings.

MAL124 Introduction to Algebra and Matrix Analysis
4 credits (3-1-0)
Overlaps with: MAL120, MAL122
Group theory: Groups, subgroups, Normal subgroups, Factor subgroups, Lagrange theorem, Homomorphism and Isomorphism theorems, Permutation groups, Matrix groups, Abelian groups.

Rings and Fields, Ideals, Homomorphism, Euclidean domains, Finite and Infinite fields, Polynomial rings Matrix rings.

Linear Algebra and Matrix Theory: Vector spaces, subspaces, direct sums, bases and dimension, Linear transformation, Matrix of the linear transformation, Change of basis, Eigen values and Eigen vectors, The Characteristic and Minimal polynomials, Diagonalization.

Finite dimensional inner product spaces, Graham Schmidt orthogonolization process, Linear functionals, Adjoints of linear operators. Self-adjoint and normal linear operators. Normal linear spaces, Examples of Banach and Hilbert spaces.

MAL140 Probability and Statistics
4 credits (3-1-0)
Overlaps with: MAL220, MAL250
Probability, Conditional probability, random variables, expected value, Specific discrete and continuous distributions, e.g. binomial, Poisson, geometric, Pascal, hypergeometric, Uniform, exponential and normal, Poisson process, Multidimensional random variables, Multinomial and bivariate normal distributions, moment generating function, Law of large numbers and central limit theorem, Sampling distributions, Point and interval estimation, Testing of hypothesis, Goodness of fit and contingency tables. Linear regression.

MAL145 Number Theory
4 credits (3-1-0)
Congruences, Arithmetical functions, Theory of partitions, Diophantine approximations, Binary quadratic forms, diophantine equations, Distributions of primes.

MAL146 Combinatorics
4 credits (3-1-0)
Overlaps with: MAL147
Dilworth's theorem and extremal set theory, partitions, latin squares, Hadamard matrices and Reed-Muller codes, (0,1) matrices and min-max theorems, codes and designs, projective and combinatorial geometries, Polya's theory of counting.

MAL147 Combinatorial Mathematics
4 credits (3-1-0)
Overlaps with: MAL146
Elementary counting; Recursions and generating functions; Principle of

Inclusion and Exclusion; Inversion formula; Cayley's Tree theorem; Colourings of graphs; Ramsey's theorem; Basics of Ramsey numbers; Turan's theorem and external graph theory; system of distinct representatives and Hall's marriage theorem; Harems and tournaments.

MAN150 Introduction to Mathematics and Computing
2 credits (0-0-4)
Lecture-demonstrations to introduce the art of reasoning in the discrete world and illustrate the complexities of mathematical software development; hands-on experience with various mathematical and statistical software; interactive sessions with professionals from industry and R&D institutions.

MAL180 Discrete Mathematical Structures
4 credits (3-1-0)
Overlaps with: CSL105
Propositional Logic: Language of Propositional logic, truth table, natural deduction, Predicate logic: language of predicate logic, Logical inference with Quantifiers. Proof Techniques; Combinatorics: Counting techniques: recurrence relation and its application to analysis of algorithm; Basic Discrete Probability, probabilistic counting. Graph theory: Graph as a discrete structure, Modeling applications using Graphs, Hamiltonian graphs, Planar graphs, Graph coloring, Network flows, Matching. Algebra: Groups and Examples, Cosets and Normal subgroups, Lagrange theorem, cyclic groups, permutation groups, Finite Abelan groups, Homomorphisms, Matrix groups. Rings, Ideals, Firleds, Finite fields, Polynomial rings, Unique Factorization. Introduction to lattices and Boolean algebra.

MAL210 Optimization Methods and Applications
4 credits (3-1-0)
Pre-requisites: MAL110/ MAL111/ MAL115
Linear programming problem, SIMPLEX alorithm, duality, transportation and asignment problems. Integer linear programming problem, branch and bound and cutting plane methods. Karmarkar's algorithm for linear programming. Non-linear programming problem, Karush-Kuhn-Tucker conditions and duality in non-linear programming, Wolf's method for quadratic programming. Applications of linear, integer and quadratic programming to various areas of science and engineering. Fuzzy linear programming.

MAL220 Basic Probability and Statistical Inference
4 credits (3-1-0)
Pre-requisites: MAL110/ MAL111/ MAL120
Overlaps with: MAL140/MAL250
Probability space, Conditional probability, Random variable, distribution function, pmf and pdf, Standard probability distributions, multidimensional random variables, marginal and conditional probability distribution, independence of random variables, bivariate normal and multinomial distributions, functions of one and more random variables, Expectation, moments, and moment generating functions, correlation, moment inequalities, Markov and Chebychev inequality, conditional expectation and regression, random sums, convergence in probability, Weak Law of Large Numbers, Central Limit Theorem, Sampling Distributions, unbiased and consistent estimators, moment and maximum likelihood estimators, interval estimation, simple and composite statistical hypotheses, power of statistical test, standard statistical tests for population means, variances and proportions, Tests of goodness of fit and linearity of regression.

MAL230 Numerical Methods and Computation
4 credits (3-1-0)
Pre-requisites: MAL110/ MAL111/ MAL115
Errors in computation, instability. Nonlinear equation in one variable: direct and iterative methods, order of convergence. Iterative methods for systems of nonlinear equations. Linear systems of equations direct and iterative methods, rate of convergence of iterative methods, ill-conditionedness of systems and condition numbers. Interpolation: Lagrange, Newton divided difference formula, equispaced Newton's interpolations, errors in interpolation. Approximation: least square and uniform approximations. Differentiation: differentiation using interpolation

formulas. Integration using interpolation: Newton-Cotes formulas, Gauss quadrature rules. Ordinary differential equations: Taylor, Euler and Runge-Kutta formulas. Computer implementation of the methods.

MAL240 Algebra
4 credits (3-1-0)
Pre-requisites: MAL110/ MAL111/ MAL115/ MAL124
Definition and examples of group, rings and fields; Subgroups. Normal subgroups and factor groups, Isomorphism theorems. Sylow theorems of finite groups and applications, Fundamental theorem for finitely generated Abelian groups. Nilpotent and solvable groups.

Commutative rings, Prime ideals, Maximal ideals, Polynomial rings in several variables. Algebraic field extensions, Splitting fields, Finite separable and normal extensions, Fundamental theorem of Galois theory.

MAL245 Topology and Functional Analysis
4 credits (3-1-0)
Pre-requisites: MAL122
Basic concepts of toplogical spaces, continuous functions and homeomorphisms. Hausdorff, Tychonoff and normal spaces. Compactness and connectedness. Normed linear spaces and Banach spaces. Hahn-Banach Theorem, Open mapping theorem and Closed graph theorem. Principle of uniform boundedness. Hilbert Spaces, orthogonal complements and direct sums, othonormal sets. Reisz representation theorem, self adjoint, unitary and normal linear operators.

MAL250 Introduction to Probability Theory and Stochastic Processes
4 credits (3-1-0)
Pre-requisites: MAL110/ MAL111/ MAL115/ MAL120/ MAL122/ MAL124
Overlaps with: MAL140/MAL220
Axioms of probability, Probability space, conditional probability, independence, Baye's rule, Repeated trials, Bernoulli trials, Random variables: discrete r.v., probability mass functions, c.d.f., common distributions, continuous r.v., probability density and distributions of r.v., joint distributions, order statistics, expectation; moments, transforms, conditional expectations, stochastic processes, Markov chains and Markov processes (birth, death, etc.), Queuing models.

MAL255 Linear Algebra
4 credits (3-1-0)
Pre-requisites: MAL110/ MAL115
Overlaps with: EPL333, MAL124
Finite dimensional vector spaces over arbitrary fields. Linear independence, basis, dimension. Direct sum of subspaces. Linear transformations and their matrices. The minimal and the characteristic polynomials. Eigen values, eigen vectors and digonalization of linear transformations. The primary decomposition theorem. Rational and Jordan forms. Inner product spaces. Hermitian, unitary and normal linear operators. Spectral theorem and polar decomposition. Bilinear and quadratic forms. Digonalization of symmetric bilinear forms.

MAL256 Modern Algebra
4 credits (3-1-0)
Pre-requisites: MAL110/ MAL115/ MAL111
Overlaps with: MAL124
Monoids, Groups and Group actions. Lagrange's theorem, Cyclic groups. Linear Groups. Permutation groups. Isomorphism theorems. Automorphisms. Direct producta. Fundamental Theorem for Finitely Generated Abelian Groups. Sylow Theorems and their applications. Free groups. Rings and Fields. Principal ideal domains, Euclidean domains, Unique factorization domains. Polynomial rings, Modules over commutative rings. Field extensions. Splitting fields. Roots of unity and Cyclotomic field extensions.

Normal and separable field extensions. Galois theory. Basic concepts of categories and functors.

MAL260 Boundary Value Problems
4 credits (3-1-0)
Pre-requisites: (MAL110/ MAL111/ MAL115) & (MAL120/ MAL122/ MAL124)
Boundary Value Problems, existence and uniqueness of solution, shooting method, finite difference method, orthogonal set of functions, regular and singular Strum Liouville problems, Eigen function expansions, Green's functions, equivalent integral equations and numerical methods for their solution, analytic and numerical solution of BVPs in PDEs, Ritz Galerkin and Collocation Methods.

MAL270 Measure, Integral and Probability
4 credits (3-1-0)
Pre-requisites: (MAL110/ MAL111/ MAL115)
Measurable spaces, Measurable seats, Measurable functions, Measures, Outer Measures and Generation of Measures, Lebesgue Integration, Basic Integration Theorems, Comparison of Lebesgue and Riemann Integrals, Various Models of Convergence of Measurable Functions, Signed Measure, Hahn and Jordan Decomposition Theorems, The Radon-Nikodym Theorem, Product Measures and Fubini's Theorem, Probability Measures and Spaces, Independent Events and Random Variables, Conditional Probability, Expectation, Weak and Strong Laws of Large Numbers, Kolmogorov's Zero-One Law, The Lindeberg and Lyapounov Central Limit Theorems, Infinitely Divisible Distributions.

MAP290 System Design Laboratory
2 credits (0-0-4)
Pre-requisites: CSL101
Laboratory assignments on various topics covered in MA754 and MA715.

MAL311 Parallel Algorithms
4 credits (3-0-2)
Pre-requisites: MAL230
Parallel architecture: shared/local memory systems, pipelining, hypercubes, mesh toroidal, etc. Degree of parallelism, speed up (Sp) and efficiency (Ep) of a parallel algorithm. Parallel algorithms: Searching and sorting, prime finding algorithm, matrix vector and matrix – matrix multiplication for dense, band and triangular matrices. Parallel algorithms for direct methods for dense, band and triangular matrices. Choleski method solving recurrence relations. Parallel interactive methods for finite difference equations of elliptic boundary value problems: point-Jacobi, line Jacobi, block-Jacobi methods, 2-colour and multicolour Gauss-Seidel, SOR, SSOR methods. Domain decomposition method in one and two dimensions. Parallel preconditioned conjugate gradient methods. Quadrant interlocking factorization.

MAL335 Differential Equations: Theory and Numerical Methods
4 credits (3-1-0)
Pre-requisites: (MAL115/ MAL110/ MAL111) & (MAL120/ MAL122 & MAL230)
Overlaps with: EPL333
IVPs for scalar and system of ODEs, existence and uniqueness, method of solving higher order ode's with constant coefficients, Laplace transform and applications to IVPs, regular singular points , Frobenius method, regular and singular Strum Liouville problems. Numerical methods for solving IVPs: Difference equations, Routh-Hurwitz criterion, Test Equation. Single step methods: Taylor series method, explicit Runge-Kutta methods, convergence, order, relative and absolute stability. Multistep methods: Development of linear multistep method using interpolation and undetermined parameter approach, convergence, order, relative and absolute stability, Predictor Corrector methods.

MAL341 File Structures and Information Systems Design
4 credits (3-0-2)
Pre-requisites: CSL201
Secondary storage media, blocking, buffering, External sorting techniques, Concept of a file, primary key and secondary key, sequential, Indexed and relative file organizations. Updation of indexed sequential and random access files, Creation and Updation of relative files, dynamic hashing techniques, list structure, multiring and inverted files, grid files, etc. Introduction to concurrent operations on the structures.

MAL342 Analysis and Design of Algorithms
4 credits (3-1-0)
Pre-requisites: CSL201
Overlaps with: CSL356
Algorithm Fundamentals: space and time complexities, asymptotic notations, randomized algorithms; Basic Algorithms for Different Data Structures: linear, non-linear, priority queues, graphs and their analysis; Divide and Conquer Algorithms - Master theorem; Sorting Algorithms -lower bound, sorting in linear time; Greedy Methods - knapsack, minimum cost spanning trees, single source shortest paths, Huffman coding; Dynamic Programming - matrix multiplication, Travelling salesman, 0/1 knapsack; Search Techniques - depth-first, breadth first, heuristic search algorithms, backtracking and bounding; NP-completeness.

MAD35O Mini Project (MT)
3 credits (0-0-6)
Pre-requisites: EC 80
Design/fabrication/implementation work under the guidance of a faculty member. Prior to registration, a detailed plan of work should be submitted by the student to the Head of the Department for approval.

MAL353 Algebraic Methods in Computer Science
4 credits (3-1-0)
Pre-requisites: MAL124 / MAL180
Universal Algebra: Basic constructions, equationally defined classes of algebras, implicationally defined classes of algebras. Algebraic specifications of abstract data types, algebraic semantics of recursive programme schemes, applications of universal algebra to structural aspects such as syntax and semantics, data abstraction, etc. Group theoretical methods in computer science in general and in image processing, image understanding and computer vision in particular. Representation Theory of the classical groups SO(2), SO(3), and SU(2), and applications. Algebraic and projective invariants in computer vision.

MAL355 Partial Differential Equations: Theory and Computation
4 credits (3-1-0)
Pre-requisites: (MAL115/ MAL120 /MAL111) & (MAL230)
Theory : First order equations, Cauchy Kowalewski theorem.

Classification of second order equations. Characteristics, uniqueness theorems for hyperbolic equations with initial and boundary conditions, elliptic equations, Dirichlet and Neumann problems, Maximum and minimum theorem, Poisson's integral, Green's and Neumann's functions. heat equations.

Computation: Parabolic and hyperbolic equations, finite difference methods. Iterative methods, split operator methods, Convergence, stability and consistency of difference methods. Elliptic equations, Self adjoint elliptic equations and elliptic equations with mixed partial derivatives.

MAL358 Operating Systems
4 credits (3-0-2)
Pre-requisites: EEL308
Overlaps with: MAL708/EEL358/CSL373
Operating System components, process creation, management and scheduling in a multiprogramming, multiprocessing, and multitasking system; inter-process communication mechanisms, virtual storage; interactive and batch processing; file management facilities; distributed operating system design issues; load distribution in distributed operating systems; network file system management.

MAL365 Mathematical Programming Techniques
4 credits (3-1-0)
Pre-requisites: EC 60
Overlaps with: CSL856
Upper bound techniques, Fractional programming, convex programming, networks, Multi criteria decision making, Goal programming, Search and gradient methods, Complexity, Karmarkar's algorithm for linear programming, Game theory.

MAL373 Wavelet and Applications
4 credits (3-1-0)
Pre-requisites: EC 60
Fourier transform of square integrable functions, Riesz Fischer theorem, Integral wavelet transform, orthogonal bases of wavelets, multi resolution analysis, compactly supported wavelets, cardinal spline wavelets, fast wavelet transform, numerical algorithms, recent developments and applications.

MAL375 Programming Languages
4 credits (3-0-2)
Pre-requisites: CSL201
Overlaps with: CSL302
Language Definition and Processing - syntax, semantics, translation issues; Data abstraction - encapsulation, storage management, inheritance; Control constructs - sequence control, subprogram control, parameter passing, runtime structures and operating environments; Issues of Language Design - Chomsky hierarchy, features of imperative and functional languages, features of object -based languages; untyped and simply-typed Lambda calculus, Study of a functional language; Meta languages and SML, Logic Programming languages and Prolog.

MAL376 Graph Algorithms
4 credits (3-1-0)
Pre-requisites: CSL201
Overlaps with: CSL851, MAL468
Introduction to Graphs: Definition and basic concepts, Efficient representations of Graphs; Graph Searching: DFS and BFS; Application of Graph Searching: finding connected components, bi-connected components, testing for bipartite graphs, finding cycle in graph; Trees: Different MST algorithms, enumeration of all spanning trees of a graph;

Paths and Distance in Graphs: Single source shortest path problem, All pairs shortest path problem, center and median of a graph, activity digraph and critical path; Hamiltonian Graphs: sufficient conditions for Hamiltonian graphs, traveling Salesman problem; Eulerian Graphs: characterization of Eulerian graphs, construction of Eulerian tour, The Chinese Postman problem; Planar Graphs: properties of planar graphs, a planarity testing algorithms; Graph Coloring: vertex coloring, chromatic polynomials, edge coloring, planar graph coloring; Matching: maximum matching in bipartite graphs, maximum matching in general graphs; Networks: The Max-flow min-cut theorem, max-flow algorithm; NP-Complete Graph problems; Approximation algorithms for some NP-Hard graph problems; Algorithms for some NP-Hard graph problems on special graph classes.

MAL380 Numerical Linear Algebra
4 credits (3-1-0)
Pre-requisites: MAL230 & MAL255
Triangular form, Matrix norms, Conditioning of linear system, Singular value Decomposition, Direct Methods (Gauss, Cholesky, Householder), Iteartive methods (Jacobi,Gauss-seidel, relaxation) methods for solving linear systems. Linear least square problem. Computation of Eigen values and Eigen vectors (Jacobi, Givens, Householder, QR, Inverse methods), Conjugate gradient method and its pre-conditioning.

MAL381 Finite Element Theory and Applications
4 credits (3-0-2)
Pre-requisites: MAL245
Variational Formulation of elliptic boundary value problems; Lax Milgram. Lemma; existence and uniqueness of solutions; equivalence of Galerkin and Ritz variational formulations; Triangulations of ordinary domains - rectangles, polygons, circles, ellipses, etc. Finite element problems; conforming and non-conforming methods; Ce'a's Lemma, Interpolation on simplexes in Rn, different Lagrange and Hermite finite elements; Affine, isoparametric,sub-parametric, super parametric finite elements; Triangulation using isoparametric mapping; approximation of boundary; Numerical integration, construction of element stiffness matrices and assembly into global stiffness matrix, Skyline method of solution of finite element equations; Solution of model problems and computer implementation procedures; Asymptotic error estimate results; Eigenvalue problems of Laplace operator.

MAL382 Theory of Automata
4 credits (3-1-0)
Pre-requisites: CSL201
Overlaps with: CSL 705
Finite State Automata and regular languages. Structure of Recognizable sets. Sequential and linear sequential machines. Infinite Digital Computation. Pushdown automata: Context free languages. Linear bounded automata: Context sensitive languages. Turing machines: Recursive languages.

MAL390 Statistical Methods and Algorithms
4 credits (3-1-0)
Pre-requisites: MAL250
Mathematical methods and algorithms predominantly applied to statistical data drawn in social sciences with a desire to design of experiments.

MAC450 Colloquium (MT)
3 credits (0-3-0)
Pre-requisites: registered for MAT450
Students will present seminars on topics of their interest including one on the training taken in the previous summer.

MAT450 Practical Training (MT)
Non credit
Pre-requisites: EC 90 at the end of 5th sem.
Students will work for fifty working days to complete training in a research/industrial organization.

MAL465 Parallel Computing
4 credits (3-1-0)
Pre-requisites: MAL342
Introduction to Parallel Computing: Need, Scope, issues and motivation; Models of Parallel Computation: Taxonomy of Parallel Architectures-SIMD, MIMD; PRAM model of computation; Interconnection Networks: Tree, Hypercube, Mesh, etc, dynamic Interconnection Network; Routing and communication mechanisms for static interconnection networks; elementary Parallel algorithms: Parallel reduction, Parallel prefix sums, List ranking, preorder Tree traversal, Merging. Basic Communication Operations: point to point message transfer, broadcasting, all to all broadcasting, one to all and all to all personalized communication. Parallel programming Paradigm: Explicit versus implicit, shared address space versus Message Passing, data parallelism versus Control Parallelism; Introduction to Message passing Interface (MPI); Parallel Programming Using MPI; Performance and Scalability of Parallel Systems, Basic design techniques; Parallel Algorithms for matrix computation, sorting, graph algorithms, Mapping and scheduling.

MAL466 Multivariate Statistical Methods
4 credits (3-1-0)
Pre-requisites: MAL390
Multivariate Normal Distribution and sampling from it, Hotelling's T2 and Mahalanobis D2 statistics, Multivariate analysis of variance, Multivariate regression model, Discriminant function and classification problems, Canonical correlation, Analysis of covariance structures, Principal Component Analysis, Factor analysis, cluster analysis, pattern recognition.

MAL468 Graph Theory
4 credits (3-1-0)
Pre-requisites: EC 90
Overlaps with: EEL311, MAL376, CSL851
Introduction to Graphs: Definition and basic concepts; Trees: characterizations of trees, minimum spanning tree; Paths and Distance

in Graphs: distance in graphs, center and median of a graph, activity digraph and critical path; Hamiltonian Graphs: sufficient conditions for Hamiltonian graphs, traveling Salesman problem; Eulerian Graphs: characterization of Eulerian graphs, The Chinese Postman problem; Planar Graphs: properties of planar graphs, a planarity testing algorithms, dual graph, genus of a graph; Graph Coloring: vertex coloring, chromatic polynomials, edge coloring, planar graph coloring; Matching and Factorizations: maximum matching in bipartite graphs, maximum matching in general graphs, Hall's marriage theorem, factorization; Networks: The Max-flow min-cut theorem, max-flow algorithm, connectivity and edge connectivity, Menger's theorem; Graph representations; Graph searching: BFS, DFS. Basic Graph Algorithms: MST, shortest paths, biconnectivity, strong connectivity, etc.

MAL503 Linear Algebra
4 credits (3-1-0)
Overlaps with: MAL255
Vector spaces. Homomorphisms, Dual and double dual. Inner product spaces. Linear Transformations and Matrices., Eigen values and eigen vectors. Annihilating polynomials. Tringularization and diagonalization. The Primary Decomposition Theorem. The Rational and Jordan Canonical Forms. Semi-simple operators. Unitary and Normal Operators. Spectral Theory of normal operators on finite dimensional vector spaces. Bilinear forms and groups preserving bilinear forms.

MAL509 Probability Theory
4 credits (3-1-0)
Overlaps with:MAL250
The objective of this course is to understand the theory of probability. And also, to give a concise account of the fundamental concepts of probability theory so as to probe into topics like random variables, distributions, characteristic functions and various modes of convergence.

Probability as a set function, Borel-field and extension of probability measure. Random variables as Borel measurable functions. Distribution function. Multi-dimensional random variables. Conditional probability and statistical independence. Moments, correlation and regression. Characteristic function, uniqueness and inversion theorems.

Convergence of sequence of random variables and various modes of convergence. Laws of large numbers. Central limit theorem, Liapunov's and Lindeberg-Feller's theorem, Law of iterated logarithm.

MAL513 Real Analysis
4 credits (3-1-0)
Train the students for a first Course in Analysis and Lebesgue Integration 1. Metric spaces, continuous andUniformly continuous functions. Bounded, Totally , Compact sets Heine Borel theorem. Completeness,Cantor's Intersection Theorem, Baire spaces. 2. Measureable spaces, Lebesgue integration, Faton's Lemma, Montone Convergence theorem, Riemann Integral as Lebesgue integral. 3. Functions of several variables, differentiability partial derivatives, Jacobian, Inverse function theorem Implicit Function theorem.

MAL514 Complex Analysis
4 credits (3-1-0)
Study of functions of a single Complex variable.

MAL516 Algebra
4 credits (3-1-0)
This is a basic core course for any student in M. Sc. (Mathematics). Review of groups and rings. The Transformation groups.. Polynomial rings, Principal ideal domains. Unique factorization domains, Prime fields and the Euclidean algorithm.Modules, Free Modules, Bi-products and the dual modules. Noetherian modules, cyclic primary modules. The decomposition theorem. Application to Abelian groups. The Sylow heory, nilpotent and solvable groups.Galois theory. Splitting fields, Normal extensions. The fundamental theorem of Galois theory.

MAL517 Differential Equations
4 credits (3-1-0)
Overlaps with:MAL235
To use Calculus in solving differential equations and also to give a concise account of fundamental concepts of existence, uniqueness, stability and qualitative properties of solutions.

Initial value problems, theorems on existence, uniqueness and continuous dependence of solutions on initial data, general theory of linear differential systems, Sturms theory on separation and comparison properties of solutions, Power series method, regular singular points, General existence and uniqueness theorems for nonlinear ODE, Boundary value problems, Green functions, Sturm-Liouville problems, autonomous systems and concepts of stability.

MAL518 Methods of Applied Mathematics
4 credits (3-1-0)
To use students knowledge in basic analysis, calculus and Linear algebra to solve some interesting problems in Applied sciences and mechanics.

Expansion in eigenfunctions, Fourier series and Fourier integral, orthogonal expansions, mean square approximation, completeness, orthogonal polynomials, and their properties, integral transforms and their applications, linear functional, general variation of a functional, direct variational methods for solution of boundary value problems, integral equations of voltera and Fredhlom type, seperable and symmetric kernels, Hilbert-Schmidt theory, singular integral equations, approximate methods of solving integral equations.

MAL519 Introduction to Computers and Programming
4 credits (3-0-2)
To teach the students basics of computer programming Introduction to Computers – CPU, ALU, I/O devices, Introduction to C Programming – data types , variables, statements, iterative statements, functions, procedures, passing arguments to procedures, pointer variables, file handling, concept of recursion. Introduction to C++.

MAL522 Statistical Inference
4 credits (3-1-0)
Mathematics of statistical estimation and testing, inferences about population characteristics.

Sampling distributions, Order statistics, The sufficiency principle, the invariance principle and the likelihood principle of data reduction, minimal sufficiency, ancillary statistics, complete statistics. Point estimation, Blackwell-Rao theorem, Cramer-Rao inequality, efficiency and consistency, methods of point estimation. Set estimation, uniformly most accurate and shortest length interval estimators. Tests of hypothesis, Neyman-Pearson theory, monotone likelihood ratio, uniformly most powerful tests, unbiased and invariant tests, similar tests. Likelihood ratio tests. Standard tests.

MAL524 Numerical Analysis
4 credits (3-1-0)
To discuss some of the central problems which arise in application of mathematics, to develop p constructive methods for the numerical solution of these problems, and to study the associated questions of accuracy. Approximation and algorihms. Interpolation: Lagrange Interpolation Newton's divided difference interpolation. Finite differences. Hermite Interpolation. Numerical differentiation. Numerical Integration: Newton cotes formulas, Gaussian Quadrature composite quadrature formulas Approximation: Least squares approximation, minimum maximum error techniques. Legendre and Chebyshev polynomials. Solution of Nonlinear equations: Fixed point iteration bisection, secant Regula-Falsi, Newton-Raphson methods, Bairstows and Graiffs's root squaring Method. System of nonlinear equation. Solution of linear systems: Direct methods, Gauss elimination, LU

and Cholesky factorizations. Iterative methods – Jacobi, Gauss-Seidel and SOR methods. Eigen-Value problems: Power and Inverse power method. Jacobi, Giveres and Householder methods for symmetric eigenvalue problem. Numerical Solution of ODE. Taylor series, Euler and Runge-Kutta methods.

MAL526 Computer Oriented Operation Research
4 credits (3-0-2)
Pre-requisites:MAL513
Overlaps with:MAL245
To discuss the theory and algorithms for solving linear programming problems systematically and to study its various applications in other related areas like integer programming and networks Linear Programming, Transportation and Assignment Problems, Integer Programming, Sequencing Theory, Dynamic Programming, Theory of games, Network Analysis, Introduction to Nonlinear programming.

MAL601 Topology
4 credits (3-1-0) redits (3-1-0)
Pre-requisites: MAL513
Overlaps with:MAL245
Train the students for a first Course on Point Set Topology. 1.Topological spaces, base and subspace. Countability axioms, separation axiom, 2. Continuity, homeomorphism, Compactness, connectedness, Paracompactness, 3.Metrization Theorems embedding theorems, 4.Function spaces, 5.Homotopy, Fundamental group.

MAL602 Functional Analysis
4 credits (3-1-0)
Pre-requisites: MAL601,MAL514
Overlaps with:MAL245
Basic functional Analysis Link.

Between Algebra Analysis. Same as listed in the courses of study.

MAL607 Mathematical Logic
4 credits (3-1-0)
To familiarize the student with. modern algebraic techniques in logic and its applications to computing Proposition calculus, truth proof, adequacy, decidability Predicate Calculus, soundness, deduction theorem, consistency completeness, models, Godels completeness and incompleteness Theorem Turing machines and undecidability of Predicate calculus. Gentzen systems, Natural deduction, Applications to Computer Sciences.

MAL609 Basic Computer Science
4 credits (3-0-2)
To continue developing a disciplined approach to the design, coding and testing of programs written in a high-level language, to introduce basic data structures other than those normal provided as basic types in current programming languages; for example, linked lists, stacks, queues and trees to provide an understanding of the different implementations of these data structures, to introduce the analysis of algorithm and role of data structures in algorithm analysis. To introduce searching and sorting algorithms and their analysis. To introduce various algorithm design paradigms; for example, Greedy, Divide and Conquer, Dynamic Programming etc. Introduction to algorithms; Definition, Pseudo code; concepts of analysis of algorithms; Time complexity, space complexity, worst-case, average-case, big Oh and other notatons; Recursion and recurrence relation; Introduction to basic data structures; Stack, Queue, Linked list, Trees, Binary trees. Sorting and searching algorithms; algorithm design techniques: Greedy, divide and conquer, Dynamic programming, Backtracking and branch and bound.

MAL611 Principles of Fluid Mechanics
4 credits (3-1-0)
To use students knowledge in geometry and differential equations to solve basic fluid mechanics problems and to give a concise account of basic concepts of Fluid Mechanics and some application in Engg.

MAL614 Advanced Matrix Theory
4 credits (3-1-0)
To provide indepth knowledge about special topics in Matrix   Theory that are very useful in applications of Science and Engineering.

Review of Linear Algebra;   Matrix calculus, Diagonalization,   Canonical forms and invariant   Factors. Quadratic forms, Courant-Fischer minimax and related Theorems. Perron-Frobenius theory, Matrix stability, Inequalities g-inverses. Direct, iterative, projection and rotation methods for   solving linear systems and eigenvalue problems. Applications.

MAL617 Combinatorial Methods
4 credits (3-1-0)
Introduction of combinatorial   methods and techniques   Basic combinatorial methods; Recurrence relations and generating functions; Latin squares and SDRs; Extremal set theory, Steiner Triple systems, Ramsey's Theorem.

MAL621 Computational Methods for Ordinary Differential Equations
4 credits (3-1-0)
To bridge theory and practice providing sufficient theory to motivate the various methods and algorithms, yet devoting considerable attention to the practical   capabilities of the method for Numerical Solution of Ordinary Differential Equations.

Initial value problem for the systems of ODE's. Single step methods, Explicit and implicit, R-K methods. Linear multistep methods, Conver-genece, order, consistency and zero stability, weak stability theory, Predictor-Corrector methods. Hybrid methods. Extrapolation methods. First order systems and stiffness. LMM for special second order ODEs. Two point boundary value problem for ODEs. Finite difference method Spline methods, deffered correction and extrapolation. Methods for Sturm-Liouville problems. Computer implementation of Algorithms.

MAL630 Partial Differential Equations
4 credits (3-1-0)
To use students knowledge in Multivariable calculus in solving Partial differential equations and also to give a concise account of fundamental concepts of existence, uniqueness and qualitative properties of strong and weak solutions. Linear, quasi linear and general first order equations, Cauchy problem, Method of   characteristics, Cauchy-Kowalevsky theorem, Second order equations: Elliptic, parabolic and hyperbolic equations, Duhamel's principle, method of spherical means, Maximum principles, Perron's method, Green's function, Definition and existence of weak solutions, Eigen value problems.

MAL638 Applied Nonlinear Programming
4 credits (3-1-0)
To give concise theory of non linear programming in elementary but rigorous manner and to develop skill in using this theory to solve non linear problems.

Review of simplex methods, Revised simplex method and decomposition principle for linear programming, Kuhn-Tucker conditions, methods for solving quadratic and convex programming problems, separable programming, fractional programming, Geometric programming, Multi objective programming, variations methods.

MAL656 Graph Theory
4 credits (3-1-0)
Graph is one of the important mathematical   models in modeling several applications in computer science and engineering. The course aims at presenting a rigorous introduction to the theory of graphs. The course also emphasizes the role of graph theory in modeling applications in computer sciences and solving these applications using graph algorithms. Introduction to Graphs, Definition and basic concepts, Trees; characterizations of trees, minimum spanning tree; Paths and distance in Graphs: distance in graphs, center and median of a graph, activity digraph and critical path; Hamiltonian Graphs; sufficient conditions for Hamiltonian graphs, traveling salesman problem; Eulerian raphs;characterization of Eulerian graphs, The Chinese Postman

problem; Planar Graphs: properties of planar graphs, a planarity testing algorithms, dual graph, genus of a graph; Graph coloring: vertex coloring chromatic polynomials, edge coloring, planar graph coloring; Matching and Factorizations: maximum matching in bipartite graphs, maximum matching in general graphs, Hall's marriage theorem, 'factorization; Networks: The Max-flow min-cut theorem, max-flow algorithm, connectivity and edge connectivity, Menger's theorem; Graph representation; Graph searching: BFS,DFS Basic Graph Algorithms: MST, shortest paths, biconnectivity, Strong connectivity, etc.

MAL658 Programming Languages
4 credits (3-1-0)
To import object oriented programming concepts in C++ and JAVA Concepts of object-oriented . computing. Introduction to Object Oriented Systems Design and Analysis, Programming C++ and JAVA. Introduction to Web Programming.

MAL701 Introduction to Programming and Data Structures
3 credits (3-0-2)
Definition of a programme. Programming methodology. Concepts of structured programming. Definitions and operations on arrays, stacks, queues, lists, trees. Evaluation of arithmetic expressions using stacks. List representation. Recursive and non-recursive definitions of tree structures. Operations using recursive and non-recursive algorithms. Forests. Simple searching and sorting algorithms. Hashing techniques.

MAP701 Computing Laboratory
2 credits (0-0-4)
The objectives of the course are to (i) familiarize the students with the working of mathematical software likes MATHEMATICA, STATISTICA, MATLAB, UNIX Commands and other IDEs and (ii) provide hands on experience with programming on/matrix computation (Laboratory/ design activites could also be included) Programming Assignments using MATHEMATICA, STATISTICA, MATLAB And UNIX Commands Computing assignments to be chosen from the following topic Matrix Computation: Matrix multiplication: traditional matrix multiplication Algorithm, Strassen's algorithm; solving systems of linear equations; inverting Matrices; symmetric positive definite matrices and least squares approximation.

Non-singular Varieties, Tangent Spaces, Jacobian Criterion. Elliptic Curves Zariski's Main Theorem and related topics.

MAL702 File System and Data Management
3 credits (3-0-0)
Definitions. Basic hardware parameters. Blocks and buffer storage architecture. Basic file organisations : sequential, Relative indexed, index- sequential, direct multiring. Hybrid file organisations : simple, tree structured, multilevel indexing, index-sequential implementation, hierarchical structures, complex ring organizations, virtual storage. Techniques of file system evaluation : cost, benefits, usage. Introduction to programming in Cobol, Creating and updating of Indexed & Relative files.

MAP702 Computing Laboratory
2 credits (0-0-4)
To develop in depth knowledge in mathematical software like MATHEMATICA, STATISTICA, MATLAB, UNIX and continue the work done in MAP 701.

MAD703 Project Part 1
4 credits (3-1-0)
To encourage the students to do some innovative work in one of the areas of Mathematics, viz. Pure Mathematics, Applied Mathematics, Statistics, Operations Research, and Computer Science.

MAL703 Numerical Algorithms for Parallel Computing
3 credits (3-0-0)
Current trends in the development and analysis of software in parallel computing. Parallel algorithms in computational linear algebra, large sparse systems, finding roots of polynomials, two-point boundary-value problems, partial differential equations, etc.

MAD704 Project Part 2
4 credits (0-0-8)
To encourage the students to continue the innovative work done in Project Part-1 in one of the areas of Mathematics, viz. Pure Mathematics, Applied Mathematics, Statistics, Operations Research, and Computer Science.

MAL704 Numerical Optimization
3 credits (3-0-2)
Algorithms and complexity, the classes P and NP. NP complete problems. Simplex method for linear programming and its computational complexity: Karmarkar's projective scaling algorithm. Unconstrained optimization: basic descent methods, conjugate direction methods and quasi-Newton methods. Constrained optimization: primal methods, penalty and barrier methods, cutting plane and dual methods. Parallel algorithms for numerical optimization. Optimization and Neural Networks.

MAL705 Discrete Mathematical Structures
3 credits (3-0-0)
Sets, functions, and relations; equivalence relations, partial orders and tolerance relations. Counting techniques; number representations to a base, elementary combinatorics. Graphs and trees. Algebraic structures : monoids, groups, semirings, rings, modules, vector spaces and algebras. Universal algebra, categories and functors. Ordered structures : lattices, Heyting algebras and Boolean algebras. Conventional computing logic : sentential and predicate calculi : adequacy, compactness, consistency and completeness.

MAP706 Scientific Software Laboratory
3 credits (0-0-6)
Implementation/development of scientific software.

MAP707 Programming Languages Laboratory
2 credits (0-0-4)
Development and implementation of programs using high level languages.

MAL708 Computer Organization and Operating Systems
4 credits (3-0-2)
Information representation and binary arithmetic; Basic combinational and sequential circuit design; RTL representation; subsystems of a computer; instructions and their formats; assembly programming; CPU organizations; micro-programming; memory organization; I/O structures; interrupt, DMA; Overview: functions of Operating systems, layered architecture; basic concept; interrupt architecture, system calls and notion of a process and threads; synchronization and protection issues; scheduling; memory management including virtual memory and paging techniques; i/o architecture and device management; file systems.

MAL710 Database Management Systems
4 credits (3-0-2)
Pre-requisites: CSL201
Overlaps with: CSL332/CSL771
Introduction to database concepts: data independence, consistency, security and integrity; Relational Algegra and Relational Calculus; Query languages; Database design: Functional dependencies, Normal forms, Decomposition of Relations; Indexing, Physical design, Transactions and concurrency control: Schedules and serializability, concurrency control techniques, locking mechanisms; Recovery and security: Types of failures and recovery manager, Transaction logging and checkpointing; Concepts of Object oriented data bases; Introduction to Distributed databases.

MAL711 Algorithmic Combinatorics
3 credits (3-0-0)
Analysis of algorithms, complexity theory, graph theory algorithms : topological sort, connectivity, matching, min-max flow, planarity. Algebraic algorithms : Strassen algorithm, fast Fourier transforms, power series multiplication, division.

MAL712 Numerical Analysis of Differential Equations
3 credits (3-0-0)
Solution of initial-value problems of systems of ODEs. Single step and multistep methods, convergence and stability analysis, choice of an algorithm and its computer implementation. Finite difference methods for the solution of two-point boundary-value problems and eigenvalue problems. Elliptic, parabolic and hyperbolic partial differential equations, covergence and stability analysis. Computer implementation.

MAL713 Matrix Computation
3 credits (3-0-0)
Direct solution of linear systems : Gauss elimination, triangular decomposition, effects of round-off errors norms, condition numbers, inverses of perturbed matrices, accuracy of solution of linear systems, iterative refinements. Orthogonal triangularization. Eigenvalues and eigenvectors, similarity transformations, sensitivity of eigenvalues and eigenvectors, singular value decomposition. The Q-R algorithm, Hessenberg and triangular forms, the power and inverse power methods. Explicitly and implicitly shifted Q-R algorithms, computing singular values and vectors. The generalized eigenvalue problem. Sparse systems.

MAL714 Finite Element Techniques and Computer Implementation
3 credits (3-0-0)
Finite element formulations of different boundary value problems of elliptic PDEs. Element topology generation on computers: triangulation of domains, semi-automatic and automatic mesh generation. Different finite elements : affine and isoparametric elements. Numerical integration on triangles and rectangles. Element stiffness matrices for different elements. Different schemes of assembly and computer storage of global stiffness matrix. Computer programs for equation solvers; frontal technique and its computer implementation. Solution of a two-dimensional model problem.

MAL715 Statistical Computing
3 credits (3-0-0)
Fundamentals of sampling theory. Computer applications involving the sample size determination, statistical decision-making, computer packages for tabulating the various distributions of statistical decision-making. Correlation and regression. Experimental design : programs for analysis of variance in one way and two way design, multivariate data analysis.

MAL715 Digital Image Processing
4 credits (3-0-2)
Pre-requisites: CSL201
Overlaps with: EEL715/CSL783/PHL756
Digital image fundamentals - representation, monochrome, and colour models, image sampling and quantization, Image transforms, Image representation by stochastic models, Image enhancement techniques, Image restoration, Image Analysis - edge detection, segmentation, Scene representation and description, Object recognition and image interpretation. Image compression.

MAL716 Theory of Automata and Formal Languages
3 credits (3-0-0)
Rewriting systems, grammars and automata: deciding, accepting and generating. Regular languages and finite-state automata, context-free languages, push-down automata and tree-automata, context-sensitive languages, recursive sets and Turing machines. Formal languages in theoretical biology. Developmental languages. Tesselation automata.

MAL717 Fuzzy Sets and Applications
4 credits (3-1-0)
Pre-requisites: EC 90
Fuzzy sets as model for non-deterministic reasoning, logic and mathematical formalisms, fuzzy theory and algebraic theories, applications to: automata theory, decision theory, logic, dynamical systems, theory of computation, optimization.

MAL718 Computational Fluid Dynamics
3 credits (3-0-0)
Equations for incompressible planar flows, stream functions and vorticity equations, conservative form, normalising systems, transport equations. Methods for solving vorticity transport equations, stability analysis : one-step explicit methods, implicit methods, multistep explicit methods, ADI methods, ADE methods. Transporative and conservative differencing. Methods for solving stream function equations : direct methods, Richardson's methods and Leihman's methods. SOR method. Fourier series method. Numerical treatment of boundary conditions for the vorticity and stream function equation. Basic computational methods of compressible flows, methods using explicit and implicit artificial viscosities. Programming, testing and information processing of numerical methods.

MAL720 Neurocomputing and Applications
3 credits (3-0-0)
Pre-requisites: EC 90
Overlaps with: EEL781
Biological and Artificial Neuron, Perceptron model, Adaline model, Different types of Activation functions, Learning Techniques: Supervised and Unsupervised, Multilayered feedforward networks, Back-propagation algorithm and its improvements, Applications of Back-propagation algorithm to Statistical Pattern Recognition, classification and regression problems, Advantages of Neural Networks over statistical classification techniques, Recurrent networks, Radial Basis Function Networks as an interpolation model, Time delay neural networks for forecasting problems, Probabilistic Neural Networks, Kohonen's self-organizing maps with quadratic functions and its applications to medical imaging, Adaptive Resonance Theory model, Applications of Art model for knowledge acquisition, Extensive sessions in MATLAB for solving problems.

MAL724 Cryptology
3 credits (3-0-0)
Mathematics of secure communications, secure communications and crypto-complexity, crypto-systems based on Knapsack problem, public key crypto-systems, algorithms for encryption and decryption, RSA systems, some applications of number theory and algebraic coding theory to cryptosystems. Recent advances in cryptology.

MAL725 Stochastic Processes and Applications
4 credits (3-1-0)
The objective of this course is to apply theory of stochastic processes to gain insight into the problems arise in queueing theory, reliability analysis and financial mathematics. Queueing theory and reliability analysis are introduced and studied; used for the analysis and evaluation of computer and communication systems. Stochastic problems arise in financial mathematics are also studied. Different solution methods (such as analytical and numerical) are used to evaluate these models and to gain insight into the behavior of the above stochastic systems. Stochastic processes, classifications, discrete and continuous time Markov chains, Poisson processes, renewal processes, Little's formula, martingales, Brownian motion Erlangs loss system ((M/M/m/m-queue), finite source population, M/M/1-queue; M/M/m-queue, multidimensional queues. M/G/1-queue, GI/M/1-queue, GI/G/1-queue, bulk queues, priority queues, solution techniques, steady state and transient analysis, performance measures.

MAL726 Principles of Optimization Theory
4 credits (3-1-0)
Elements of convex analysis, Karush-Kuhn-Tucker conditions, Convex opitimization, Nonsmooth optimization, Conjugate functions and Fenchal

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duality, Fractional programming, Nonlinear Lagrangian and nonconvex duality, Monotone and generalized monotone maps.

MAL727 Applied Multivariate Data Analysis
4 credits (3-1-0)
To give a concise account of the multivariate statistical technique and use these for data analysis. Multivariate data and multivariate statistics, Principal component analysis, Cluster analysis, The generalized linear model, Regression and analysis of variance, Discrimination and classification, Factor analysis, Minor component analysis, Independent component analysis.

MAL728 Category Theory
4 credits (3-1-0)
To introduce the student to category theory which serves to unify the concepts distributed across various pure and applied branches of mathematical sciences. This will enable the student to access contemporary thinking in a number of subjects in mathematics and computer sciences.

    i)   Categories, functors, natural transformations, 2-categories.
    ii)   Adjoint functions, monads, Kleisli construction.
    iii)   Closed categories, and toposes.
    iv)   Allegories.
    v)   Applications to theoretical computer science.

MAL729 Computational Algebra and its Applications
4 credits (3-0-2)
To update knowledge and empower students with the advanced computations in modern algebraic structures and their applications in coding theory, cryptography apart from mathematics.

Applying the corresponding algorithms /programmes. (laboratory/design activities could also be included).

Finite fields: Construction and examples. Polynomials on finite fields and Their factorization/irreducibility and their application to coding theory Combinatorial applications. Symmetric and Public key cryptosystems particularly on Elliptic curves. Combinatorial group theory: investigation of groups on computers, finitely presented groups, coset enumeration. Fundamental problems of combinatorial group theory. Coset enumeration, Nielsen transformations.

Braid Group cryptography. Automorphism groups. Computational methods for determining automorphism groups of certain finite groups. Computations of characters and representations of finite groups. Computer algebra programs. Computations of units in rings and group rings. Calculations in Lie algebras.

MAL730 Cryptography
4 credits (3-1-0)
To update knowledge in modern cryptosystems their analysis and applications to other fields. Course contents Applying the corresponding algorithms/ programmes. (laboratory/design activities could also be included) Classical cryptosystems, Preview from number theory, Congruences and residue class rings, DES- security and generalizations, Prime number generation. Public Key Cryptosystems of RSA, Rabin, etc. their security and cryptanalysis. Primality, factorization and quadratic sieve, efficiency of other factoring algorithms. Finite fields: Construction and examples. Diffie-Hellman key exchange. Discrete logarithm problem in general and on finite fields. Cryptosystems based on Discrete logarithm problem such as Massey-Omura cryptosystems. Algorithms For finding discrete logarithms, their analysis. Polynomials on finite fields and Their factorization/irreducibility and their application to coding theory. Elliptic curves, Public key cryptosystems particularly on Elliptic curves. Problems of key exchange, discrete logarithms and the elliptic curve logarithm problem. Implementation of elliptic curve cryptosystems. Counting of points on Elliptic Curves over Galois Fields of order 2^m. Other systems such as Hyper Elliptic Curve And cryptosystems based on them. Combinatorial group theory: investigation of groups on computers, finitely presented groups, coset enumeration. Fundamental problems of combinatorial group theory. Coset enumeration, Nielsen and Tietze transformations. Braid Group

cryptography. Cryptographic hash functions. Authentication, Digital Signatures, Identification, certification infrastructure and other applied aspects.

MAL731 Introduction to Chaotic Dynamical Systems
4 credits (3-1-0)
The aim is to introduce students to current research in chaotic dynamical System.

We begin with an analysis of the dynamic of one-dimensional maps of both the interval and the circle. Topics to be covered include chaos, elementary bifurcations. Darkovski's theorem Schwarzian derivative symbolic dynamics and chaotic behaviour. Midway we discuss higher dimensional dynamics, including special examples like horse shoe and Henon attraction.

The latter part will be devated to special topics like tent map, logistic functions, Cellular automaton.

MAL732 Financial Mathematics
4 credits (3-1-0)
Some Basic Definitions and Terminology; Basic option theory: single and multi-period binomial pricing models, Cox-Ross-Rubinstein (CRR) model, Black- Scholes formula for option pricing as a limit of CRR model; Brownian and Geometric Brownian motion, Theory of Martingales. Stochastic Calculus, Stochastic differential equations, Lto's formula to solve SDE's. Feymann-Kac theorem. Applications of stochastic calculus in option pricing. Black-Scholes partial differential equation and Black-Scholes formula.

MAL733 Stochastics of Finance
4 credits (3-1-0)
Stochastic Processes; Brownian and Geometric Brownian motion; Conditional Expectation and Martingales; Stochastic Integrals, Ito's formula; Stochastic Differential Equations; Girsanov Theorem and Feymann-Kac theorem; Applications of stochastic calculus in finance, Option pricing and Interest Rate Derivatives.

MAL734 Algebraic Geometry
4 credits (3-1-0)
To expose the students to the fundamentals of Algebraic Geometry which is currently one of the most important subject in Mathematics.

Commutative Algebra: Hilbert Basis Theorem and Applications, Localisation, Integral Extensions, Polynomial rings in several variables. Affine Varieties: Affine algebraic sets, Regular functions, Irreducible algebraic sets, Affine Varieties. Examples, Curves and surfaces. Projective Varieties. Fundamental concepts on Morphisms and Products.

Non-singular Varieties, Tangent Spaces, Jacobian Criterion. Elliptic Curves Zariski's Main Theorem and related topics.

MAL735 Number Theory
4 credits (3-1-0)
To introduce students to the basic concepts in the Theory of Number, amalgamating classical results with modern techniques using algebraic and analytic concepts.

Congruences: Some elementary properties and theorems, linear and systems of linear congruences, Chinese Remainder Theorem, quadratic congruences, Quadratic Reciprocity Law, Primitive roots.

Some elementary arithmetical functions and their average order, Mobius Inversion formula, Integer partitions, simple continued fractions, Definite and Indefinite Binary Quadratic Forms some Diophantine equations.

MAL736 Information Integrity
4 credits (3-1-0)
Pre-requisites: EC 90
Information Integrity, concepts and definitions; direct integrity and its mechanism; modeling information error; system's view of Information Integrity; open system view of business enterprise system; business process IS view as integral to close loop information and control system and as information origination process; information envelope, uncertainties therein, error Implications and loss of Information Integrity; inadequacy of existing integrity mechanisms; criticality of

Information Integrity for efficient and economic processing of information in IS view; Usefulness- Usability - Integrity paradigm; cost benefit analysis of Information Integrity; mathematical equations for information value and for improvement of Information Integrity; design basis for Information Integrity analyzer and controller.

MAL737 Differential Geometry
4 credits (3-1-0)
Pre-requisties: EC 90
To introduce the students to geometry of hypersurfaces. Curves in plane and space, curvature, isoperimetric inequality, sufraces in three dimensions, First fundamental form, curvature of surfaces, Geodesics, Gauss's Theorem.

MAL740 Queueing Networks for Computer of Communication Systems
4 credits (3-0-2)
Stochastic processes, classifications, discrete and continuous time Markov chains, Poisson processes, renewal processes, Little's formula.

Erlangs loss system (M/M/m/m-queue), finite source population, M/M/1-queue; M/M/m-queue, multidimensional queues.

M/G/1-queue, GI/M/1-queue, GI/G/1-queue, bulk queues, priority queues.

Open (Jacksons) queueing networks; closed queueing networks, mean value analysis (MVA), time reversibility, Burke's theorem.

Solution techniques, steady state and transient analysis, Petri nets, discrete event simulation, performance measures.

Applications of above queueing systems in availability, reliability, computer systems, communication systems such as wired, wireless and mobile ad hoc networks.

MAL741 Fractal Geometry
4 Credits (3-1-0)
Pre-requisites: EC90
Code spaces, Hausdorff metric, Hausdorff measures, fractal dimensions, Hausdorff dimension, box – counting dimensions, groups and rings of fractal dimension, semigroups of iterated function schemes (IFS) and self-similarity, Cantor sets, Cantor dusts, Koch Snowflake, Sierspinski's triangle, Diophantine approximation, chaos games, attractors, fractals, superfractals and multifractal measures, Mandelbrot and Julia sets, random fractals, fractals in Brownian motion.

MAL745 Software Engineering
4 credits (3-0-2)
Pre-requisites: CSL201
Overlaps with: CSL740
An introduction to software life cycle models; analysis, design, coding and testing methods, software size estimation; cost and schedule estimation; project management; risk management; formal technical reviews; configuration management and change control; and software reliability estimation. Emphasis on large development projects.

MAL754 Principles of Computer Graphics
4 credits (3-0-2)
Pre-requisites: CSL201
Overlaps with: EEL754/CSL781
Overview of Graphics Systems, Output primitives and their attributes, Geometric primitives in 2D, 2D transformations, 2D viewing, Clipping, Geometric primitives in 3D, 3D Object representations, 3D transformations, 3D viewing, GUI primitives, Computational geometry topics – Binary space partitioning trees, Triangulation, Polygon partitioning, Visible surface detection, Surface rendering, Illumination models, Basics of computer animation.

MAL755 Algebraic Geometry
4 credits (3-1-0)
Pre-requisites: MAL124 / MAL255
Polynomials in one and several variables with coefficients in an arbitrary field. Affine space and affine varities. Parametrizations of affine varities. The Hilbert basis theorem and Groebner bases. The geometry of cubic curves. The theory of plane curves. Sphere with handles. Functions and differentials on a curve, surfaces and hyper surfaces. Resolution of singularities of algebraic surfaces. Hilbert's nullstallensatz. Radical ideals and the ideal varieties correspondence. Zariski topology. Irreducible varities and prime ideals. Decomposition of a variety into irreducibles. Symmetric polynomials and introduction to invariant theory. Projective algebraic geometry. Projective spaces and and projective varieties. Homogeneous coordinates. Projective planes. Intersections of projective curves. Projective invariants.

MAL760 Advanced Algorithms
4 credits (3-0-2)
Pre-requisites: MAL342
Overlaps with: CSL758
Algorithm with advanced data structures: R-B tree, B-tree, Splay Tree, disjoint set forest, Binomial heap, Fibonacci heap, interval tree. Randomized algorithms: Search trees, sorting, skip lists. Advanced graph algorithm: Graph matching algorithms, Network flows, Random graphs. String/vector matching algorithm: Rabin Karp algorithm, string matching with FSA, KMP – algorithm, Boyce+Moore, Dynamic programming algorithms. NP completeness: Basic concepts, NP completeness and reducibility, Cook's theorem, Examples of NP – complete problems. Approximation Algorithms: Vertex-color problems, set-covering problem, subset-sum problem.

MAL780 Special Topics in Computer Applications
4 credits (3-0-2)
Pre-requisites: EC 90
Topic and course contents will be announced before registration by the concerned faculty.

MAL782 Data Mining and Knowledge Discovery
4 credits (3-0-2)
Pre-requisites: MAL342 & MAL372
Introduction to Data Mining, Data Cleaning and transformation, Data Warehousing architecture, Front end data warehousing operations, data cubes and other visualizations, data synchronization with operational databases, Classificatory knowledge Extraction and prediction, Decision Trees, Association Rule Mining, Error analysis, LIFT charts and ROC curves, Bagging and Boosting, Clustering, Sequence analysis, Design of parallel and distributed data mining systems, mining complex data. Laboratory assignments: Implementation of the above concepts.

MAL785 Natural Language Processing
4 credits (3-0-2)
Pre-requisites: MAL342 & MAL375 & MAL390
Lingustics Essentials: Parts of Speech and Morphology, Inflectional vs. Derivational Morphology, Phrase Structure Grammar (dependency, ambiguity), Syntax and Syntactic Theory, Semantics, Language variations, Pragmatics - language as a means of communication.

Study of Words: Frequency, Hypothesis testing, Collocation, n-gram models, Word-sense Disambiguation - supervised, unsupervised, dictionary-based.

Lexical Acquisition: Verb Categorization, Semantic Similarity.

Grammar: Markov Models, Parts-of-speech Tagging, Transformation-based learning of taggers, Tagging accuracy, Context free Grammars, Parsing and probabilistic parsing, study of divergence.

Applications: Statistical Alignment techniques (length based, word-based, cognate-based), Machine Translation and its various approaches, Information retrieval (vector-based model, term distribution model), Text Categorization.

MAL786 Cryptology
4 credits (3-1-0)
Pre-requisites: EC 90
Private Key Cryptosystems: classical techniques, modern techniques, algorithms like DES, IDEA, RC5, Blowfish, etc, confidentiality using

Conventional Encryption; Public Key Encryption and Hash Functions: principles of public key cryptosystems, Diffie-Hellman key exchange, RSA, introduction to elliptic curve cryptography; Introduction to Number Theory: modular arithmetic, Fermat's and Euler's theorem, primality testing, Chinese remainder theorem, discrete logarithms; Basics of Finite fields; Message Authentication and Hash function: MD5, SHa-1, HMAC etc.; Digital Signature and authentication protocols: Digital signature, DSS, Authentication protocols; Differential and Linear cryptanalysis; existing cryptosystems and their security. Cryptanalysis of existing systems. Zero-knowledge protocols, One-way functions. Advanced protocols for different applications, e.g. e-cheque, e-cash etc. Network and System level security issues.

MAL790 Special Topics in Computer Science
4 credits (3-0-2)
Pre-requisites: EC 90
The course contents will be announced by concerned faculty member before registration.

MAL803 Pattern Recognition
3 credits (3-0-0)
Statistical and geometrical techniques of pattern recognition, classification and cluster analysis, linear discrimination analysis and feature extraction theory. Application of entropy principles and mathematical programming techniques to pattern recognition. Fuzzy theoretic approach to pattern recognition.

MAL805 Mathematical Modelling and Computer Simulation
3 credits (3-0-0)
Modelling of non-linear transport process in the context of urban air pollution and dispersion of suspended matter in waterways; large-scale motions in the atmosphere and oceans; humidity transport equations; models in population ecology, predator-prey interactions models of renewable resource harvesting; case studies and computer simulation.

MAL807 Compiler Construction
3 credits (3-0-0)
Compilers and translators. Structure of a compiler. Lexical analysis and syntax analysis. LL and LR parsing techniques and parser generators. Symbol tables. Internal form of source programs. Semantic routines. Error detection and recovery code generation. Code optimization.

MAL809 Numerical Software
3 credits (3-0-0)
Concept of a software library; design principles. Numerical library for a large industrial organization : using the NAG library in industrial research. Linear and non-linear algebra : singular-value decomposition, software for sparse matrices, non-linear algebraic equations in process engineering calculations, data fitting algorithms. Differential and integral equations; solution of large systems, stiff initial-value problems, efficiency of stiff integration routines, numerical software for integral equations, problem of algorithm design for PDEs. Optimization : mathematical programming systems.

MAL811 Mathematical Foundation of Artificial Intelligence
3 credits (3-0-0)
Knowledge Base as conventional and non-conventional logics, the basic problems of incompleteness, inconsistency, non-monotonicity, inaccuracy, uncertainty and imprecision in representation of a knowledge-base. Deduction and computation : the inference systems, arities, sorts and many-sorted algebras, polymorphisms. The categorical formulation. Confluence and termination, Knuth-Benedix method. The Church- Rosser property and sequential computation. Logic programming, PROLOG and other logic programming languages. Functional programming.

MAL819 Statistical Simulation on Computers
3 credits (3-0-0)
Random number generation tests for randomness, random variate generation, rejection principle, compo-sition, variance reduction techniques, simulation from multivariate distributions. Analysis of simulation with general purpose languages. A minor application.

MAL823 Special Topics in Computer Applications
3 credits (3-0-0)

MAL843 Mathematical Modeling of Credit Risk
3 credits (3-0-0)
Review of elementary stochastic calculus and Black - Scholes - Merton theory of option pricing. Corporate liabilities and contingent claims. Risk structure of interest rates. Statistical techniques for analyzing defaults. Credit scoring modeling using logistic regression, Discriminant Analysis and support vector machines. Rating based term structure models. Credit risk and interest rate swaps. Credit default swaps (CDS), collateralized debt obligations (CDO's) and other related products. The copula approach. Portfolio credit risk analysis using coherant risk measures.

MAD851 Major Project Part 1 (MT)
6 credits (0-0-12)
Pre-requisites: EC 165
A student will take up project under the guidance of a faculty member in an area of the student's choice. Projects are to be executed individually.

MAD852 Major Project Part 2 (MT)
14 credits (0-0-28)
Pre-requisites: MAD851
Students will continue with the projects taken up in the first part, MAD851, under the guidance of the same faculty member.

MAL851 Applied Numerical Analysis
3 credits (3-0-0)
Error analysis and stability of algorithms. Nonlinear equations: Newton Raphson method, Muller's method, criterion for acceptance of a root, system of non-linear equations. Roots of polynomial equations. Linear system of algebraic equations : Gauss elimination method, LU-decomposition method; matrix inversion, iterative methods, ill-conditioned systems. Eigenvalue problems : Jacobi, Given's and Householder's methods for symmetric matrices, Rutishauser method for general matrices, Power and inverse power methods. Interpolation and approximation : Newton's, Lagrange and Hermite interpolating polynomials, cubic splines; least square and minimax approximations.

Numerical differentiation and integration: Newton-Cotes and Gaussian type quadrature methods.

Ordinary differential equations : Initial value problems: single step and multistep methods, stability and their convergence. Boundary value problems: Shooting and difference methods.

Partial Differential Equations : Difference methods for solution of parabolic and hyperbolic equations in one and two-space dimensions, stability and their convergence, difference methods for elliptic equations.

MAL853 Methods of Applied Mathematics
3 credits (3-0-0)
Classification of a system of PDEs. Riemann invariants and applications. Group theoretic methods for the solution of non-linear differential equations of physical and engineering systems.

MAL854 Interpolation and Approximation
3 credits (3-0-0)
Interpolation : general problem, representation theorems, remainder theory, convergence of interpolatory processes. Approximation : best,

uniform and least-squares, degree of approximation. Approximation of linear functionals : Optimal approximations in Hilbert spaces, roots and extremals : Convergence of Newton's method in Banach spaces, minimizing functionals on normed linear spaces, applications to integral equations and control theory.

Splines : applications to computer-aided design.

Filters : linear, least-squares and Chebyshev.

Applications to signal processing.

MAL855 Multiple Decision Procedures in Ranking and Selection
3 credits (3-0-0)
The problem of ranking and selection, different approaches to the solution of problem. Indifference zone formulation : Ranking normal population in terms of means single and two stage procedures. Ranking normal population in terms of variances. Ranking binomial population-fixed sample size and multistage procedures, play the winner rules and vector at a time sampling. Ranking Gamma population with largest (smallest) scale parameter. Optimal properties of fixed subset size proceduresBayes, minimax and admissibilities properties, subset selection formulation : Decision theoretical formulation, best invariant rules. Restricted subset selection. Subset selection of normal population w.r.t. means and variances, selection of t-best. Subset selection in binomial and gamma populations. Comparison of population with a control. Normal and exponential populations.

MAL856 Lie Algebras
3 credits (3-0-0)
Definitions and examples. Basic concepts. Solvable and Nilpotent Lie algebras, The Engel's theorem, Lie's theorem, Cartan's criterion, Killing form, Finite dimensional semi-simple Lie algebras and their representation theory. The Weyl's theorem. Representations of sl (2,C). Root space decomposition. Rationality properties. Root systems, The Weyl group. Isomorphism and conjugacy theorems (Cartan subalgebras, Borel subalgebras). Universal enveloping algebras, PBW theorem, Serre's theorem. Representation theory and characters. Formulas of Weyl, Kostant and Steinberg. Introduction to infinite dimensional Lie algebras.

MAL860 Linear Algebra
3 credits (3-0-0)
Vector spaces, linear transformations, Eigenvalues and eigenvectors, Diagonalization, Simultaneous triangulation and diagonalization. The primary decomposition theorem. Cyclic decomposition and the rational and Jordan canonical forms. Computation of invariant factors. Inner product spaces, unitary operators, spectral theorem for normal operators, polar decomposition. Bilinear and quadratic forms, Symmetric and Skew-symmetric bilinear forms. Non-negative matrices, Perron-Frobenius theory, generalized inverse of a matrix.

MAL863 Algebraic Number Theory
3 credits (3-0-0)
Algebraic number fields, cyclotomic fields, quadratic and cubic fields, integral extensions, conjugate elements and conjugate fields, norms

and traces. The discriminant. Noetherian rings and Dedekind domains. Finiteness of the class group. Dirichlet's unit theorem and its applications.

MAL874 Analysis
3 credits (3-0-0)
Review of Banach and Hilbert spaces. The Hahn-Banach, Open mapping and Banach-Steinhaus theorems. The Riesz representation theorem, the spaces $L^p(0,1)$ and $L^2(0,1)$ Spectral theory and Sturm-Liouville systems, fixed point theory. The theorems by Banach, Browder and Schauder and applications. Picard's theorem. Integral equation of Fredholm, Volterra and Hammerstein. Nonlinear operators : The complementarity problem and its uses. Banach algebras and C* algebras. Best approximation in normed linear spaces.

MAL883 Physical Fluid Mechanics
3 credits (3-0-0)
Description of principles of flow phenomena : pipe and channel flow laminar flow, transition, turbulance; flow past an object;boundary layer, wake, separation, vortices, drag, convection in horizontal layers, transition from periodic to chaotic behaviour;equations of motion; dynamical scaling, sample viscous flows; inviscid flows. Flow in rotating fluids; hydrodynamic stability.

MAL888 Boundary Elements Methods with Computer Implementation
3 credits (3-0-0)
Distributions and Sobolev spaces of fractional order. Elliptic boundary value problems on unbounded domains in IR^n (n=2,3).

Fundamental solution of elliptic equations.

Simple layer and double layer potentials Fredholm integral equations of first and second kinds. Singular and hypersingular kernels.

Interior and exterior Dirichlet problems and integral representations of their solutions.

Variational formulation of problems defined on boundary. Solution of some model problems by boundary element methods, approximate integrations over boundary, solution methods of algebraic equations; computer implementation of boundary element methods for a model problem. Coupling of boundary element and finite element methods.

Some advanced topics of boundary integral methods integrals with hypersingular kernel, a method of elimination of singularity, Lagrange multiplier method.

MAL890 Wavelet Analysis and Applications
3 credits (3-0-0)
Integral Wavelet Transform. Wavelet frames. Orthonormal wavelet basis. Multiresolution analysis. Compactly supported wavelets. Cardinal spline wavelets. Fast wavelet transform, Numerical Algorithms.

MAL899 Selected Topics (Self-study)
3 credits (3-0-0)

Department of Mechanical Engineering

MEL110 Graphic Science
4 credits (2-0-4)
Orthographic, Axonometric, Isometric, Oblique, Perspective projections. Lettering, instruments and line work, free hand sketching, plane geometric constructions, auxiliary planes. Intersection and development of surfaces, planes and solids with their spatial relationships. Transition pieces, rules and conventions for sectioning and dimensioning. Introduction to computer aided drawing. Examples of graphic communication.

MEN110 Introduction to Mechanical Engineering
2 credits (0-0-4)
Exposure to a wide range of applications of mechanical engineering through a variety of activities, including hands-on assembly and disassembly of machines, such as, bicycle, sewing machine, pumps, engines, air-conditioners, machine-tools, amongst others; observational study of complex systems via cut sections, visits, videos and computer simulations; design of simple machines/systems including specifications formulation; visits to industries, and discussions with senior students and alumni.

MEL120 Manufacturing Practices
4 credits (2-0-4)
The objective of the course is to expose students to basics of manufacturing as it plays a direct role in improvement of quality of human life and creating wealth for the nation. The second objective of the course is to expose students to hands-on practice with common manufacturing processes. It will cover: (i) importance of manufacturing, (ii) relation between materials and manufacturing, (iii) an overview of manufacturing processes, (iv) product manufacturing, (v) importance of product assembly and inspection, (vi) an overview of manufacturing planning, and (vii) manufacturing automation and computer aided manufacturing for industry.

MEN120 Introduction to Production and Industrial Engineering
2 credits (0-0-4)
Exposure to a wide range of production engineering and industrial engineering applications through hands-on experience in assembly-disassembly of machines and machine-tools, use of machines to produce simple parts; simulation (physical and/or computer) of manufacturing and assembly processes; applications of industrial engineering, such as, quality control and production management, amongst others. Several visits to factories will be included as also video and computer simulations on manufacturing processes and systems, and discussions with industry representatives.

MEL140 Engineering Thermodynamics
4 credits (3-1-0)
Introduction to applications. Basic concepts and definitions – system, boundary, equilibrium, steady state and others. Thermodynamic properties of a pure substance – saturated and other states. Work and heat – definition and applications. 1st Law – internal energy and enthalpy, applications to non-flow/closed and flow/open systems (SSSF and USUF), reacting systems and gas-vapor mixtures. 2nd Law – corollaries, Clausius inequality, entropy. Introduction to availability, irreversibility and exergy. Carnot cycle. Basics of gas-vapor mixtures and reacting systems. Vapor power cycles – Rankine cycle and its modifications. Air standard cycles – Otto, Diesel, Brayton cycles. Vapor compression and absorption refrigeration cycles. Material deformation, electro-magnetics and other applications.

MEP201 Mechanical Engineering Drawing
3 credits (1-0-4)
Pre-requisites: MEL110
Introduction to design process and drawings. Review of sectioning, drawing standards, dimensioning and notes. Fasteners – screws, bolts and nuts, riveted joints, pins, locking devices, welded joints, pipe joints, unions and valves. Assembly drawings with sectioning and bill of materials. Cotter and Knuckle Joints. Assemblies involving machine elements like shafts, couplings, bearing, pulleys, gears, belts, brackets. Tool drawings including jigs and fixtures. Engine mechanisms-assembly and disassembly. Detailed part drawings from assembly drawings. Production drawings - limits, fits and tolerances, dimensional and geometric tolerances, surface finish symbols. Layout drawings. Schematics, process and instrumentiation diagrams, piping drawings.

Structural drawings - examples for reading and interpretation. Computer aided design and use of software packages for engineering drawings.

MEP202 Design Innovation and Manufacturing
2 credits (0-0-4)
Pre-requisites: MEL110 & MEL120
Practical exercises involving: (a) Identification of engineering solution parameters like materials, manufacturing and configuration variables, (b) Study and improvement of existing designs, (c) Open ended design problems for generating innovative designs/solutions and engineering problem solving, and (d) Product design with other life-cycle considerations in mind such as manufacturing, maintenance and environmental considerations.

MEL211 Kinematics and Dynamics of Machines
4 credits (3-0-2)
Pre-requisites: AML110 & MEL110
Kinematic pairs, diagram and inversion. Mobility and range of movements. Displacement, velocity and acceleration analysis of planar linkages. Dimensional synthesis for motion, function and path generation. Cam profile synthesis. Gears dynamic force analysis, flywheel, inertia forces and their balancing for rotating and reciprocating machines. Hydrodynamic and boundary lubrication in journal and thrust bearings.

MEL221 Industrial Engineering and Operations Research
4 credits (3-0-2)
Pre-requisites: MAL120
Introduction to Industrial Engineering, Evolution of key Concepts, Work study, Productivity, Partial and Total Productivity, Strategies to improve productivity, Management, Functions of management, Management Information System, Decision Making, Prescriptive and Descriptive models, Type of Production systems and Layouts, Allocation Problems, Design of Assembly Line System, etc, Introduction to Operations Research, Role of modeling, Nature of Problems, Graphical method, Simplex method, various cases of LP problems, Duality, Sensitivity, Special topics etc.

MEL231 Casting and Welding
4 credits (3-0-2)
Pre-requisites: MEL120
Overlaps with: MEL232
This course exposes the student to foundry and welding technologies. The course covers introduction, applications, basic physics involved in various processes, latest trends, basic extractive and engineering physical metallurgy etc. Familiarization and identification of various raw material, equipment and power sources, melting of metals, properties of sand, castings based on various processes. Welding practice, behaviour of covered electrodes, welding in different positions, Basic exercises in SAW, GMAW, GTAW and underwater welding.

MEL232 Casting, Welding and Forming
4 credits (3-0-2)
Pre-requisites: MEL120
Overlaps with: MEL231
Study of metal casting processes; Study of welding and other joining processes; Study of metal forming processes; Processing of plastics; Process planning and process analysis casting, welding and forming processes; Economic and quality issues in casting, welding and forming processes.
Laboratory activities on study of bulk and sheet forming processes, dies and presses for forming, conventional and unconventional machining processes.

MEL233 Machining, Machine Tools and Metrology
4 credits (3-0-2)
Pre-requisites: MEL120
Overlaps with: MEL234
Introduction to machine tools and machining operations. Mechanics of metal machining. Cutting forces, friction, cutting fluids and surface finish, lubrication, temperatures and heat transfer and its measurement,

tool life and tool wear aspects. Theoretical models of shear angle solution, Basic concepts of cost and economics of metal cutting operations, Tool nomenclature, chip control and design for machining. Electrical discharge Machining, Electrochemical Machining, Ultrasonic machining, Abrasive Jet Machining, Laser Beam Machining, Water Jet and Electron Beam machining. Construction of Machine tools, alignment, metrology and inspection.

MEL234 Metal Forming and Machining
5 credits (3-1-2)
Pre-requisites: MEL120
Overlaps with: MEL233
Mechanical behaviour of metals in elastic and plastic deformation, stress-strain relationships, Yield criteria, Application to tensile testing, Concept of flow stress by true stress-strain curves, Fundamentals of metalworking, Strain rate and temperature in metal working, Hot deformation, Cold working and annealing, Analysis of bulk forming processes like forging, rolling, extrusion, wire drawing by slab method, Technology and practice of these processes, Sheet metal forming processes, High Energy rate forming processes, Fundamentals of metal cutting and common machining operations, Mechanics of metal cutting, Heat generation in metal cutting, Tool wear and tool life, Nomenclature of cutting tools and cutting tool materials, Cutting fluids, Abrasive machining, Surface finish, Economics of machining, Non-conventional machining processes.

MEL235 Metrology and Quality Assurance
4 credits (3-0-2)
Pre-requisites: MEL120
Introduction to Metrology and its relevance, standardization, dimensional measurement, limits, fits and tolerances, limit gauging, linear and angular measurements and their applications, surface roughness-quantification and measurement, alignment testing of machine tools, feature inspection and online inspection. Introduction to quality assurance and quality control,Various elements in Quality Assurance program, On-line and Off-line quality control, Statistical concepts in quality, Central limit theorem, Quality Characteristics, QC Tools, Chance and assignable causes of quality variation, Process control charts for variables, Control chart parameters, Target process setting/ Centering, Control limits and specification limits. Process capability studies, Remedial / Corrective actions, Special purpose control charts, Reject limits, Variables inspection and attributes Inspection, Control charts for attributes, Defects classification, Sensitivity of control charts. Sampling inspection for product acceptance,

MEL241 Energy Conversion
4 credits (3-0-2)
Pre-requisites: MEL140
Overview of energy conversion technologies. Combustion and applications – IC engines, burners, furnaces and components. Compressible flow fundamentals – Mach number, normal shock, adiabatic 1-D flow through variable area passages. Turbo-machinery – flow through a stationary and moving passage, velocity triangles, impulse and reaction principles, characteristics and components of axial and centrifugal turbo-machines. Refrigeration and air-conditioning – system analysis, components design, psychrometry, and air-conditioning calculations. Steam generation and its use – power plants, co-generation, combined cycles. Steam and gas turbine construction and performance. Equipment studies and performance calculations in the laboratory will concurrently accompany lectures.

MEL242 Heat and Mass Transfer
4 credits (3-1-0)
Pre-requisites: AML160
Modes of heat transfer in various applications. Conduction: Heat diffusion equation, 1-D steady state conduction in extended surfaces, infinite and semi-infinite walls, heat generation, lumped capacitance and simple transient models. Convection: Forced and free convection - mass, momentum and energy conservation equations, non-dimensional numbers, hydrodynamic and thermal boundary layers, basics of heat transfer in external and internal laminar and turbulent flows, and use

of co-relations. Boiling and condensation: physical phenomena and co-relations. Mass transfer – Fick's law, similarity with convection and correlations. Radiation: properties, Laws, 3-surface network for diffuse-gray surfaces. Heat exchanger fundamentals and design.

MED310 Mini Project (ME)
4 credits (0-0-8)
Pre-requisites: EC 80
Team formation. Formulating work plan, learning objectives and deliverables. Need identification, assessment of alternative approaches, defining design and performance specifications. Defining testing and/or validation procedure(s). Detailed work including preparation of engineering drawings, fabrication and procuring parts. Assembly and testing. Performing experiments. Model development, writing code, its validation, and user's and programmers manuals. Display of outcome at an Open House. Documentation and coding of entire work and knowledge gained.

MEL310 Concurrent Engineering
4 credits (3-1-0)
Pre-requisites: EC 60
Concurrent Engineering- meaning and need. Review of Engineering Problem Solving methods. Description of methods of Analysis, Decision Making, Creativity and Information processing and their role in engineering. Discussion of Emerging engineering strategies of Total Design, Design for Manufacturing and Assembly, Quality Function Deployment, and Constraint networks.

Integrating concurrent approaches with those of conventional. Implementation of concurrent engineering in industrial environment especially those of IT and high speed computation.

MEL311 Machine Element Design
5 credits (3-1-2)
Pre-requisites: MEL211 & AML140 &
& MEP201 & MEP202
Mechanical Engineering Design vis-à-vis Solid Mechanics, factor of safety, standards and design equations. Selection of materials and processes. Standard numbering system including BIS designations of materials. Application of theories of failure to design. Design procedure and its application to static strength. Design of elements subjected to simple loading: screws including power screws, bolted joints including eccentrically loaded joints, axles, and coupling, clutches and brakes. Introduction to design for fatigue strength. Endurance and modifying factors. Surface strength. Review of design procedure of fatigue failure with application to the design of bolts and springs subjected to fatigue loading. Design of shafts, spur, helical, bevel and worm gears, journal and rolling contact bearings, belts and chains. Introduction to CAD. Design exercises of systems like those of mechanical drives which may also involve the assistance of a computer.

MEP311 Mechanisms Laboratory
1 credit (0-0-2)
Pre-requisites: MEL211
A set of 10 experiments based on Reuleaux basic mechanical devices, Grashoff mechanisms, Linkages, gear and gear trains, gear tooth profile, cams, belts, brakes, clutches, bearings and lubrication, friction, Coriolis acceleration, gyroscopic couple, balancing of rotating and reciprocating masses, free and forced vibrations, transmission system of automobile vehicles, etc.

MEL312 Control Theory and Applications
5 credits (3-1-2)
Pre-requisites: MAL110 & AML110 & (EEL101 / EEL102) and EC 60
Overlaps with: EEL301/CHL261/MEL334
Introduction to automatic controls. Modeling of flow, heat transfer and electrical, pneumatic and vibration systems. Block diagram and transfer function.Modeling of continuous systems. Extraction of reduced order models. Transient and frequency response evaluation using Laplace transform. Characteristics of hydraulic controller, pneumatic, electronic

controller, electro-hydraulic and electro-pneumatic controllers. PID control. Stability. Gain and phase margins.Control system design using root and compensation. Application to Machine tool, Boiler, Engine Governing, Aerospace, Active vibration control, etc. Auto-tuning. Sequence control, Logic diagram. Introduction to digital control, Implementation using computer. Introduction to control of MIMO systems. State Space modeling.

Practicals include studies on hydraulic, pneumatics, electronic controller. Control of various parameters such as speed, temperature, level, pressure, etc. Tutorials for control problems in these areas using MATLAB.

MEL314 Noise Engineering
4 credits (3-0-2)
Pre-requisites: MAL110 / MAL120 and EC 60
Overlaps with: ITL760
Fundamentals of vibrations, vibrations of strings and bars, Vibrations of membranes and plates. Acoustic wave equation, Acoustic energy and sound intensity. Propagation of sound, Concept of Acoustic impedance.Sound power transmission, Transmission Loss. Human Response and ratings, Various Measures of Sound. Weighting filters, Loudness, Indices of Loudness. Acoustic radiation from spherical source and piston source. Acoustic sensors. Measuring Techniques and Instruments, Octave Filtering, Sound Intensity Measurement, Intensity Mapping. Different types of measurement environment and uses. Response of beam subjected to an accoustic plane wave. Transmission loss of panels. Sound absorption coefficient. Noise control measures in building. Reverberation time and auditorium design. Industrial Noise control, Noise in Machinery, Traffic Noise, Vehicle Noise. Design of silencers and mufflers. Active noise control.Duct noise control and cabin noise control. Practicals on noise measurements in different situations.

MEL316 Mechanical Vibrations
4 credits (3-0-2)
Pre-requisites: MEL211
Vibration of single degree of freedom (SDF) system. Modelling of stiffness and damping (both Viscous and Coulomb). Estimation of damping by decay plots and half power method. Impulse, transient and forced vibration response of SDF system. Theory and practice of vibration isolation. Vibration measuring instrurments. Two degree freedom system. Application to undamped and damped absorbers. Multi-degree freedom systems. Modal analysis. Rayleigh's and Dunkerley's method. Holzer's and Myklestad-Prohl transfer matrix methods.Continuous systems governed by wave equation and Euler Bernoulli equation. Free and forced vibrations including modal analysis. Finite element based dynamic analysis of simple systems. Introduction to modal testing and system identification problems. Industrial applications - rotors and other systems, balancing, vibration standards, vibration monitoring.

MED320 Mini Project (PE)
4 credits (0-0-8)
Pre-requisites: EC 80
Team formation. Formulating and executing the work plan on a topic related to production engineering or industrial engineering. Nature of work could be either hardware based , theoretical or computer simulation type. Display of outcome at an Open House and making a presentation. Documentation and coding of entire work and knowledge gained.

MEL321 Ergonomics
4 credits (3-0-2)
Pre-requisites: MEL221
Introduction to Ergonomics: Definition and importance of ergonomics, History of Ergonomics; Introduction to Human-machine systems ;Human-machine systems – Interfaces; Ergonomics at the Workplace: Anthropometrics principles; Work-related Musculoskeletal Disorders; Workplace Design ; Environmental Factors at Work; visual environment; thermal environment; auditory environment; Vibration; Ergonomic Workplace Analysis: Introduction to workplace analysis; Ergonomics workplace analysis; Ergonomic awareness checklist; Legal and safety issues, Various case studies.

MEL322 Operations Planning and Control
4 credits (3-0-2)
Pre-requisites: MEL221
Production systems and performance measures. Life Cycle of a production system. Major managerial decisions in the life of a production system, Product design and process selection. Location and Layout of production systems, Product,Process and Cellular layouts, Demand Forecasting, Aggregate production planning, Inventory and MRP, Scheduling decisions and emerging trends.

MEL323 Investment Planning
4 credits (3-0-2)
Pre-requisites: MEL221/MAL250
Basic framework of a firm. Investment options. Various instruments. Portfolio concept. The Basic Theory of Interest, Impact of Inflation. Opportunity Cost of Capital. Deterministic Cash Flows, Project Net present Value, Other Project Evaluation Criteria. Single Period Random Cash Flows, Mean-Variance Portfolio Theory, Portfolio Analysis and Management, Mathematical Programming approach, Single Index Models, Capital Asset Pricing Model. Options and Futures. Black Scholes Equation. Risk evaluation. Case studies from various sectors.

MEL324 Value Engineering
4 credits (3-0-2)
Pre-requisites: MEL221
Introduction to Value Engineering (V.E.) and Value Analysis, Life Cycle of a Product, Methodology of V.E., Quantitative definition of Value, Use Value and Prestige Value, Estimation of product quality/performance, Types of Functions, Relationship between Use Functions and Esteem Functions in product design, Functional Cost and Functional Worth, Effect of value improvement on profitability, Aims of VE systematic Approach.

Introduction to V.E. Job plan / Functional Approach to Value Improvement, Various phases and techniques of the job plan, Factors governing project selection, Life Cycle Costing for managing the Total Value, Concepts in LCC, Present Value concept, Annuity concept, Net Present Value, Pay Back period, Internal rate of return on investment (IRR), Examples and illustrations.

Creative thinking and creative judgement, False material, labor and overhead saving, System Reliability, Reliability elements in series and parallel, Decision matrix, Estimation of weights and efficiencies, Sensitivity analysis, Utility functions, Fast diagramming, Critical path of functions, DARSIRI method of value analysis, Purchase price analysis.

MEL331 Machine Tools and CNC Manufacturing
4 credits (3-0-2)
Pre-requisites: MEL234
This course exposes the student to conventional machine tools and classification, machining operations, work and tool holding devices, drive systems, structures and guideways, mechanisms, NC systems, controls, programming, industrial robots and applications, measurement techniques on machine tools.

Familiarization and identification of various machine tools, study of structural features of machine tools, study of various mechanisms and their assembly, study of machine tool to identify the existing limitations and to suggest changes.

MEP331 Process Engineering and Tool Design Project
3 credits (1-0-4)
Pre-requisites: MEL231 & MEL234 & MEL235
Introduction to process planning, part print analysis, make-or-buy decision, product drawing analysis, establishing the sequence of processes, economic processing considerations, machine selection, payback comparison, tooling costs, process documentation, routing, operation sheets, tolerance charting, computing dimensions and tolerances and computer aided process planning

MEL332 Design and Manufacturing of Composites
4 credits (3-0-2)
Pre-requisites: MEL120 & AML140 and EC 60
FRP Composites, fiber types, fiber forms and properties, matrices type

and properties, lamina, laminate, orthotropy, anisotropy, composites – macro and micro-mechanical analysis and properties, Failure theories - Tsai-Hill, Tsai-Wu, Primary and Secondary Manufacturing - Lay-up, Autoclave Molding Filament Winding, Pultrusion, Compression Molding, RTM, RIM, SRIM, Machining, drill-ing, routing etc., design, structural and testing, applications. Metal Matrix Composites and Ceramic Matrix composites - Manufacturing routes and applications.

MEL333 Metrology
4 credits (3-0-2)
Pre-requisites: MEL233
Introduction to Metrology and its relevance, standardization, dimensional measurement, limits, fits and tolerances, limit gauging, linear and angular measurements and their applications, surface roughness-quantification and measurement, alignment testing of machine tools, feature inspection and Computer Aided inspection.

MEL334 Low Cost Automation
4 credits (3-0-2)
Pre-requisites: MEL233 / MEL234
Overlaps with: MEL312/EEL301/CHL261
Introduction, Types of systems - mechanical, electrical, electronics, fluidics; Hydraulics Systems and components; Pneumatic Systems Control; Sequence operatio of more than two culinders and motors; Applications of relays/switches; Measuring systems, Transducers; Feed back control systems; Programmable controllers; Small components feeders; Automatic orientation and assembly; Design of components for assembly. Cost considerations and case studies. Laboratory work will be hands-on design and operation of automatic systems.

MEL335 Advances in Metal Forming
4 credits (3-1-0)
Pre-requisites: MEL234
Elements of theory of plasticity, Formulation of plastic deformation problems and different methods of solution, Application of theory of plasticity for solving metal forming problems, Numerical methods in metal forming, Friction and lubrication in cold and hot working, Technological advances in metal forming processes- forging, rolling, extrusion, wire drawing and sheet metal forming. Computer aided die design for forging, extrusion and wire drawing, Automation in metal forming processes, Advances in sheet metal forming, Concept of Formability and its evaluation, Hydro-forming of sheets and tubes.

MEL336 Advances in Welding
4 credits (3-0-2)
Pre-requisites: MEL231
This course introduces the concept of welding technology involving metallurgy, designing, automation, welding of high speciality alloys and materials and inspection procedures. Familiarization and identification of various processes, equipment, power sources, consumables, correlations between various responses and welding parameters and under water welding.

MEL341 Gas Dynamics and Propulsion
4 credits (3-0-2)
Pre-requisites: MEL241
Revision of fundamentals. Thermodynamics of compressibleflow – wave motion in compressible medium, Mach number and cone, properties. Steady one-dimensional compressible flow through variable area ducts. Converging and converging-diverging nozzles and diffusers. Effects of heating and friction in duct flow, Rayleigh and Fanno lines. Flows with normal shocks. Oblique shocks and reflection. Expansion waves. Prandtl-Meyer flow. Flow over bodies. Measurements and applications. Jet propulsion – types of engines, propulsion fundamentals. Compressor, combustor and turbines construction and performance. Rocket propulsion – basics, solid and liquid propelled engines, parametric studies, construction features, single and multi-stage rockets. Thrust chamber and nozzle models. Studies of in-use engines. Environmental aspects.

MEP341 Thermal Engineering Laboratory
1.5 credits (0-0-3)
Pre-requisites: MEL242 & MEL241
Experiments related to courses MEL242 Energy Conversion and MEL243

Heat and Mass Transfer courses. Application of uncertainty analyses. Experiments will be conducted in a group of two students. A professional report is to be prepared for each experiment.

MEL342 Power Plant Technologies
4 credits (3-0-2)
Pre-requisites: MEL241 & AML160
Introduction to power systems and technologies. Demand variation and forecasting. Grid features. Siting and costing. Diesel generators: systems, equipment and layout. Fossil-fuelled steam power plants: Boiler and accessories. turbine and accessories, feed cycle equipment, generator. Combined cycle power plants: gas turbine, heat recovery boiler. Nuclear power: nuclear reactions, fuel, moderator and coolant, Neutron life cycle. Light water, Heavy water, Gas-cooled and fast reactors. Hydroelectric plants: Features and siting, Pelton, Francis, Kaplan and propeller turbines construction, mini- and micro-turbines. Renewable energy: solar, geothermal, wind, biomass, ocean, fuel cells, unique features of decentralized systems. Co-generation systems. Environmental issues, sustainability and future scenarios.

MEL343 Fuels, Combustion and Pollution
4 credits (3-0-2)
Pre-requisites: MEL241
Introduction. Fuels: gaseous, liquid and solid. Sources, method of procurement, transportation and end uses. National and international perspectives - economic and social aspects, and policies. Physical and chemical characterizations. Chemical thermodynamics and kinetics. Conservation equations for multi-component systems. Premixed systems: detonation and deflagration. Laminar flame problems and effects of different variables. Measurement of flame velocity. Flammability limits. Ignition and quenching. Turbulent premixed flames. Non-premixed systems: laminar diffusion flame jet, droplet burning. Combustion of solids: drying, devolatilization and char combustion. Coal combustion. Pollution: Main pollutants and their environmental impact. NOx, CO and SOx formation chemistry. Particulate pollutants. Emissions from engines, power plants and industrial applications. Low NOx burners and furnace design.

MEL344 Refrigeration and Air-Conditioning
4 credits (3-0-2)
Pre-requisites: MEL140 and EC 60
Revision of fundamentals. Applications. Environmental issues. Vapor compression system: Ideal and real cycle analyses, design and optimization. Refrigerants: designation, properties, environmental considerations. Advanced vapor compression cycles, part-load operation. Gas cycle refrigeration. Components: condensers, evaporators, compressors and expansion devices – construction, operation and performance. Vapor absorption cycles: operation, system design, components. Psychrometry: definitions, heating, cooling, humidification and dehumidification processes, evaporative cooling systems. Environmental comfort specifications and standards. Cooling load estimation and use of standards. Airconditioning systems and apparatus, air flow ducts, air quality. Control and optimization of HVAC systems.

MEL345 Internal Combustion Engines
4 credits (3-0-2)
Pre-requisites: MEL140 and EC 60
Thermodynamics of fuel-air cycles, real cycles; Unburned and burned gas mixture charts; Ignition, normal and abnormal combustion in SI and CI engines; Conventional and alternative fuels for engines; Conventional and electronic fuel management systems for SI and CI engines; Design of combustion chamber for SI and CI engines; Engine emissions; Lubrication; Cooling; Supercharging and Turbocharging; Modern developments in IC engines.

MEL346 Turbo-machinery
4 credits (3-0-2)
Pre-requisites: MEL140 & AML160 and EC 60
Revision of fundamentals. Types of turbomachines and their applications. Dimensional analysis and performance parameters. Cascade theory: types of cascades, flow and geometric parameters, boundary layer development.

Wind tunnels: types, designs, construction features and instrumentation. Axial flow turbines, axial flow compressors, propellers, centrifugal fans, blowers and compressors – fluid flow, types of blading, velocity triangles, diffusers and nozzles, pressure change, multi-staging, stall, enthalpy-entropy diagram, efficiency, acoustics, applications. Wind turbines – types, analysis, site, atmospheric aspects. Solar plant turbines: principles, construction features and performance. Future trends.

MEC410 Colloquium (ME)
3 credits (0-3-0)
Pre-requisites: Registered for MET410
Introduction to planning, preparing and making presentations – preparation of slides, time management, communication aspects, etc. Making a presentation on practical training with response sheet for testing audience. Reading an assigned project report, making a presentation with audience response sheet and a critique on writing style, completeness and editorial get-up. Performing patent searches on an allotted product and making a presentation using diagrams/figures only. Preparing posters on practical training and presenting these at a poster session.

MEL410 Creativity in Engineering
4 credits (3-1-0)
Pre-requisites: EC 90
Nature of engineering problems and solutions. Optimal engineering solutions via analysis, decision Making, creativity and information technology. Study of search for existing solutions, modification of existing solutions and innovative or inventive solutions in history of technology. Discussion of creative practices like automated solution searches, check listing, brainstorming, analogy, empathy, inversion, morphological synthesis, inventors' methods, stretching of constraint networks and problem identification. Automation strategies of creativity like those of genetic algorithms, computer aided idea searches.

MET410 Practical Training (ME)
Non credit
Pre-requisites: EC 90 at the end of 5th sem.
Prior to training, students and faculty identify industries where training that will meet the course objectives, in particular, linkages to the core mechanical engineering curriculum. An evaluation and monitoring plan is drawn up. Students spend at least 50 working days in the industry and submit regular progress reports to training coordinator. Training activities comprise study and participation in various aspects of a manufacturing enterprise and impacts on humans/society and environment. Before returning, each student submits a comprehensive training report, report(s) on projects, posters, presentation, response sheet and self-assessment. Training in academic institutions, software industry, laboratories, and organizations with narrow specialization is not permitted.

MED411 Major Project Part 1 (ME)
3 credits (0-0-6)
Pre-requisites: EC 120
Team formation for designing, manufacturing and operating a selected product, formulating project management procedures. Need identification, assessment of alternative designs, selection of design for development, defining design and performance specifications, and testing procedure. Detailed mechanical, thermal and manufacturing-related design of systems, assemblies, sub-assemblies and components culminating in engineering drawings and material specifications; preparing bill of materials and identification of standard components and bought-out parts.

MEL411 Mechatronics
4 credits (3-0-2)
Pre-requisites: MEL312 & (EEL101 / EEL102)
Overlaps with: MEL433/MEL749/EEL482
Introduction to mechatronic systems and components. Principle of basic electronics. Microprocessors and their applications, integrated circuits,

sensors, actuators, and other electrical/electronic hardware in mechatronic systems. Principles of electronic/system communication. Interfacing, DA and AD converters, software and hardware principles and tools to build mechatronic systems. Selection of mechatronic systems, namely, sensors like encoders and resolvers. Stepper and servomotors; Solenoid like actuators; Transmission elements like Ball screw; and Controllers. Analysis and synthesis of mechatronic systems with applications to robotics, CNC systems, and others.

MED412 Major Project Part 2 (ME)
7 credits (0-0-14)
Pre-requisites: MED411
The same student team continues working as per work plan of Part-1. MED411, and facilitators. Using engineering drawings, the process sheets are developed based on available materials, machine tools and other fabrication facilities. Materials and standard components are procured and manufacturing is carried out. After inspection, parts are accepted. Assembly procedure is finalized and the machine is assembled. Acceptance tests are carried out vis-à-vis specifications from Part-1. Functioning product is displayed at an Open House. Professional quality documentation of all designs, data, drawings, and results, change history, overall assessment, etc. is mandatory, along with a final presentation.

MEL412 Advanced Mechanical Design
4 credits (3-0-2)
Pre-requisites: MEL311
Concepts of fatigue and creep design. Production considerations in design. Advanced concepts for design of spur, bevel, worm and other types of gear drives, bearings, rotating discs, pressure vessels, etc. Optimization in design and computer aided design methods.

MEL413 Design of Mechanisms
4 credits (3-1-0)
Pre-requisites: MEL211 and EC 90
Study of existing mechanisms used in industry, machine tools, vehicles, high speed machinery. Classification of mechanisms. Structural analysis and synthesis for conceptual design. Theory of path curvature and finitely movements. Kinematic and dynamic design. Spatial Mechanisms. Errors in mechanisms and machines. Coding, evaluation and dimensional synthesis of mechanisms.

MEL414 Computer Aided Mechanical Design
4 credits (3-0-2)
Pre-requisites: MEL311
Overlaps with: AML710
Introduction and overview. Need and scope of Computer Aided Machine Design. Role of Geometric Modeling and Finite Element Method (FEM). Introduction to computer graphics technology and overview of hardware available for use in CAD, Geometric transformations and Projections. Windowing and view-porting. Geometric modeling; Modeling of curves, cubics, splines, beziers and b-splines, Modeling of surfaces, Modeling of solids – b-rep, CSG, octree, feature based modeling, Introduction to the Finite Element Method, principle of potential energy, 1D elements, Derivation of Stiffness and Mass matrices for a bar, a beam and a shaft, Comparison with Analytical results, Solution of static problems and case studies in stress analysis of mechanical components, FEA using 2D and 3D elements. Automatic meshing techniques, Interfacing with CAD software, Case studies using FEM for Design of simple element geometries. Introduction to Dynamic analysis, Non-linear problems and FEA for plastic materials.

MEL415 Vibrations Engineering Design
4 credits (3-0-2)
Pre-requisites: MEL312
Overview. Need of vibration engineering design for mechanical equipment. Theoretical and Experimental routes to dynamic design., Modelling and simulation to predict vibration behavior of mechanical

systems and products. Techniques for vibration control including designing for reduced excitation , choice of materials and configurations , isolation ,passive and active techniques etc Finite Element model updating. Vibration engineering design

Using techniques of modal testing, Finite element model updating, system identification and structural dynamic modification. Integration of dynamic design in mechanical engineering design. Some case studies of actual systems like machine tools, pumps, compressors, turbines, transportation systems. etc.

MEL416 Robotics Engineering
4 credits (3-1-0)
Pre-requisites: MEL311 & (EEL101 / EEL102) and EC 90
Evolution of automatons, manipulators and autonomous systems. Forward and Inverse Kinematics. Velocity control, Jacobian control of abundant systems, singular value decompositions and null spaces. Interpolation in 3-D spaces, dual numbers, quaternions and screws. Dynamics of manipulators, EL and NE formulations. Parallel Manipulators. Basics of vision systems. Robotic AI Paradigms and Navigation.

MEL417 Lubrication
4 credits (3-0-2)
Pre-requisites: MEL311
Importance of lubrication, mechanisms and regimes of lubrication. Viscosity and its measurement. Bearing varieties and selection. Hydrodynamic lubrication-Journal and Thrust Bearings. Lubricants. Bearing materials. Rolling Bearings.

MEL420 Total Quality Management
4 credits (3-0-2)
Pre-requisites: Completion of Practical Training in any program (xxT4y0)
Evolution of quality paradigms, Customer-orientation, Quality philosophies, TQM in manufacturing and services. Tools and improvement cycle (PDCA). Life cycle approach to quality costs-Prevention; Appraisal and Failure costs.

Organizational, Communicational and Team requirements. Attitude, value sys-tem and behavioral patterns. Use of teams in process management. Group dynamics, Quality circles, high performance and self-directed teams, Empowerment. Seven QC tools and their applications, Quality Function Deployment. Statistical process Control,Process capability, Total Productive Maintenance, Importance of Standardization (National and international) Quality Systems, Quality Manuals, Quality Information Systems and documentation. Auditing. Basics of ISO-9000 and ISO 14000:Relevance and misconceptions, Six-sigma philosophy Quality strategy and policy. Motivation and leadership theories. Continuous vs. breakthrough improvements. Management of change. Quality award models and role of self-assessment. Benchmarking. Impact on society-Environment implications. Implementation barriers to TQM practices.

MEC420 Colloquium (PE)
3 credits (0-3-0)
Pre-requisites: Registered for MET420
Introduction to planning, preparing and making presentations – preparation of slides, time management, communication aspects, etc. Making a presentation on practical training with response sheet for testing audience. Reading an assigned project report, making a presentation with audience response sheet and a critique on writing style, completeness and editorial get-up. Performing patent searches on a production or industrial engineering process/ product and making a presentation. Preparing posters on practical training and presenting these at a poster session.

MET420 Practical Training (PE)
Non credit
Pre-requisites: EC 90 at the end of 5th sem.
In the year prior to training, students and faculty identify industries where training will meet the course objectives, in particular, linkages to the core production and industrial engineering curriculum. An evaluation and monitoring plan is drawn up. Student spends at least 50 working

days in the industry and submits regular progress reports to program's training coordinator. Before returning, each student submits a comprehensive training report, report(s) on projects executed, posters, presentation, an audience response sheet and self-assessment of training. The work will focus on production and/or industrial engineering.

MED421 Major Project Part 1 (PE)
3 credits (0-0-6)
Pre-requisites: EC 120
Team formation and problem identification. Preparing work plan for Parts 1 and 2, and project management procedure. Identification of milestones, deliverables and final outcome. Literature review, revision of basic courses. Formulating a detailed problem statement, knowledge base and completing about 30% of the total work.

MEL421 Production Management
4 credits (3-0-2)
Pre-requisites: MET410
The generalized model of a production system. Financial evaluation of new product polices. Profit Volume Charts, Risk analysis, Product mix decisions, Location and layout analysis, Product, process and cellular layouts, Demand forecasting, Aggregate production planning, Materials planning, MRP and inventory management, scheduling in job and flow shops

MED422 Major Project Part 2 (PE)
7 credits (0-0-14)
Pre-requisites: MED421
The same student team continues working as per the work plan developed in Part-1, MED421, with same guide. Work is continued until all stated objectives and deliverables are met. The project outcome is displayed at an Open House. Professional quality documentation of the entire project is mandatory single, double, multiple and sequential sampling schemes; OC, AOQ, ASN and ATI curves; Design of sampling plans, Standard sampling systems; Economics of product inspection, quality costs, ISO 9000 quality system; Problems and illustrations in quality assurance.

MEL422 Project Management
4 credits (3-0-2)
Pre-requisites: MET410 / MET420
The nature of projects, the project as a non-repetitive unit production system, the project as an agent of change. Project Identification considering objectives and SWOT analysis, Screening of Project Ideas, Technical, Market, Financial, Socio-economic and Ecological Appraisal of a project. Work break down structure and network development. Basic Scheduling, Critical Path and four kinds of floats. Scheduling under probabilistic durations, Time Cost tradeoffs, Project Monitoring with PERT/Cost, Organizational aspects, Computer packages and Project Completion.

MEL423 Computers in Manufacturing Enterprises
4 credits (3-0-2)
Pre-requisites: MET420
Evolving Manufacturing Environment, Role of IT, Manufacturing Enterprise System Concepts, Application of Computers in Manufacturing Enterprise Systems, Automation Strategies, Hard Automation, Programmable Automation, Flexible Automation, Flexible Manufacturing Systems, Computer Integrated Manufacturing Systems (CIMS), Enterprise Resource Planning (ERP), Supply Chains, Extended Enterprises, e-manufacturing, e-Business, Concurrent Engineering (CE), Group Technology, Artificial Intelligence in Manufacturing, Expert System Applications, Computer Simulation, Modeling, Towards Agile Manufacturing Enterprises etc.

MEL424 Knowledge Management for Competitiveness
4 credits (3-0-2)
Pre-requisites: MET420 & MED421
Knowledge Management (KM) Introduction, Definitions, Industrial

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Relevance, Evolving Industrial Competition (Multi-Attributed Competition), Complex and Dynamic Systems, Growing Need for Knowledge and its Effective Management, Role of IT, KM and CRM, KM Technical Concepts: (Data .vs. Information vs. Knowledge), The Knowledge Edge, Knowledge Engineering, KM Framework (Process Steps), Aligning KM with Manufacturing Strategy, Business Strategy etc.),Design and Deployment of KM in Industrial Enterprises (KM Team, KM System Analysis, Developing Effective Systems, Knowledge Audit), IT based Tools (Role of Simulation, Intelligent Systems) KM Challenges and Opportunities, Managing Innovations, Performance Measurement, KM and Competitiveness Link, Applications, Cases, Presentations. Group Exercises.

MEL425 Flexible Manufacturing Systems
4 credits (3-0-2)
Pre-requisites: MET410 / MET420
Flexible Manufacturing Systems: Introduction, Definitions, Industrial Relevance, Need for FMS, Problems of conventional batch manufacturing systems, Role of Information Technology, Overview of Multi model and mixed model flexible lines, Understanding Flexibility, Types of Flexibility in FMS, Flexible and Dynamic Manufacturing Systems, IT facilitated flexibility, integration and automation, Role of Integrated and automated material handling systems, Typical FMS operation, IT based Tools: Computer simulation and AI for FMS, Group technology, Decision Support Systems, Design, Planning, Scheduling and Control Issues in FMS, Real time control strategies, Various FMS configurations, Computer configurations, FMS as mini-CIM, Benefits and Justification for FMS, Future challenges and research issues etc.

MEL426 Materials Management
4 credits (3-0-2)
Pre-requisites: MET420 & MEL221
Introduction, Relevance of Materials Management, Need for Integrated approach, Deterministic models: EOQ, EPQ, Discount, backlogging, multi-item models etc., sensitivity analysis, basic systems of inventory management , inventory costing. Aggregate inventory models, Stochastic inventory models, service level, single period model, etc., Role of uncertainty, Selective Inventory control. Material planning, forecasting, Warehousing, Storage etc., documentation for purchasing etc. MRP- concepts, logic, computerized models, implementation issues, case studies. JIT-Philosophy, logic, applications, implementation. Vendor selection, and evaluation, Vendor relations, consolidation of vendor base, single sourcing. Information systems for Materials, Documentation , e-procurement and internet based purchasing, e-commerce and materials management. Organizational issues, and evaluation of materials function.

MEL427 Manufacturing Economics and Analysis
4 credits (3-0-2)
Pre-requisites: MET420 & MEL221
Basics of Engineering economic analysis, concepts of varous types of costs, Decision making: Investment in a new machine, Replacement of the existing machine, Make-or-buy, break-even point, Decision about the product mix, Justifying the investment in advanced manufacturing technology, Various economic measure: NPW, IRR, Pay-back period etc.

Concept and various methods of depreciation, tax considerations, Stochasticity analysis.

Multi-attribute decision-making framework , concept of utility. The traditional accounting system (standard costing) and contemporary costing systems such as Activity Based Costing (ABC), Target Costing, and Information system required for analysis.

MEL431 CNC Machines and Programming
4 credits (3-0-2)
Pre-requisites: MEL331 / MEL233
An overview of CNC machines - need, benefits and limitations, classification of CNC machines, Constructional features of CNC machines, CNC part programming - Preparatory and Miscellaneous codes, transformations, subroutines, canned cycles for CNC lathe and milling, CNC program verification tools, CNC program generation from CAD, CNC controller and motion control in CNC system, Applications of CNC and recent advances in CNC machines.

MEL432 Microprocessor Applications in Manufacturing
4 credits (3-0-2)
Pre-requisites: (MET410 / MET420) & (EEL101 / EEL102)
Overlaps with: MEL411/EEL375/CSP413
Review of manufacturing and need and integration of microprocessor applications. Digital electronics review: number system, gates, flip-flops, counters, registers, tri-state concept, TTL and CMOS circuits, memories, op-amps, comparators, etc.

Microprocessors: Microprocessor architecture and computer systems, timing diagrams and machine cycles, interrupts, instruction set, memory and I/O interfacing, programming techniques, PPI, Timer/Counters, Serial Interfacing andcommunications, Interfacing to keyboards and displays, Standard busses.Microcontrollers and their applications. 8051 architecture and instruction set.

Microprocessor based measurement and control: D/A and A/D conversion, data acquisition systems, optical interrupters and couplers, incremental encoders, interfacing of motors and transducers, open loop and closed loop systems, PID control, motion control and robotics.

Case studies of applications in process and discrete manufacturing.

MEL433 Micro- and Nano-Manufacturing
4 credits (3-0-2)
Pre-requisites: MEL120 and EC 90
An overview of micro and nano mechanical systems and their applications in Mechanical Engineering, MEMS Microfabrication methods, Silicon Micromachining methods, Laser Micromachining methods, Mechanical Micromachining techniques, Nanomanufacturing methods, CAD/CAM Tools for Micro- and Nanomanufactuirng processes.

MEL434 Design for Manufacturing and Assembly
4 credits (3-0-2)
Pre-requisites: MEL331 / MEL233 and EC 90
An overview of three stages of product design, generating and evaluating conceptual alternatives from manufacturability point of view, selection of materials and processes, Evaluating part configurations for manufacturability, Evaluating parametric designs for manufacturability, DFM analysis for various manufacturing processes, Product design for manual assembly, product design for high-speed automatic assembly and product design for robot assembly.

MEL435 Geometric Modelling for Manufacturing
4 credits (3-0-2)
Pre-requisites: MEP201 and EC 90
Geometric representation of curves, surfaces and solids, Machining of free-form surfaces from geometric models, geometric modeling for die/mold design, geometric model driven process simulation and process planning, use of geometric models in inspection of curved geometries and reverse engineering, realization of free-form solids by layered manufacturing, computational geometry for manufacturing and inspection.

MEL436 Injection Molding and Mould Design
4 credits (2-0-4)
Pre-requisites: MEL311
Nature of engineering plastics, visco-elasticity, design methods and grade selection

Principles of Injection Molding, Injection molding machine and types, capacity and clamping tonnage, mold size, plasticating extruder concepts, molding properties and control parameters, molding cycle.

Injection Molds for thermoplastics, cavity and core- integer and insert type, product consideration, material consideration, shrinkage, flow length, mold temperature, molding stresses, parting line, feeding system design - sprue, runner, gate, weld line strength, ejection system design, mold cooling systems, runnerless molding, gas assisted and thermosets molding.

Exercises on CAD/ CAM of molds, mold flow analysis, molding of articles, process control and defect identification.

MEL441 Modeling and Experiments in Heat Transfer
4 credits (2-0-4)
Pre-requisites: MEP341 & MEL242
Introduction Geometrical and physical models of heat transfer applications, comparison with experimental data, assumptions and their implications. Property data and its modeling. Mathematical models: algebraic, ordinary and partial differential equations, boundary and initial conditions, solution methodologies. Results: representation and interpretation, uncertainty and error bands. Heat transfer experiments: design, uncertainty analysis, selection of geometrical and physical parameters, engineering drawings, fabrication and instrumentation, rig calibration. Temperature, pressure and flow rate measurements. Systemic errors in temperature measurement: thermocouple and thermowell conduction, radiation and other phenomena. Data acquisition systems: basics and applications. Project-type work involving modeling, and designing and performing experiments related to heat transfer applications.

MEL442 Thermal Analysis of Bio-systems
4 credits (3-0-2)
Pre-requisites: MEL242 and EC 90
Introduction. Bio-fluid dynamics: Blood system network and physiology, blood rheology, Vessel structure and mechanical properties. Heart and pumping process. Blood flow in body tissues. Engineering applications – dialysis, heart-lung machines. Lung and airways system network and physiology. Air and particle flow in airway passages, Alveolar dynamics. Eye, ear and nose system. Fluid mechanics of flight and swimming. Heat transfer: Body temperature and moisture regulation, heat balance and control system, applications to abnormal conditions. Bioheat equation, temperature distribution in tissue, applications to abnormal situations. Heat transfer in animals, fish, birds and insects. Thermodynamics of muscle. Micro-scale heat transfer and bio-systems. Properties of tissue. Laws, codes and regulations. Applications, plants, food processing, eco-systems.

MEC601 Mechanical Engineering Seminars
(Non-credit Audit) 1 credit (0-1-0)
The seminar series will be a mix of talks by faculty, students (Ph.D. and M.Tech.) and guest speakers from industry and academia on contemporary topics broadly related to thermal engineering. In their 4th semester every second year M.Tech. (Thermal Engg.) student will make a presentation. Each session will comprise about 40-45 minutes of presentation followed by an interactive session. There will be one seminar per week throughout the semester. A faculty member will coordinate the series. Each student will register for this course every semester. Pass/Fail will be on the basis of attendance.

MEP601 Introduction to Computers and Programming
(Non-credit Audit) 2 credits (0-0-4)
Operating system and system software. Application software. Hardware-controller software, drivers. Viruses and other system control programs. Hardware problems and trouble shooting; Computer networks and connectivity. Introduction to institute computing facilities and department computer resources.Introduction to Windows, Windows-NT and Linux/Unix environments. Concepts of progra-mming: flow-charting, pseudocoding, coding, entry, compilation, debugging and testing. Modularity and program structure. Syntax rules of C/C++/ JAVA languages. Simple program tutorials. Introduction to compilers available in department and institute. Preparing user and programmer manuals. Office Software: Word processing, spreadsheets, presentations. Mathe-matical Software. Modeling and drafting software. Data acquisition softwares. Specialist softwares: property tables, CFD, FEM. Post-processing and plotting softwares.

MEL626 Mechanical Equipment in Power Plants
3 credits (3-0-0)
Recapitulation of basics. Feasibility studies. Systems and equipment– fuel, ash, flue gas, steam, condensate, boiler feedwater, cooling water,

lubrication and control, generator cooling, HVAC, material handling, water treatment, hydrogen, compressed air, fire fighting. Equipment– turbine, pumps, condenser, deaerator, feedwater heater and other heat exchangers, coal mills, vacuum pumps, piping, C&I, safety. Operation, maintenance and condition monitoring. Future trends.

MEL661 Materials Management
3 credits (2-0-2)
Introduction to materials productivity and role of materials management techniques in improved materials productivity. Cost reduction and value improvement. Role of purchasing in cost reduction. Value analysis for right choice and rationalisation of materials. Purchasing research identification of right sources of supplies. Vendor rating. Standardisation and variety reduction. Negotiations and purchase. Price analysis. Organisation of purchasing function. Product explosion. Materials requirements planning. Make or buy decision. Incoming materials control acceptance, sampling, inspection. Vendor certification plans. Vendor and supply reliability.

Inventory management. ABC-VED analysis. Various inventory models. Inventory models with quantity discount. Exchange curve concept and coverage analysis. JIT. Infor-mation systems for inventory management. Stores management and warehousing. Optimal stocking and issuing policies. Inventory management of perishable commodities. Surplus management. Design of inventory distribution systems. Monitoring MM effectiveness. Case studies.

MEL667 Long Range Planning
3 credits (3-0-0)
Introduction. Nature of planning. Strategic/tactical planning. Systems approach. Choice of corporate objectives. SWOT analysis.

Technological forecasting using Delphi technique, growth curves, trend extrapolation. Combining forecasts using cross-impact analysis. Causal models for forecasting. Scenario building. System dynamics for long range planning.

Normative methods including relevance trees. Morphological models and mission-flow diagrams. Policy and strategic planning. Capital budgeting. Corporate planning under conditions of risk and uncertainty. Portfolio selection. Planning research and development. Case studies.

MEL671 Value Engineering
3 credits (2-0-2)
Introductory concepts in value and costs value analysis. Value engineering and value assurance. Product lifecycle and value-oriented efforts. Value engineering job plan. Value tests. Techniques of value engineering. Value analysis and decision theory. Design tree and decision matrix. Purchase price analysis. Evaluation of value alternatives. FAST diagramming. Function-cost matrix, matrix evaluation. Brain storming and creativity.

Elements of product cost and cost classification. Investment criteria in value analysis. Case studies in value engineering.

MEL674 Principles of Management
3 credits (3-0-0)
Introduction to management. Theories of management : Traditional behavioural, contingency and systems approach. Organisation as a system. Interaction with external environment. Managerial decision-making and MIS. Planning approach to organisational analysis, design of organisation structure; job design and enrichment; job evaluation and merit rating. Motivation and productivity. Theories of motivation, leadership styles and managerial grid. Co-ordination, monitoring and control in organisations. Techniques of control. Japanese management techniques. Case studies.

MEP691 Basic Mechanical Laboratory
1 credit (0-0-2)
Basic experiments related to thermodynamics, fluid mechanics and heat transfer.

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MED700 Design Project

4 credits (0-1-6)

Formulation of project team - students from different programs (maximum 2) and one or more faculty facilitators (to be done in the preceding semester). Selection of a product/machine/device from engineering industry for study–the life cycle should encompass aspects of thermal and mechanical design, and manufacturing. Setting objectives, making project schedule, and record management process. Some examples of products: centrifugal pump, heat exchanger, turbine blade, control system, cooling tower, burner, instrument.

Development of conceptual alternatives and selecting one for detailed working; conceptual design; detailed design using knowledge of PG core and elective courses, and design and production engineering courses; use of codes and standards; preparation of engineering drawings; process planning; manufacturing, assembly, testing, and as possible, testing to failure, and failure analysis; documentation.

MEL703 Advanced Thermodynamics

3 credits (3-0-0)

Recapitulation of fundamentals. The two laws of thermodynamics–Caratheodory's formulation, analysis of typical simple closed systems, analysis of open systems–exergy analysis. Multi-component systems–concepts of fugacity, chemical potential. General conditions for thermodynamic equilibrium–instability of thermodynamic equilibrium and phase transition. Thermodynamics of reactive mixtures. Elements of irreversible thermodynamics.

MEL705 Experimental Methods in Thermal Engineering

4 credits (2-0-4)

Statistics: Distributions, estimators, confidence levels, sample size, test of hypothesis, Goodness-of-fit test Chauvenet's criteria; Regression analysis, co-relations. Uncertainty analysis. Design of experiments.

Instruments: Specifications. Static and dynamic characteristics. Instruments for measuring distance, profile, pressure, temperature, velocity, flow rate, level, speed, force, torque, noise, chemical analyses. Estimation of systematic errors.

Signal conditioning, data acquisition and analysis. Transducers, A-D & D-A convertors, interfacing with computers and PLCs.

Control theory fundamentals: Steady state and transient response, Stability analysis Routh and Nyquist criteria, Root locus method. Sequence and programmable logic controllers. Hydraulic, pneumatic and electrical systems.

Laboratory: Calibration. Experiments related to heat transfer, fluid mechanics, thermodynamics and gas dynamics. Project on experiment design including drawings, wiring diagrams, selection of instruments and computer interfacing. Use of various controllers and actuators. Data management and presentation.

MEL707 Applied Mathematics for Mechanical Engineers

3 credits (2-0-2)

In relation to mechanical engineering applications, such as, heat transfer, fluid mechanics, vibrations, dynamics and others, the following topics will be covered:

Partial differential equations - characteristics and classification of 2nd order PDEs. separation of variables, special functions, eigenfunction expansions, Fourier integrals and transforms, Laplace transfroms, methods of characteristics, self-similarity.

Linear algebra: matrix theory, solution of linear system of algebraic and differential equations; round-off errors, pivoting and ill-conditioned matrices. Eigenvalues and eigenvectors. Unitary, hermitian and normal matrices.

Numerical Methods: Lagrange interpolation, splines. integration–trapezoid, Romberg, Gauss, adaptive quadrature. Explicit and implicit methods, multi-step methods, Runge-Kutta and predictor-corrector methods,

boundary value problems, eigenvalue problems, systems of differential equations, stiffness. Accuracy, stability and convergence. Alternating direction implicit methods. Non-linear equations.

MEL708 Combustion Generated Pollution and Control

4 credits (3-0-2)

Generation and nature of pollutants from various combustion sources, their effects on health and the environment. Emission indices. Thermochemistry of pollutant fomation, stiochiometry, chemical thermodynamics, kinetics. Pollutants from I.C. engines, power plants, domestic and other sources. Meteorology and dispersion of polutants, instruments for pollutant measurement and monitoring. Legislation and emission standards.

MEL709 Heat Exchangers

4 credits (3-0-2)

Applications. Basic design methodologies – LMTD and effective-ness-NTU methods. Overall heat transfer coefficient, fouling. Correlations for heat transfer coefficient and friction factor. Classification and types of heat exchangers and construction details. Design and rating of double pipe heat exchangers, compact heat exchangers, plate and heat pipe type, condensers, cooling towers. Heat exchanger standards and testing, Heat transfer enhancement and efficient surfaces. Use of commercial software packages for design and analysis, optimization.

MED710 Mini Project

3 credits (0-3-0)

Identification of faculty supervisor(s), topic, objectives, deliverables and work plan (in the preceding semester prior to registration); regular work during the semester with weekly coordination meetings (about 1 hour) with the faculty supervisor; and an end-semester demonstration to all faculty and students. Grade to be decided on the basis of a mid-term and an end-semester presentation following the open demonstration vis-a-vis the approved work plan. The topic should be of advanced standing requiring use of knowledge from program core courses and be preferably hardware oriented. The mini-project would be available aerosols; codes and standards.

Only in the 2nd and 3rd semesters and should be carried out individually. In the 3rd semester, the topic will have to be different from the major project.

MEL710 Air-conditioning

4 credits (3-0-2)

Introduction. Psychometric processes. Air-conditioning calculations. Comfort scales, design conditions, solar heat gains. Cooling and heating load calculations. Design of air-conditioning equipment–cooling and dehumidifying coils, spray washers. Evaporative air cooling. Desiccant dehumidification. Air distribution system–duct design, inlets/outlets, air handling units, pipe sizing. Energy recovery and thermal storage. Indoor air quality. Various types of air-conditioning systems. Building management systems, Energy monitoring.

MEL711 Refrigeration and Air-conditioning Technologies

4 credits (3-0-2)

Introduction. Environmental impact of refrigerants. Analysis of VCR cycles–multistage, multievaporator, cascade systems, supercritical and other advanced cycles. Properties and selection of pure and mixed refrigerants. Properties of binary mixtures. Analysis of vapor absorption cycles–Aqua ammonia and LiBr water cycles. Air cycle refrigeration, vortex tube, steam jet ejector refrigeration, thermoelectric refrigeration, cryogenics, desiccant cooling–solid and liquid systems, hybrid systems, heat pumps and heat transformers.

MEL712 Advanced Power Plant Cycles

4 credits (2-0-4)

Review of various ideal cycles–Rankine and Brayton–and fuel-air cycles. Thermodynamics optimization of design parameters. Real cycle effects–internal and external irreversibilitites, pressure drops, heat loss, condenser air leakage, fouling of heat transfer surfaces, combustion losses–and their impact on the thermodynamic cycle. Optimization of

real and double reheat cycles. Analysis of off-design performance. Combined cycles–ideal and real cycles–thermodynamic analysis. Design of alternate schemes for combined cycles–single, dual and triple pressure cycles, and their optimization. Retrofit of ageing power plants. Parametric analysis–effects of gas and steam cycle variables. Binary vapour and Kalina cycles. Thermochemical and H_2-O_2 cycles. Cycles for nuclear power plants (PWR, BWR, PHWR, FBR). All simulations will involve extensive use of numerical techniques as part of laboratory work.

MEL713 Design of I.C. Engine Components and Sub-systems
4 credits (3-0-2)
Introduction to different types of I.C. engine systems. Engine design and operating parameters. Fuels for engines and their characteristics. Fuel-air mixing, gas exchange, combustion. Fuel injection systems. Ignition and combustion. Combustion chamber designs for spark-ignition and compression-ignition engines. Engine cooling and cooling system design. Engine lubrication systems. Emission control and electronic management systems. Design of supercharged engines. Testing and performance of I.C. engines.

MEL714 Thermal and Nuclear Steam Power Plants
4 credits (3-0-2)
Recapitulation: types of power plants, cycles, site and equipment selection, feasibility studies. Fuels and combustion. Fuel and air handling equipment. Steam generators, supercritical and LEBS. Nuclear power plants–reaction physics, type and sizing of reactors and steam generators. Turbines, feedwater heaters, condensers, deaeration–sizing and performance calculations. Cooling water systems–sizing and load calculations. Cogeneration systems–types and sizing. Control and instrumentation. Environmental and safety aspects. Operation, performance and condition monitoring. Future trends.

MEL715 Gas Dynamics
4 credits (3-0-2)
Recapitulation of fundamentals, introduction to numerical analysis of compressible flow. Oblique shocks, compression and expansion waves, Prandtl Meyer expansion. Interaction of shock waves and shock-boundary layer interaction. Flow with friction and heat transfer. Introduction to 1-D transient and 2-D compressible flow. Method of characteristics. Applications in measurement of subsonic and supersonic flows, wind tunnels, medical, aircraft and rocket propulsion. Introduction to hypersonic, high-temperature flows and astro gas dynamics.

MEL716 Micro/Nano Scale Heat Transfer
4 credits (3-0-2)
Introduction to micro/nano scale transport phenomena, size effect behaviour, overview of Engg. applications, fundamentals of micro/nano scale fluid mechanics and heat transfer - kinetic theory, quantum mechanics considerations, Boltzmann transport equation, molecular dynamics modelling, microfluidics, Knudsen number, slip theory, micro/nano scale heat conduction thermal conductivity models, specific heat, thin films, convection in microtubes and channels, boiling and condensation, nanoparticles and nanofluids - preparation and transport properties, microscale radiative heat transfer - modelling, properties, measurements at microscale, Engg. applications- flow in microchannels, micro heat pipes, microelectronics, superconducting films, radiation etc.

MEP720 Advanced Mechanical Laboratory
3 credits (0-1-4)
Basic and advanced measurements and their use in fluid mechanics, heat transfer, emission and vibration applications. Introduction to computers and their use for preparing engineering drawings. Introduction to mathematical packages. Use of computers and microprocessors for data acquisition. Introduction to advanced computational packages for fluid flow, heat transfer, combustion, stress analysis and dynamics calculations.

MEL725 Power Plant Steam Generators
3 credits (3-0-0)
Recapitulation of basics, design methodology, fuel preparation and combustion system design. Burners - coal, oil and gas, steam-water system design, circulation beat exchange components, fouling and corrosion, draft system (air and flue gas) design, boiler controls. Mechanical design of pressure parts, heat recovery boiler-design, water quality and its control, case studies.

MEL727 Power Plant Turbo-machinery
3 credits (3-0-0)
Recapitulation of basic fluid mechanics and thermodynamics. Introduction to turbo-machine flow phenomena, dimensional analysis, design and performance parameters, Flow through nozzle and diffuser cascades, wind tunnel tests, loss correlations. Stages, velocity triangles, degree of reaction, impulse and reaction, work and efficiency expressions. Losses, 3-D flow. Axial and centrifugal compressors and fans. Surge, stall. Hydraulic turbines and pumps.

MEL730 Hydroelectric Power Plants
3 credits (3-0-0)
Introduction and historical perspective. Basic features of a hydroelectric power system - dam, power house, reservoir. Feasibility report preparation. Hydrology - topology, rainfall, reservoir simulation. Site investigations geology, seismic activity, silting. Types of dams and their features. Hydraulic turbines- Pelton wheel, Francis turbine, Kaplan and propeller turbines, design principles, fluid dynamics, control and regulation. Generator and auxiliaries-governing, lubrication, cooling and sealing systems. Safety and interlock systems. Turbine testing, Small, mini and micro-hydropower systems. Pumped storage systems. Techno-socio-economic aspects of hydropower plants.

MEL731 Design of Mechanisms and Manipulators
4 credits (3-0-2)
Classification of closed- and open-loop kinematic systems, Definition of mechanisms and manipulators, Kinematic constraints, Degree of freedom (DOF) and Mobility; DH parameters, Coordinate transformations, Matrix methods; Structural analysis and synthesis of mechanisms; Forward kinematics of robot manipulators with examples; Inverse kinematics; Jacobian and singularity; Alternative design solutions of mechanisms and manipulators; Evaluation and selection of optimum mechanism; Type and number synthesis, Design of mechanisms; Indexes of merit; Graphical, Algebraic and Optimization techniques; Design of function, path, and motion generators; Dynamic considerations, Rigid body dynamics, Newton-Euler formulation, Equations of motion; Methodologies for inverse and forward dynamics.

Practicals will include numerical problem solutions; Basic practices in MATLAB, ADAMS and ULTRAGRIP software; Analysis and Synthesis using software.

MEL732 Machine Tool Design
4 credits (3-0-2)
Design requirements of machine tools. A design approach for machine tools. Identification and quantification of objectives and constraints in machine tool design. Estimation of power requirements and selection of motor for metal cutting machine tool spindles. Design of gearbox, spindle and guideways. Principles of design of structural components, namely, head stock, tail stock, carriage, table, knee, column and overarms to achieve desired static & fatigue strength, stiffness, dynamic characteristics and other requirements. Exercises on the design of machine tools using existing CAD software packages.

Introduction to computer integrated manufacturing systems and CNC machine tools. Design/selection of linear motion systems, ball, screws, CNC feedback devices, controllers, feed drives and servomotors for CNC machine tools. Recent developments in CNC and other machine tools.

MEL733 Vibration Engineering
4 credits (3-0-2)

Introduction to unwanted mechanical vibrations and their harmful effects including those on human beings. Vibration control strategies and case studies. Experimental and theoretical routes to vibration engineering. Vibration Testing. Spatial, Modal and Response models of vibrating systems. Lumped parameter and distributed parameter modelling of mechanical vibratory systems. Free vibrations and Forced response solutions of Single- and multi- degree- of-freedom models including modelling of damping. Applications of numerical procedures to determine natural frequencies and mode shapes. Finite Element Method for dynamic analysis. Distributed parameter models of rods, bars and beams.

Vibration control solutions. Balancing of rotating and reciprocating machines. Design of vibration isolators. Auxiliary mass systems including tuned dampers for vibration control. Application of damping treatment for vibration control in machines and structures. Dynamic instability control. Introduction to Modal testing, model updating and structural dynamic modification to improve dynamic design of machine structures. Active control of vibrations. Introduction to NVH and its control.

MEL734 Noise Engineering
4 credits (3-0-2)

Introduction to Engineering acoustics. Review of normal mode analysis random vibration and spectral analysis. Wave approach to sound Noise measurement and instrumentation standards. Sound pressure, power and intensity. Noise radiation from vibrating bodies. Noise source identification. Noise in machines and machine elements. Fan and flow noise. Combustion noise. Noise in piping systems. Industrial noise. Jet noise Response of structures to noise Active and passive noise control. Human factors in noise engineerng.

Practicals: Measurement of sound pressure, power and intensity. Directivity of noise sources. Estimation of reverberation time of halls. Design for noise control. Verification of inverse square law. Addition of two noise sources.

MEL735 Computer Methods in Mechanical Design
4 credits (3-0-2)

Introduction and overview. Need and Scope of Computer Aided Machine Design. Role of Geometric Modelling, FE and Optimization; Principles of interactive computer graphics, and overview of hardware available for use in CAD; Geometric transformations and Projections. Windowing and view-porting; Geometric modeling; Modelling of curves, cubics, splines, beziers and b-splines;

Modeling of surfaces; Modeling of solids–b-rep, CSG, octree, feature based modelin; Introduction to the Finite Element Method, principle of potential energy; 1D elements, Derivation of Stiffness and Mass matrices for a bar, a beam and a shaft, Comparison with Analytical results; Solution of static problems and case studies in stress analysis of mechanical components; FEA using 2D and 3D elements; Plain strain and plain stress problems, FE using plates / shell elements; Importance of Finite element mesh, Automatic meshing techniques; Interfacing with CAD oftware, Case studies using FEM for Design of simple element geometries such as a tapered bar, a plate with a hole and a spanner;

Introduction to Dynamic analysis; Limitations of FEM, Introduction to Non-linear problems and FEA for plastic materials.

Practicals:Practice of transformation. Use of CAD Package for developing typical objects using Boolean, and sweep operations on primitives, use of CAD models for other applcations. Development of FEM models for Static / Dynamic analysis of a bar, beam and a shaft. Practice in using an FEM Software on other real life problems like spanners, connecting rods etc.

MEL736 Automotive Design
4 credits (3-0-2)

Design requirement of Automobile (power-speed curves), Engine as a system and its subsystems, Lubrication system, Fuel injection systems, Cooling System; Design requirements of the automobile transmission.

Automatic transmissions; Dynamic considerations in designing of suspension system; Modern systems of suspensions; Kinematic requirements of a steering mechanism; Need for Power Steering; Braking requirements of an automobile. Brake materials; Modeling and simulation of different subsystems, e.g., suspension system, etc.; Instrumentation and Control—Gauges (Speedometer, Oil, temperature indicators, etc.); Microprocessor controlled units; Safety and comfort aspects in the automotive component designs.

Practicals: Illustrative designs of subsystems, e.g., manual transmission, suspension system, steering mechanism, and others. In these exercises, the use of available software packages, like ADAMS, MATLAB, will be undertaken; System integration—Steps and methodologies to put the designed subsystems together, Wheel alignment and balancing; Suspension and steering adjustments; Issues related to safety; Crash modelling of vehicles.

MEL737 Advanced Mechanical Engineering Design
4 credits (3-0-2)

Introduction to Advanced Mechanical Engineering Design. Review of materials & processes for machine elements. Case studies of mechanical engineering design failures. Review of static strength failure analysis - theories of failure including von-Mises theory based strength design. High cycle and low cycle fatigue. Fatigue Strength Design of Mech. Equipment Elements. Exercises of fatigue design of shafting and gears. Surface fatigue design failures. Exercises of surface fatigue design of rolling contact bearings including linear bearings. Stiffness based design. Design for creep. Combined creep and fatigue failure prevention. Design to prevent buckling and instability. Tribodesign with applications to design of sliding bearings and mechanical seals. Selection of lubrication sytems. Design for corrosion, wear, hydrogen embrittlement, fretting fatigue and other combined modes of mechanical failure. Dynamically sound designs of machine elements like springs and shafts. Introduction to dynamic design of mech. equipment and its implementation.

MEL738 Dynamics of Multibody Systems
4 credits (3-0-2)

Overview of kinematic descriptions, Serial, tree, and closed-loop chains; Degrees of freedom. Kinematic constraints of rigid and flexible systems; Lagrange, Newton-Euler, Kane's equations, and orthogonal complement approaches of deriving a dynamic model for tree and closed-loop systems consisting of rigid and/or flexible bodies; Dynamics analyses using classical approximation, FEM, and other computer software, e.g. ADAMS.

MEL739 Robotics
4 credits (3-0-2)

Review of serial robotic manipulators. Classification of parallel robots (Stewart platform, wheeled mobile robots, walking machines, etc.). Algorithms for inverse and forward kinematic/dynamic analyses of parallel robots. Kinematic design of serial and parallel robots based on singularity, workspace, manipulability, dexterity, etc. Mechanical design of robot links and joints. Introduction to control of robotic systems.

Practicals: Experiments with existing robots.

MEL740 Instrumentation and Automatic Control Systems
4 credits (3-0-2)

Classification and representation of control systems. Influence of type of control on steady state and transient response. Time and frequency domain analysis. Stability analysis using Routh & Nyquist criteria. Root locus method.Modern Control theory. Sequence control and programmable logic controllers. Control components, Comparators, hydraulic, pneumatic and electrical types of controllers, servomotors.

Electromechanical and electro-optical transducers and control elements. Signal conditioning and indicating / recording elements.

Computer based data acquisition systems , A-D and D -A converters. Microprocessor applications in measurement and control. Static and dynamic analysis of instrument systems. Signal and systems analysis. FFT analysers. Current developments in measurement and control of motion, force, torque, pressure, temperature, flow, noise etc. Virtual instrumentation, Laser Based intrumentation.

Practicals: Static and dynamic Behaviour of some important trnsduceers, calibration procedure, Development of Computer aided experimentation systems. Experimental studies on Hydraulic, Pnumatic, Electrical controller, Electromechanical actuators.

MEL741 Blade and Disc Dynamics
4 credits (3-0-2)
Types of blades and discs in turbomachines. Bending, torsional and coupled modes in blades. Radial and circumferential modes in discs. Effect of taper, twist, asymmetry of crossection, stagger angle and support stiffness in blades. Analytical and computer aided analysis methods, including FEM for dynamic analysis of blades and discs. Small aspect ratio blades analysis using plate models. Blade group frequencies and mode shapes. Damping mechanisms in blades. Steady state and transient response. Coupled disc, blade and shroud system. Cumulative damage calculation and blade life estimation. Computational and experimental techniques of analysis.

MEL742 Optimum Design of Mechanical Systems
4 credits (3-0-2)
Introduction to Optimum design of Mechanical Systems. Need of optimization of preliminary design by identification of design requirements and by use of appropriate design strategy. Introduction to detail design optimization by simulation, prototyping and optimum selection of configuration, materials and processes.

Mechanical System Design problem-economic political environment, issues of human safety & welfare, and professional ethics.

Optimum mechanical design concepts. Overview and application of optimisation methods to machine elements and mechanical system design. Prototyping, simulation, and use of standards for detail design optimization. Optimum selection of material & processes in mechanical design using material selection charts and optimisation methods. Optimising product design functionality, aesthetics and economics by employing industrial design principles and by suitable selection of material & processing including use of polymers, composites and other non metallic materials.

MEL743 Plant Equipment Design
4 credits (3-0-2)
Introduction to various kinds of plant equipment. Technological considerations in plant equipment design. Special consi-derations for typical industries such as food processing, chemical industry. Rolling mills, mass production industries and power plants.

Pressure vessel types and shapes. Design analysis of thin walled vessel for low pressure applications. Design analysis of High pressure vessels. Vessel opening, closures and seals. Manufacturing considerations for pressure vessels.

Configuration of various kinds of pumps used in process plants. Pump design considera-tions. Centrifugal pump selection Design of pipes. Piping joints, Layout of piping systems.

Material Handling Equipment, Types and use. Design considerations for hoisting equipment, Surface and Overhead equipment Stackers and elevators.

Design consideration in rotating machinery, modelling and analysis of rotor bearing system, bearing characteristics and selection, placement of critical speeds, optimum dynamic response, check for stability, effect of seals, foundation effects. Materials and manufacturing considerations in design of rotating machinery. In the excercises the use of available software packages should be undertaken.

MEL744 Design for Manufacture and Assembly
4 credits (3-0-2)
Life cycle of Mechanical Equipment Design. Requirements of life cycle personnel like customer, management, marketing, manufacturing, trans-portation, etc. Need to meet constraints of manufacturing. Advantages of designing for manufacturing and assembly to improve product quality, cost and time to the market. Design for Manufacture and Assembly

[DFMA] strategies. DFMA application case studies. Product design for manual assembly. Design for high speed automatic and robot assembly. Design for machining. Design for injection moulding, die casting and powder metal processing. Design for sheet metal working. Computer aided DFMA. Architecture of DFMA and its implementation for Mechanical system Design.

MEL746 Design for Noise, Vibration and Harshness
4 credits (3-0-2)
Fundamentals of Vibrations and their manifestations in real life systems. Review of Design of a Vibration Absorber. Vibration Reduction Measures, Unconstrained and cosntrained layer damping treatment, add on dampers, and stiffners. Changing the dynamic characteristics of a structure, Structural dynamics modification. Predicting the modification (dynamic design) Design of Isolators in machine foundations. Role of materials damping. Balancing of rotating machinery. Rigid and flexible rotor balancing. Active Vibrations control.

Introduction of wave analysis of structures and spaces. , Characteristics of Duct and Cabin Noise. Stationary modes. Random noise. Measures of a sound accoustic design, importance of reverberations time. Various types of acoustic testing chambers. Noise measurement and control instruments. Sound Intensity Mapping Noise isolation design. Noise absorber design. Design of silencers, mufflers. Acoustic Design of Buildings.

MEL748 Tribological Systems Design
4 credits (3-0-2)
Lubrication, Friction and Wear aspects in Design; Tribological Surfaces - Roughness and Mechanisms of Lubrication, Friction & Wear; Regimes of Lubrication; Viscosity - its representation and Measurement; Apparent Viscosity; Selection of Bearings - Rubbing, Fluid Film, Rolling Element; Lubricants - Types and Selection; Bearing Design - Rubbing, Fluid Film Journal and Thurst, Dynamically Loaded, Rolling Element; Lubrication Systems - Selection and Design Considerations; Maintenance of Bearings; Seals; Design of Clutches and Brakes; Linear Bearing Design; Slideways; Material Considerations for Various Applications.

MEL749 Mechatronic Product Design
4 credits (3-0-2)
Introduction to mechatronic systems and components. Principles of basic electronics. Microprocessors and their applications, integrated circuits, sensors, actuators, and other electrical/electronic hardware in mechatronic systems. Principles of electronic/system communication.

Interfacing. DA and AD converters, software and hardware principles and tools to build mechatronic systems.

Design and selection of mechatronic elements namely sensors like encoders and resolvers; stepper and servomotors, ball screws, solenoid like actuators, and controllers with applications to CNC systems, robotics, consumer electronic products etc. Design of a mechatronic product using available software CAD packages.

MEL751 Industrial Engineering and Systems
4 credits (3-0-2)
Industrial Engineering.: Definition and Evolution ,Understanding Industrial System Focus: Production/Service System . Performance measures of a Production System -Production, Productivity, Efficiency, Effectiveness, Quality, Flexibility, Agility etc.. Classical Industrial Engineering -Work Study: Method Study and Time Study, Human Factors, Ergonomics, Motivation Recent and Emerging Applications of IE -Role of IT in Systems– MIS, FMS etc. ;Japanese Influences: Just in Time (JIT), Kanban etc.; Increasing Integration in Industrial Enterprises: From MRP to ERP to Supply Chain Management; Career Opportunities in Industrial Engineering.-Career Options, Types of Jobs and Employers, Entrepreneurship .Industrial Engineering Tool Kit.-Technical skills: IE problem Solving and OR. ;Human skills–Teamwork, Communication

skills.; IT skills - Decision Support System (DSS), Intelligent Systems. Engineering Managers, System and Process (ERP) Specialists, Change Managers.

MEL752 Quality Assurance
4 credits (3-0-2)
introduction to quality assurance and quality control, Various elements in Quality Assurance program, On-line and Off-line quality control, Statistical concepts in quality, probability distributions, Central limit theorem, Chance and assignable causes of quality variation, Process control charts for variables, Control chart parameters, Target process setting / Centering, Control limits and specification limits. Process capability studies, Capability indices, Quality remedial / Corrective actions, Special purpose control charts, Reject limits, Variables inspection and attributes Inspection, Control charts for attributes, Narrow limit gauging, Quality rating, Defects classification, Average run length, Sensitivity of control charts.

Sampling inspection for product acceptance, Single, double, multiple & sequential sampling schemes, OC, AOQ, ASN, and ATI curves, Design of sampling plans, Standard sampling systems, Economics of product inspection, Quality costs, ISO 9000 quality system, Product quality and reliability, Failure data analysis and life testing. Problems and illustrations in Quality Assurance.

MEL754 Operations Planning and Control
4 credits (3-0-2)
Generalised model of a production system, the national economy as a Leontief's input- output system, decisions in the life cycle of a production system, evaluation of investments in new product and services, risk analysis using decision trees, product mix decisions, deterministic and stochastic models, different kinds of production systems, mass, batch job and cellular production, location decisions: multi-criteria approach, mathematical models for facility location and layout, use of iso-cost lines in location decisions, demand forecasting using qualitative and quantitative methods, aggregate production planning, hierarchical production planning, materials requirements planning versus conventional inventory control.

MEL756 Supply Chain Management
4 credits (3-0-2)
Historical evolution of SCM, Supply Chain components: Inbound logistics, Operations, Outbound logistics, Forecasting, Inventory strategy, Transportation Strategy, Warehouse management. Information Strategy for SCM, Role of Information Technology in SCM, Performance measurement, Organization design and structure for effective supply chain.

MEL760 Project Management
3 credits (2-0-2)
Project as a goal fulfillment venture, projects versus routine production, life cycle of a project, generation of new project ideas, brainstorming, screening of ideas, project appraisal on various fronts: market and demand, technical feasibility, financial evaluation, ecological appraisal, multi-criteria evaluation of projects, work breakdown structure, project network development, project sheduling using PERT and CPM, floats and their interpretation, project simulation, project crashing and resource aggregation, leveling and allocation, project monitoring and control using earned value and the concept of critical chain, human factors in project management.

MEV760 Special Topics in Industrial Engineering
2 credits (2-0-0)
The contents for this course will vary from time to time based on the emergent industrial scenario. Concepts such as BPR, ERP, SCM and the practitioners view on the same will be presented through case studies and experience sharing sessions. There will be case studies, software demonstrations and experience sharing sessions from faculty (total 14 sessions each of 2 hour duration).

MEL761 Statistics for Decision Making
4 credits (3-0-2)
Fundamentals of probability theory and statistical inference used in engineering and applied science, descriptive statistics, Probability models, random variables, expectations, moment generating functions and its properties, conditional probability, useful discrete and continuous distributions, their properties and applications in Q-ing, reliability, quality control and simulation, law of large numbers, central limit theorem and its applications, case studies, statistical inference, confidence interval estimation, point estimation, case studies, concept of null hypothesis, testing of hypothesis, goodness of fit tests, linear regression, non-parametric test procedures, industrial applications, curve fitting and other techniques of estimation, introduction to software in statistics.

MEL762 Facility Planning and Plant Engineering
3 credits (2-0-2)
Plant location Factors and theories. Location of plant with multi-plant operation, locational dynamics, transportation model in plant location. Facilities planning types of layouts. Charts required for facilities planning. Role of templates in plant layout. Quantitative methods in process layouts. Computerized layout planning. CRAFT, CORELAP, ALDEP. Single and multi-facilities location and layout models. Min-max location. Location allocation models. Production and assembly line balancing. Various algorithms in assembly line balancing. Job enlargement in line production. Plant maintenance. Characteristics of optimal maintenance policies. Preventive maintenance policy selection. Manpower planning and scheduling for maintenance. Concepts in tero-technology. Case studies.

MEL763 Methods Engineering and Ergonomics
3 credits (2-0-2)
Introduction to work study & its techniques. Method Study, Motion study & Principles of Motion Economy, Work Measurement and its techniques of Time study. Production study. Work sampling, Standard Data systems, PMTS, Job Evaluation & Merit Rating and Wage Incentive payment systems.

Introduction to Ergonomics & Man Machine systems. Basic Ergonomics and work physiology, Measurement of work, Applied Ergonomics & work Design & work place layout.

MEL764 Human Factors Engineering
3 credits (2-0-2)
Introduction to Basic Ergonomics its physiological & psychological Aspects. Physical & Mental fatigue and measure-ment techniques , Design of Displays & control Anthropometry data & its application in design of Physical facilities & Equipment and work place, Paced and Unpaced working & their effects.

Concepts of H.R.D, safety, selection, and training aspects, Environmental aspects physical & psychological Design and effects.

MEL765 Operations Research-I
4 credits (3-0-2)
Introduction to operations research, its historical development, introduction to mathematical programming models and computational techniques, linear programming and simplex method, sensitivity analysis, transportation problem, dynamic programming ,Integer programming, goal programming, network analysis, some of the main stochastic models used in engineering and operations research applications: Poisson process, birth and death processes with applications in queuing models, inventory models.

MEL768 Quality Management: A Systems Perspective
3 credits (2-0-2)
Attributes of Quality, Evolution of Philosophy of Quality Management. Quality Assurance and Total Quality Management, Models of Quality Management, Customer Value Enhancement, Product Quality

Improvement, QFD, Taguchi Methods , 7 QC tools , Statistical Process Control, Acceptance Sampling, Service Quality, Tools and Techniques of Service Quality Improvement, Quality Costs,

Strategic Quality Planning, Quality in Non-Manufacturing Activities : Finance, Marketing, Human Resource Management, Administration, Quality System Implementation: ISO 9000, Quality Information Systems, Quality Audit & Reporting, Human Resource Management in TQM Environment, Case Studies.

MEL769 Metal Forming Analysis
4 credits (3-0-2)
Stress-strain relations in elastic and plastic deformations, Yield criteria for ductile metals, Work hardening and Anisotropy in yielding, Flow curves, Elements of theory of plasticity, Formulation of plastic deformation problems, Application of theory of plasticity for solving metal forming problems using slab method, Upper and lower bound methods, slip line field theory, extremium principles, Effect of temperature and strain rate in metal working, Friction and lubrication in cold and hot working, Technology and Analysis of important metal forming processes–Forging, Rolling, Extrusion, Wire Drawing, Sheet metal forming processes like Deep drawing, Stretch forming, Bending, Introduction to Finite Element Analysis of metal forming processes.

MEL770 Introduction to Stochastic Modeling and Simulation
4 credits (3-0-2)
Quick review : basic probability, random variables; Introduction to Discrete Time Markov Chains - definition and characterization, Transient Distributions, Limiting Behaviour, Cost models, First passage times, Applications/Case studies; Poisson Processes, Continous Time Markov Chains - Introduction, Transient and limiting behaviour, Cost models, Applications/Case studies; Simulation - basics, discrete event simulation, Monte Carlo Simulation, Variance Reduction Techniques, Applications to queuing, Finance Lab Activity : Problem solving, applications/case studies for the Markovian Theory component; Simulation software for simulation component.

MEL772 Metal Forming Technology
3 credits (3-0-0)
Technological advances in metal forming processes- forging, rolling, extrusion, wire drawing and sheet metal forming, Design of roll pass and rolling schedules, Description of typical cold rolling and hot rolling mill plants, Computer aided die design for forging, extrusion and wire drawing, Automation in metal forming processes, Recent developments in forming equipment (high speed presses etc.), Advances in sheet metal forming, Sheet metal die design, Formability evaluation, Unconventional forming processes like Hydrostatic extrusion, High energy rate forming processes, Hydro-forming of sheets and tubes, Powder forming, Finite Element Simulation of forming processes.

MEL775 IT in Manufacturing Enterprises
3 credits (3-0-0)
Production Systems, Manufacturing Enterprises as Systems, Appreciate the evolving manufacturing environment and multi-attributed competition: IT role Challenges and Opportunities, Evolving Role of Information Technology in Enterprises: P&I Implications, Technology Management Challenges, Technical Fundamentals: MIS in Manufacturing Enterprises, FMS (Flexible Manufacturing Systems), CIM Systems, Intelligent Manufacturing Systems, Concurrent Engineering and Extended Enterprises, ERP (Enterprise Resource Planning), E-Business and Supply Chain Management, Discrete Event Simulation and AI Applications in manufacturing enterprises, Implementation Issues, Future Trends, Careers etc.

MEL778 Design and Metallurgy of Welded Joints
4 credits (3-0-2)
Introduction to importance of welding in fabrication, Problems & difficulties in welded structures, How to obtain a sound welded structures and analysis, Properties for selection of materials, Characteristic properties and behaviour of commonly used materials, Effect of alloying

materials, Heat flow in welds, Heating and cooling cycles in welding, Effect on HAZ, Hot cracking, Development of phases, Microstructure etc, Causes and cures for various discontinuities & defects in weldments, Weldability, Weldability of commonly used materials, Mechanical testing of weldments, Service and fabrication weldability tests and their importance, Thermal stresses and distortion, Brittle fracture and fatigue in welded joints, NDT of welds, Introduction to engineering physical metallurgy, Joining metallurgy and microstructures, Joint preparation weld symbols, Weld joint designs for strength and quality, Automation in welding, Cost analysis.

MEL780 Casting Technology
4 credits (3-0-2)
Ferrous and Non-ferrous materials and their properties, Metal Matrix Composites and their properties and suitability as casting materials, Selection of materials for casting, melting of metals, Solidification of castings, casting design considerations, mould designs for sand and die castings, gating system design, riser design, casting defects: their causes and their removal, cleaning of castings, heat treatment of castings, inspection, repair and salvage of castings, quality control in foundries, special casting processes, Specific considerations to Grey CI, steel and non-ferrous foundry practices, Foundry Mechanization Pollution control in Foundries.

MEL781 Machining Processes and Analysis
4 credits (3-0-2)
Survey of various methods of metal removal, Mechanics of orthogonal cutting, nature of contact between chip and tool, stress distribution at chip-tool interface, controlled contact tools, Mechanics of oblique cutting, Thermal aspects of metal cutting, Cutting fluids, method of selection of fluids, Dry cutting, Tool wear, Wear theories, experimental methods, Tool life, Machinability, machining economics, Dynamometry, Abrasive Machining Processes, mechanics of grinding process, grinding wheel wear, High Speed Machining, Ultra-precision Machining and hard turning, Non-Traditional Machining Processes such as EDM, ECM, USM, EBM, AJM, IBM, WJM and LBM.

MEL783 Automation in Manufacturing
4 credits (3-0-2)
Modern developments in automation in manufacturing and its effect on global competitiveness, Need and implications of automation in Manufacturing, different types of production systems and automation, hard/fixed automation including process automation, Rapid prototyping and tooling. Hydraulic and pneumatic actuators, their design and control devices, sequence operation of hydraulic/pneumatic actuators, designing of complete systems with hydraulic, electro-hydrolic and digital control devices, applications in manufacturing, material handling systems, feeders, orienting and escapement devices, their analysis and design, Automatic assembly machines, designing for automatic assembly.

MEL784 CNC Technology and Programming
4 credits (3-0-2)
Introduction to NC/CNC/DNC and its role in FMS and CIMS, Basics elements of CNC system, CNC Hardware Elements including drives, actuators & sensors, Construction of modern CNC machine tool controllers, Introduction to Part Programming, Radius and Length Compensation Schemes, Tooling & Work-holding for CNC machine tools, Advanced Programming Features & Canned Cycles, Geometric Modeling for NC machining & Machining of Free-form Surfaces, NC program generation from CAD models, NC Program verification and Virtual NC, Recent developments in CNC machine tools.

MEL786 Metrology
3 credits (2-0-2)
Introduction to dimensional metrology, limits, fits and tolerances, application of tolerances, limit gauging, design of gauges, measuring instruments, comparators and their design considerations, angular measurements, auto collimators and interferometers. applications of dimensional inspection, measurement of screw threads, thread gauges for internal and external threads, gear inspection, inspection of surface quality, parameters for assessing surface finish and experimental methods of surface finish measurements, feature inspection, straightness, flatness, parallelism, squareness, circularity and roundness, automated dimensional

measurements, automatic gauging, automatic measuring machines for inspecting multiple workpiece dimensions, measurement with coordinate measuring machines.

MEL787 Welding and Allied Processes
4 credits (3-0-2)
Introduction to joining technology, General survey and classification of welding processes, Safety and hazards in welding, Physics of the welding arc and arc characteristics, Metal transfer & its importance in arc welding, Various forces acting on a molten droplet and melting rates, Power sources for arc welding, Welding consumables: fluxes, gases and filler materials, SMAW, SAW, GTAW and related processes, GMAW and variants, PAW, Gas welding, Soldering, Brazing and diffusion bonding, Thermal cutting of metals, Surfacing and spraying of metals, Resistance welding processes: spot, seam, butt, flash, projection, percussion etc, Thermit welding, Electro-slag and electro-gas welding, Solid-state and radiant energy welding processes such as EBW; LBW; USW, Explosive welding; Friction welding etc, Welding of plastics, Advances, challenges and bottlenecks in welding.

MEP790 Process Engineering
4 credits (2-0-4)
Process engineering functions, Degrees of freedom and datum surfaces, Errors in manufacturing, factors affecting manufacturing accuracy, Preliminary analysis of processing alternatives, dimensional and tolerance analysis, Dimensional and Geometrical tolerances, detailed planning of process of manufacture, Process-planning records, Production techniques for typical components and tools Jigs and fixture design and manufacture, Group technology & CAPP.

MEL791 Composite Materials and Processing
4 credits (3-0-2)
FRP Composites, fiber types, fiber forms and properties, matrices type and properties, lamina, laminate, composites—macro and micro-mechanical analysis & properties, failure theories, primary and secondary manufacturing - Lay-up, Filament winding, Pultrusion, Compression moulding, RTM, RIM, SRIM, machining - drilling, routing etc., application Metal Matrix Composites—powder metallurgy, sintering, squeeze casting, applications Ceramic Matrix Composites—clays, whiskers, fibers, mixing, mass processing techniques, applications.

MEL792 Injection Molding and Mold Design
3 credits (2-0-2)
Nature of engineering plastics, visco-elasticity, design methods & grade selection Principles of Injection Molding, Injection molding machine and types, capacity & clamping tonnage, mold size, plasticating extruder concepts, molding properties and control parameters, molding cycle, Injection Molds for thermoplastics, cavity and core- integer & insert type, product consideration, material consideration, shrinkage, flow length, mold temperature, molding stresses, parting line, feeding system design - sprue, runner, gate, weld line strength, ejection system design, mold cooling systems, runnerless molding, gas assisted and thermosets molding.

MEL794 CAD/CAM
4 credits (3-0-2)
Introduction to CAD/CAM, representation of curves, surfaces and solids for CAD/CAM applications, computational geometry for manufacturing, product design for manufacture and assembly, computer aided process planning, computer aided assembly planning, computer aided inspection & reverse engineering, manufacturing process simulation, virtual & distributed manufacturing, computer integrated manufacturing.

MEL796 Rapid Prototyping and Tooling
4 credits (3-0-2)
Review of solid modeling techniques with comparison advantages and disadvantages. Basic Principal of RP processes, Classification of RP Processes, Various Industrial RP Systems like Sterolithography, Fused Deposition Modeling, Selective Laser Sintering, Laminated Object Manufacturing, 3D Printing, Ballistic particle modeling etc., Role of Rapid Prototyping and Rapid Tooling in Product Development and Simultaneous Engineering. Process planning for rapid prototyping, STL file generation Defects in STL files and repairing algorithms, Slicing and various slicing

procedures, Accuracy issues in Rapid Prototyping, Strength of RP Parts, Surface roughness problem in Rapid Prototyping, Part deposition orientation and issues like accuracy, surface finish, build time, support structure, cost etc., Rapid tooling techniques such as laminated metallic tooling, direct metal laser sintering, vacuum casting. Introduction to reverse engineering Integration of reverse engineering and rapid prototyping.

MEL801 Fire Dynamics and Engineering
4 credits (2-0-4)
Basics of conservation equations, turbulence, radiation and thermochemistry. Ignition of solids—burning and heat release rates. Properties of fire plumes—buoyant plumes and interactions with surfaces. Turbulent diffusion flames—structure, modeling, soot formation and radiation effects. Toxic products. Fire chemistry, thermal decomposition of bulk fuel, pyrolysis, nitrogen and halogen chemistry. Fire growth—ignition, initial conditions, flame and fire spread theory, feedback to fuel. Compartment zone models. Flashover, post-flashover and control. Fire detection, suppression methods, codes, standards and laws. Case studies of real fires—buildings, transport, industries, forests, shamiana, jhuggi-jhonpdi, etc.

MEL802 Convection Heat and Mass Transfer
3 credits (3-0-0)
Conservation equations for mass, momentum, energy and species. Boundary layer flows, similarity parameters, dimensionless numbers. External laminar flow heat transfer. Internal laminar flow heat transfer, entrance region. Turbulent flow heat transfer, turbulent Prandtl number, external and internal flows. Natural convection in external and bounded flows. Mixed convection. Boiling—pool boiling and forced convection boiling in tubes. Condensation over a plate, tube and tube banks. Mass transfer. Applications to engineering problems.

MEL804 Radiation and Conduction Heat Transfer
3 credits (3-0-0)
Radiation: Recapitulation. Radiative properties of opaque surfaces. Configuration factors. Enclosure analysis for diffuse-gray surfaces and non-diffuse non-gray surfaces. Radiation in absorbing, emitting and scattering media. Engineering treatment of gas radiation inenclosures. Radiation measurements.

Conduction: Recapitulation, 3-D conduction, isotropic, orthotropic and anisotropic solids. Mathematical formulation, analytical solutions, variation of parameters, integral method, periodic boundary conditions, Duhamel's theorem and Green's function. Stationary and moving heat sources and sinks. Moving boundary problems. Inverse heat conduction problems. Microscale heat transfer. Bio-heat transfer. Combined mode heat transfer, integro-differential equations, introduction to Monte Carlo technique.

MEL806 Thermal Systems Simulation and Design
3 credits (2-0-2)
Types of simulation. Modeling of thermodynamic properties. Modeling of typical thermal equipment. Steady state simulation. Typical case studies. Dynamic response of thermal systems. Introduction to optimization techniques. Comprehensive case studies of some thermal systems.

MEL807 Computational Heat Transfer
4 credits (2-0-4)
Introduction. 1-, 2- and 3-D conduction for steady state and transient conditions. Boundary conditions, implementation and solution methods. Convection in incompressible flows; stream function-vorticity and primitive variables formulations, staggered grid, SIMPLE and SIMPLER pressure-velocity coupling methods, boundary conditions and implementation issues. External and internal flow simulations. Numerical methods for radiation—enclosures with gray gas, Hottel zone method. Combined convection and radiation. Applications of Monte-Carlo method. Special topics.

MEL808 Refrigeration Systems and Components Design
4 credits (2-0-4)

Introduction to various components. Thermal design of reciprocating, centrifugal and screw compressors. Capacity control methods. Thermal design of different evaporators–DX, flooded, etc. Thermal design of condensers–water-cooled and air-cooled. Sizing of capillary. Selection of expansion valves and other refrigerant control devices. Components balancing. Testing and charging methods. Design of absorber and generator of vapor absorption systems. Design of cold storages, mobile refrigeration, refrigerators, commercial appliances.

MEL809 Heat Transfer Applications
3 credits (1-0-4)

Design, including experimental and numerical analysis, of heat transfer devices/systems related to a wide variety of applications, such as, energy conversion, food processing, manufacturing, solar energy, electronic and electrical equipment cooling, microscale heat transfer, heat sinks, heat exchangers, heat pipes, biomedical applications, measurements and instrumentation, amongst others. The tasks will involve fabrication and experimental measurements.

MES810 Independent Study (Thermal Engineering)
3 credits (0-3-0)

Identification of faculty supervisor(s), topic, objectives, deliverables and work plan (in the preceding semester prior to registration); regular work during the semester with weekly coordination meetings (about 1 hour) with the faculty supervisor. Grade to be decided on the basis of a mid-term and an end-semester presentations (to all faculty and students) vis-a-vis the approved work plan. The topic should be of advanced standing requiring use of knowledge from program core courses. The independent study would be availableonly in the 2nd and 3rd semesters and should be carried out individually or in groups of two students. In the 3rd semester, the topic will have to be different from the major project.

MED811 Major Project Part–1
6 credits (0-0-12)

Formation of project team (one student and one or more faculty supervisor(s)), evaluation committee and selection of topic in the 2nd semester. The topic should be of advanced standing requiring knowledge of program core courses. During the summer after 2nd semester, the student should work full-time on literature review, detailing of the work plan and deliverables at the end of Parts I and II. In the 1st week of the 3rd semester, the student should present these to the evaluation committee for review, approval and assessment. During the semester the progress will be assessed by the supervisor(s) at weekly coordination meetings. At the end of the semester, the committee will evaluate the work where the student will make a presentation. Grade will be decided on the basis of the two assessments.

MEL811 Steam and Gas Turbines
4 credits (3-0-2)

Introduction, thermodynamics and fluid dynamics of compressible flow through turbines. Recapitulation of heat cycles of steam power plants and gas turbine engines. Application of CFD in turbines. Energy conversion in a turbine stage. Geometrical and gas dynamic characteristics of turbine cascades. Turbine cascades and losses in turbine stage efficiency. Multi-stage turbines, radial turbines, partial admission turbines, turbines for nuclear power plants. Steam turbines for co-generation, supercritical and marine applications. Steam and gas turbine components. Governing of steam and gas turbines. Strength and vibration aspects. Steam and gas turbines of major manufacturers. Future trends.

MED812 Major Project–2
12 credits (0-0-24)

The student will continue working full-time as per the approved work plan of Part–I during the winter after the 3rd semester and during the 4th semester.

The progress will be monitored at weekly coordination meetings with the supervisor(s). During the semester, the student will give a departmental seminar that will serve as the mid-term evaluation also. At the end of the semester, the student will make a presentation to the committee for evaluation. The grade to be decided on the basis of the two assessments. The project will also be displayed at an open house.

MEL812 Combustion
4 credits (3-0-2)

Introduction. Chemical thermodynamics and chemical kinetics. Conservation equations for multi-component systems. Premixed systems - detonation and deflagration, laminar flames, effects of different variables on burning velocity, methods for measuring burning velocity, flammability limits, ignition and quenching turbulent pre-mixed flames. Non-premixed systems: laminar diffusion flame jet, droplet burning. Combustion of solids: drying, devolatilization and char combustion. Practical aspects of coal combustion.

MEL813 Cascade Theory
4 credits (3-0-2)

Introduction to cascades, meriodional and cascade planes, flow and geometrical influencing parameters. Instrumentation and observation techniques in cascade testing, evaluation of prediction accuracy. Cascade design, fabrication, instrumentation and assembly. Low speed cascade testing of rectilinear turbine and compressor cascades. 3-D flows, radial and annular cascades. High speed turbine and compressor cascade testing. Boundary layer development. Experimental and CFD techniques. Stalled and separated flow in compressors, flutter and vibrations. Unsteady flow simulation and measurement. Applications: boundary layer and circulation control, turbine blade cooling, new blade designs. Design application for cascades information, future trends.

MEL814 Turbocompressors
4 credits (3-0-2)

Introduction. axial flow compressors, propellers, centrifugal compressors. Equations of motion in axial and radial turbomachines. Operation and performance of compressors. Compressor cascades and loss correlations. Compressor instrumentation and testing. Supersonic compressors. Special aspects. Future trends.

MEL815 Applied Combustion
4 credits (2-0-4)

Review of combustion fundamentals. Gas-fired furnace combustion. Oil-fired furnace combustion. Gas turbine spray combustion. Combustion of solids. Industrial applications involving combustion. Burner design, testing and control. Emissions. Combustion safety.

MEL816 Analysis of I.C. Engine Processes
4 credits (3-0-2)

Introduction to basic I.C. engine processes, air standard and fuel-air cycles, computation of fuel-air and exhaust gas properties. Real cycles and their comparison with standard cycles. Thermodynamic analysis and modeling of salient I.C. engine processes. Modeling engine emissions. Cycle simulation of the I.C. engine.

MEL818 Multiphase Flows
4 credits (2-0-4)

Industrial applications of multiphase flows; general equations and two-phase flow modeling; particle-fluid interaction; Lagrangian and Eulerian approaches; gas-liquid systems–sprays, dispersion, heat and mass transfer; bubble-liquid systems; gas-solid systems–dusty flows, entrainment, dispersion, aerosol dynamics; pneumatic conveying; fluidization–regimes, hydrodynamics, heat transfer and combustion; separation–gas-solid and liquid-solid; design and performance of filters and scrubbers; numerical techniques; measurements in multi-phase flows and aerosols; Codes and standards.

MES830 Independent Study (Design of Mechanical Equipment)
4 credits (0-4-0)

MED831 Major Project Part –1 (Design of Mechanical Equipment)
6 credits (0-0-12)

MEL831 Advanced Theory of Vibration
4 credits (3-0-2)
Introduction to variational calculus and derivation of equations of motion of vibrating systems. Ritz. Galerkin and Kantrovich methods. Transform methods for free and forced vibrations. Modal analysis, Green's functions Operators and free response. Linear and compact operators, Eigenvalue estimates. Forced response passive and active control of machine and structural vibrations. Distributed modal control.

Graphical and analytical methods of solution of non-linear systems. Systems with variable coefficient. Stability criteria. Nonlinear vibrations of continuous systems like beams and plates. Chaos in dynamic systems. Computational and experimental techniques of analysis.

MED832 Major Project Part-2 (Design of Mechanical Equipment)
12 credits (0-0-24)

MEL832 Multibody System Vibration Design
4 credits (3-0-2)
Definition of multibody systems, Introduction to rigid, multibody dynamics, Virtual work, Euler-Lagrange and Orthogonal complement approaches to derive the dynamic equations of multibody systems; Dynamics of flexible-body system, Modeling with flexible bodies; Mode shapes, modal analyses; Discrete and finite element modeling; Introduction to modal updating, Technique of correlation of analytical and experimental models.

MEL833 Impact Dynamics
4 credits (3-0-2)
Introduction to Analysis of low speed impact, basic principles of analyzing impact, rigid body and flexible body impact. Rigid body theory for collinear impact, planar and 2D impact, equations of motion, concepts of energy and work of normal contact force and restitution, work of reaction impulse. 3D impact of rough rigid bodies, collision of free bodies, associated laws of motion and applications. Continuum modelling of local deformation near contact area–quasistatic compression of elastic–perfectly plastic solids, coefficient of restitution, partition of internal energy, axial impact on slender deformable bodies. Impact on assemblies of rigid elements, impact on a system of rigid bodies connected by compliant / non-compliant constraints. Case studies in crash of vehicles modeled as system of rigid bodies. Rigid body impact with discrete modelling of compliance in impact region. FE based modeling of impact, non-linear FE analysis of impact: displacement formulations of large deformations. Non linear constitutive relations of materials in impact including elastic, rubberlike, inelastic, elastoplastic and visco-plastic materials. Modeling of contact conditions and some practical considerations in non-linear FE. Iterative Solution methods and solution of non-linear equations in FE. Introduction to crash safety of vehicles, safety standards, rigid body and FE based human body models in impact.

MEL835 Special Topics
4 credits (3-0-2)
Contents of this course may vary from time-to-time.

MEL836 Advanced Lubrication Theory
4 credits (3-0-2)
Lubrication - Thick Film, Mixed Boundary and Solid;Bearings - Hydrodynamic, Hydrostatic, Elastohydrodynamic; Basic Equations - Navier Stokes, Continuity, Reynolds; Thick Film Lubrication - Externally Pressurized Bearings, Hydrodynamic Journal and Thurst Bearings; Dynamic Properties of Lubricant Films - Linear and Nonlinear Theory; Turbulence - Constantinescus Model, Ng-Panelrod Model; Elatohydrodynamic Lubrication - Theory, Contact Mechanics, Deformation, Rolling Contact Bearings; Thermal Effects - Effective Viscosity, Energy Equation, Themohydro-dynamic Theory, Journal Bearings, Thurst Bearings, Rolling Bearings; Non-Newtonian Lubrication; Gas Lubrication.

MEL837 Advanced Mechanisms
4 credits (3-0-2)
Introduction to mechanism synthesis, Analytical and numerical methods in kinematics; Dynamics of mechanisms; Matrix methods in kinematic; Envelope theory; Optimal synthesis and analysis of mechanisms; Kinematic and dynamic analyses of spatial mechanisms; Synthesis of spatial mechanisms for path and function generations.

MEL838 Rotor Dynamics
4 credits (3-0-2)
Torsional Vibration. Analysis of Rotating Machines including branched systems. Response to steady state and transient excitation. Bending critical speeds of simple shafts, Unbalance response, Orbital Analysis and Cascade Plots.

Disc gyroscopics, synchronous and non-synchronous whirl, Review of fluid film bearings and seals, Analysis of rotors mounted on hydrodynamic bearings, Application to two spool and multispool rotors. Analysis of asymmetric shafts.

Parametric excitation and instabilities. Instability due to fluid film forces and hysteresis, Effect of support non-linearities, Rigid Rotor Balancing, Influence coefficient and modal balancing techniques for flexible rotors.

MEL839 Precision Engineering
4 credits (3-0-2)
Introduction to precision machine design, Principles of accuracy, repeatibility and precision. Errors due to geometry, Kinematics, thermal expnsion, dynamic forces and instrumentation etc. System design considerations in precision engineering. Rolling and sliding contact bearings. Hydrostatic and magnetic bearings. Precision gears, positioning mechanisms and drives. Electro-magnetic piezoelectric and fluid actuators.

Microelectro-mechanical systems. Precision measurement and control devices. Three dimensional co-ordinate measuring machines. Surface finish measurement. Precision machining and finishing operations. Assembly and tolerancing.

Micromachining systems. Tribological vibrations and noise considerations in high speed mechanical units. Case studies from some of the applications like computer drives, printers,sewing machines, video and audio recorders, optical devices etc.

MEL840 Experimental Modal Analysis and Dynamic Design
4 credits (3-0-2)
Introduction to modal testing. Dynamic test data measurement and processing methods. Frequency response functions for multidegree-of-freedoms systems, forced response. Experimental and theoretical modal analysis - algorithms and codes. Applications of modal testing in system and force identification, structural dynamic modification, sensitivity analysis and frequency response coupling of substructure etc. Introduction to non-linear vibration analysis. Introduction to discrete systems and finite element modelling. Comparison of numerical data with test results. Introduction to model updating, Techniques of correlation of analytical and experimental models.

Dynamic design of mechanical equipment structures via model testing, structural dynamic modification and model updating.

MEL841 Advanced Structural Dynamics
4 credits (3-0-2)
Review of linear algebra, theory of eleasticity and the theory of plates and shells. Hamilton's principle. Lagrange's equations, Review of the dynamics of multi-degree-of-freedom systems. Modal analysis.

Dynamics of strings, rods shafts, membranes. Dynamics of beams, plates and shells. Analytical and computational methods. Substructuring. Reduced order models. Random vibration of structures. Introduction

to Statistical Energy Analysis. Introduction to wave propagation. Group velocity, phase velocity, dispersion. Examples and applications to mechanical systems. Approximate methods, the finite element method.

MEL842 Advanced Concurrent Engineering
4 credits (3-0-2)

Product life cycle, quality products, evapo-rative markets, globalization and Concurrent engineering. Review of concurrent engineering techniques like DFM (design for manufacture). DFA (design for assembly), QFD (quality function deployment), RP (rapid prototyping), TD (total design) for integrating these technologies. Product information systems and their architecture. Information environment for suppliers, management, testing & inspection design engineering, pruchasing, process control, manufacturing, support plans, operators, quality control, servicing and maintenance. Product infor-mation modeling. Integration of information models and end users applications. Computer aided simultaneous engineering systems. Integrated concurrent design and product development. Constraint networks.

MEL844 Designing With New Materials
4 credits (3-0-2)

Modern materials in design - plastics, composites, and smart materials. Design considerations for Plastics components. Thermosetting and Thermoplastics Manufacturing considerations for plastics/DFM. Compliant Design Introduction to composite material constituents - fibers, particles, flakes, matrix. Material properties, Laminate Theory for fiber composites. Estimation of equivalent properties. Micro-mechanical and Macro-mechanical modeling. Stress evaluation. Failure criteria for composite materials and laminates. Designing with short fiber and particulate composites. Case studies on design of shafts, springs, channel sections, robot arm etc. Metal matrix composites. Introduction to smart materials, electro-rheological, piezoelectric, shape-memory and magneto-strictive materials. Material characteristics of smart materials. Application of smart materials for design of intelligent structures. Modeling Analysis and design of simple mechanical systems using smart materials.

MEL850 Network Models and Applications
3 credits (2-1-0)

Matrix representation of networks. Maximum flow problems. Maximum flow min-cut theorem. Labelling algorithm for maximum flow. Multiterminal shortest chains. Minimum cost flow problem. Maximal dynamic flow problem. The capacitated trans-shipment problem. Planning the expansion of transportation, communication and industrial networks. Relation between linear programming and network flows. Multicommodity flows. Decomposition. Network synthesis and design , Design of communication networks. Network of pipelines in drilling and other applications.

MEL851 Industrial Engineering Challenges in E-Business
3 credits (3-0-0)

Changes in Industrial Enterprise Challenges, Evolving Business Systems and their Environment, Era of IT based Competitiveness, Introduction to e-Business, e-Commerce and e-Business, New Value Propositions, Multi-Attributed Competitiveness, Time based Competition, Flexible and Agile Enterprises, New Industrial Engineering Challenges in e-Business, Re-Engineering of Enterprises, e-Business and process re-engineering (BPR), e-Business Design, Cases, e-Business Architecture, Customer Relationship Management (CRM) and e-Business, e-Supply Chain, e-Procurement, e-manufacturing, Implementation Challenges, industrial cases: discussion, future trends, challenges.

MEL852 Computer Integrated Manufacturing Systems
3 credits (2-0-2)

Evolving manufacturing environment, New competitive challenges, Evolving Role Information Technology, CIM Systems: Flexibility,

Integration and Automation Opportunities, Automation of information and manufacturing systems, Automation strategies, Towards Flexible Automation, Islands of automation, Evolution Towards CIM systems, Computer based integration between various functions - manufacturing, sales, design, materials etc Flexible Manufacturing Systems (FMS) as mini CIM, Computer Integrated Production Management, ERP, Group technology, Concurrent Engineering, Simulation and AI in CIM systems, CIM and Beyond.

MES860 Independent Study (Industrial Engineering)
3 credits (0-3-0)

MED861 Major Project Part–1 (Industrial Engineering)
6 credits (0-0-12)

MEL861 Industrial Application of Simulation
3 credits (2-0-2)

Fundamentals of Monte Carlo simulation. Simulation of arbitrary pro-distributions. Random number generation; multiplicative and congruential methods. Flow charting. Development of system models. Queuing, Inventory and other industrial applications.

MED862 Major Project Part-2 (Industrial Engineering)
12 credits (0-0-24)

MEL865 Systems Dynamics Modeling and Industrial Applications
3 credits (2-0-2)

Introduction to system dynamics, Causal-loop diagramming. Flow diagramming, Positive feedback structure. Negative feedback structure. S-shaped growth structure, Delays, Counter intuitive behavior of Social System as bounded rationality.

Application in planning and policy Hesign for Production System. Dynamics created by interactions with company suppliers, labours, customers and competitors. System dynamics models to evaluate financial performance of organizations. Dynamics created by capacity expansion and professional resource expansion.

Case studies. DYNAMO, STELLA and SD based management games.

MEL866 Maintenance Management
3 credits (3-0-0)

Reliability : Hazard rate, mean time to failure.Hazards models. Constant hazard Weibul model.System Reliability: Series, parallel and mixed configurations. k-out-of-n-structure. Economics of introducing a stand by or redundancy into a production system, optimum design configuration of a series/parallel system : maximizing reliability subject to budgetary constraint optimum level of active parallel redundancy for an equipment with components subject to failure. Maintainability: Maintainability increment Equipment and mission availability. Replacement Decisions: Economic models, block replacement policy, age replacement policy, replacement policies to minimize downtime, economics of preventive maintenance. Inspection Decisions : Optimal inspection frequency to profit maximizing, minimisation of downtime and availability maximization.

Overhaul and Repair Decisions : Optimal overhaul/repair/replace maintenance policies for equipment subject to breakdown finite and infinite time horizon. Optimal repair effort of a maintenance work force to meet fluctuating taking into subcontracting opportunities.

Spares Provisioning : Spares provisioning for single and multiechelon systems under budgetary constraints.

Maintenance Organisation: Computer application in maintenance management, MIS for maintenance.

MEL868 Operations Research II
3 credits (3-0-0)
Waiting line models. Single and multiple channel models. Priority queues. Application of waiting line theory to industrial and service sectors. Replacement and maintenance models. Simulation : Basic concepts, discrete event simulation, generation of random numbers and events using Monte Carlo method. Simulation of queuing systems. Variance reduction techniques. Validation. Application to business, industry and service systems.

MEL870 Knowledge Management
3 credits (3-0-0)
Introduction, definitions, industrial motivation, Evolving Industrial Competition(multi attributed competition), flexibility, integration and automation in enterprises, growing Need for Knowledge and its effective Management (KM), role of IT, KM and challenges of CIMS, intelligent manufacturing, ERP, SCM and CRM, e-manufacturing etc. KM technical concepts: (data vs information vs knowledge), The Knowledge Edge, Knowledge Engineering, KM Framework (process steps), Aligning KM with Manufacturing Strategy, Business Strategy etc., design and deployment of KM in industrial enterprises(KM team, KM system analysis, Developing Effective Systems, Knowledge Audit), IT based tools, role of performance measurement, KM and competitive link, intelligent manufacturing, agile enterprises, cases, presentations, group exercises. Role of Simulation and Intelligent Systems, KM Deployment, Managing Innovation, Performance Measurement, Applications.

MEL871 Financial Engineering
3 credits (2-1-0)
The concept of firm, the basic theory of interest, impact of inflation, opportunity cost of capital, deterministic cash flows, project net present value, other projects evaluation criteria, concept of depreciation, before and after tax cash flow, single period random cash flows, mean variance portfolio theory, portfolio analysis and management, determining betas, single index models, capital asset pricing model, options and futures, using options in project valuations.

MEL875 Operations Research III
3 credits (3-0-0)
Dynamic programming. Decision trees. Deterministic infinite decision stages. Stochastic processes. Markov decision processes. Game theory. Geometric programming and applications. Computer search methods. Steepest ascent/descent methods of optimization. Numerical optimization. Case studies. Multiple objective decision-making and fuzzy sets.

MEL876 Advanced Quality Engineering
4 credits (3-0-2)
Pre- requisites: MEL761/ MEL752/ MEL744/ TTL773/ TTL751/ ITL711
Measurement of product/process performance, Variation reduction approaches, Online and Off-line application of Design of experiments, Multi criteria optimization for quality and reliability, Parameter design, Tolerance design, Process capability analysis, Optimal design of test plans, Life cycle cost considerations, Six Sigma approach to product and process improvement, Software quality and reliability.

MES880 Independent Study (Production Engineering)
3 credits (0-3-0)

MED881 Major Project Part –1 (Production Engineering)
6 credits (0-0-12)

MED882 Major Project Part-2 (Production Engineering)
12 credits (0-0-24)

MED895 Major Project (M.S. Research)
40 credits (0-0-80)

Department of Physics

PHP100 Physics Laboratory
2 credits (0-0-4)
Typical experiments on elastic constants, mechanically coupled oscillator systems, surface tension and viscosity of liquids, thermal conductivity of bad conductors, interference, diffraction and polarization of light, Planck's constant determination, photoelectric effects, studies of a power source characteristics, charging discharging of a capacitor, electromagnetic induction, Study of AC circuit elements of inductor and capacitor, and analysis of the behavior of RC, LR and LCR circuits, Measurement of phase by superposition.

EPL101 Classical Mechanics and Relativity
4 credits (3-1-0)
Degrees of freedom, Generalized co-ordinates; D'Alemberts Principle; Hamilton's Principle, Lagrange equations, generalized monenta, cyclic coordinates and conservation laws, Applications; Motion in a noninertial frame, Coriolis force; Motion in a central force field; Kepler's problem and its solutions; Scattering of particles and the Rutherford Law; Rigid bodies, Independent coordinates and their orthogonal transformations, Cayley Kein parameters, Euler's theorem, Moment of inertia tensor. Principal axis transformation, Force free motion of a rotating body and methods of solving the Euler equations; Motion of tops, precession and nutation; Hamilton's equations, Legendre transformations, cyclic coordinates, Canonical transformations, Poisson brackets and Liouville's Theorem; Hamilton Jacobi Theory; Dynamical systems: Basic theory, phase slow, equilibrium and stability, fixed points, nonlinearity and bifurcation, strange attractor and chaos; Lorentz Transformations, Tensor analysis, Time dilation, Length contraction and velocity addition, Invariants and conserved quantities, Newton's equations of motion in relativistic form.

EPL103 Mathematical Physics
4 credits (3-1-0)
Sturm-Liouville Equation, Hermite and Laguerre Polynomials, Laplace, Poisson, Heat diffusion and wave equations; Integral equations; Fredholm and Volterra equations; Green's functions, applications of Green's function in Quantum Mechanics and Solid State Physics; WKB, Perturbation and Variational methods; Cartesian tensors with applications in Physics; Matrices.

EPL105 Optics
4 credits (3-1-0)
Overlaps with: PHL795
Wave propagation, 1-D and 3D wave equations, Sinusoidal waves, Phase and Group velocities; Superposition of waves, Interference by division of wavefront, Concept of spatial and temporal coherence; Interference by division of amplitude: Anti-reflecting films; Colour of thin films; Newton's rings; Michelson interferometer. Multiple Beam interferometery: Fabry Perot interferometer, Resolution and Free spectral range; Interference filters; Fraunhofer diffraction: diffraction by a single slit, double slit, circular aperture; Resolving power of microscopes and telescopes; Diffraction grating, Resolving power and Dispersive power; Fresnel diffraction: diffraction of a Gaussian beam, Polarization: Concept of linear, circular and elliptical polarizations; Brewster's law and Malus's law; Double refraction by crystals; Interference of polarized light, half wave and quarter wave plates; Analysis of polarized light; Fermat's Principle, Ray equation and its solutions. Ray paths in inhomogeneous media. Applications in fiber optics, mirage formation; Introduction to lasers; interaction of radiation with matter, Einstein coefficients, line shape function, condition for amplification, optical resonators, threshold for laser oscillation.

EPL107 Electromagnetics
4 credits (3-1-0)
Revision of vector algebra and coordinate systems. Electrostatics; Electrostatic field in matter: Electric field and potential due to a dipole, Dielectrics; displacement; electrostatic energy in dielectrics; Magnetostatics: Magnetic field due to a moving charge, motion of charged particles in electric and magnetic fields; divergence and curl of a magnetic field; Magnetic field in matter and magnetic circuits; Electromagnetic Induction: Faraday's law, Lenz's law, energy in magnetic field, Maxwell's equations and electromagnetic waves: Displacement currents, generalisation of Ampere's law, Maxwell's equations, EM wave equation, plane waves; Energy flow in EM waves, Guided waves, metallic wave guides, transmission lines.

EPP109 Physics Laboratory - I
3 credits (0-0-6)
The experiments planned will be such to (i) bring clarity of understanding of the concepts and mechanisms, (ii) provide measuring capability and feel of the functional behavior, and (iii) expose to the practical aspects in the areas of Modern Physics, Optics, Electromagnetics and Lasers.

EPN110 Introduction to Engineering Physics
2 credits (0-0-4)
Demonstration and interactive sessions with faculty in the areas of optics, photonics and photonic information processing; materials design and nano-technology; computational physics and device simulation; lasers, fiber optics and communication technology; plasma processing and technology; microelectronics. Visit to major facilities like TEM, SEM, XRD, AFM and R&D institutions and/or industry.

EPP110 Physical System Design
2 credits (0-0-4)
Disassembling/reassembling of various physical systems and self-learning through this hands-on-experience; design of systems/set-ups for measurement of physical quantities; design of demonstration systems for some functions; etc will be included in this course.

PHL110 Fields and Waves
4 credits (3-1-0)
Gauss law and its applications in electrostatics in vector form, electric polarization, permittivity, energy density in an electric field, Ampere's law, charged particle motion in E and B fields, magnetization, Faraday's law of electromagnetic induction; Equation of continuity, generalized Ampere's law, Maxwell's equations, wave equation, plane wave solutions, electromagnetic wave propagation in dielectrics and conductors, reflection/refraction, polarization, interference, diffraction of EM waves Origin of quantum hypothesis, de Broglie's hypothesis of matter waves, Uncertainty principle, Wave function and wave mechanics, Schroedinger equation, QM operators, Expectation value, one-dimensional solutions: zero potential, step potential, potential barrier and potential well.

PHL120 Physics of Materials
4 credits (3-1-0)
Nature of waves and particles, Wave-packets and uncertainty, Wave particle duality, Wave mechanics and its mathematical tools, Classical and quantum statistics, Statistics of discrete energy levels, Black body spectral density, Bose condensation; Free electrons, density of states, Kronig-Penny model, Effective mass, Band structure, Electrons in various types of solids, Particle in quantum well, Harmonic oscillator and Hydrogen atom problems, Application to semiconductor doping, Non-periodic materials; Tunneling of particles and examples, Tunneling through multiple barriers and semiconductor junctions; Interaction among quantum wells: materials under electric and magnetic fields, magnetic resonance effects; Nanostructures – Concepts of electrons in low dimensional confinement, Quantum wells and Super-lattices leading to new device concepts; Lasers – Einstein coefficients, Population inversion, Light amplification, Optical resonators, Characteristics of lasers; Superconductors – Vortex, Flux quantization, SQUID, Levitation and its applications.

EPL202 Quantum Mechanics and its Applications
4 credits (3-1-0)
Pre-requisites: PHL110 / PHL120 / EPL101
Formalism of quantum mechanics, Operators, Schrodinger and Heisenberg pictures; Stationary Schroedinger Equation, Harmonic oscillator, H-atom, Bound states, scattering states; Quantum Mechanical theory of Angular Momentum, Spin, Addition of Angular Momenta and Clebsch-Gordon Coefficients; Time-independent Perturbation Theory and application to bound states, Perturbation of an oscillator, Degenerate case, Zeeman effect without spin, First-order and second order Stark effect; Hartree-Fock, Variational and WKB methods; Time-dependent Perturbation Theory, Interaction Picture, First-order and Harmonic Perturbations, Transition probability, Sudden and Adiabatic Perturbations. Semiclassical Theory of radiation, Einstein Coefficients, Principles of Laser radiation; Quantum Mechanical Scattering Theory, Scattering Amplitude, Differential and Total Cross-sections, Born Approximation, Unitary and sum rules; Density matrix and its properties, applications.

Many particle wave functions. Identical Particles, Symmetric and anti-symmetric wave functions, and the Pauli Principle

EPL204 Thermal and Statistical Physics
4 credits (3-1-0)
Pre-requisites: PHL110 / PHL120 / EPL103
First and second laws of thermodynamics, micro and macro-states, entropy and disorder, the Carnot cycle; Some practical cycles; Entropy in quantum theory: the density of states, general definition of temperature; The canonical probability distribution, spin paramagnetism, the partition function technique, photons and phonons, computation of the density of modes, radiation pressure, radiative flux, entropy and evolution. Sound waves and phonons; The chemical potential; adsorption; the quantum ideal gas, occupation numbers and their estimation; fermions and bosons at low temperatures, white dwarf stars, Bose-Einstein condensation and liquid He; The free energies: Helmhotz, Gibbs; chemical equilibrium, phase equilibrium, adiabatic cooling; superfluidity, Gibbs' phase rules, vander Waals equation of state, The Maxwillian gas equipartition theorem; Third law of thermodynamics, negative absolute temperature.

EPL206 Solid State Physics
4 credits (3-1-0)
Pre-requisites: PHL110 / PHL120 / EPL101
Crystal structure, Quasi crystals, Diffraction by a discrete lattice; X-ray, electron and neutron diffraction; Defects; Lattice vibration: concept of Debye and Einstein temperatures; thermal conductivity.

Dielectric properties of insulators: Types of polarisations, local field and Clausius-Mossotti equation, dielectric constants and dielectric loss, dielectric strength and insulation breakdown, capacitor dielectric materials, piezo, ferro and pyro electricity. Quartz oscillators and filters, piezo-spark generators, uni- and multi-axial ferroelectrics, pyroelectric detectors and devices.

Magnetic properties: Unpaired d electrons in solids, classification of magnetic materials: dia, para, ferro, antiferromagnetism; magnetic domains, soft and hard magnetic materials; ferrites Superconductors, Meissner effect, flux quantisation, field penetration and high frequency effects, coherence, energy gap, Josephson junctions, SQUID, soft and hard superconductors, superconducting magnets, HTSC.

EPL208 Principles of Electrodynamics and Plasmas
4 credits (3-1-0)
Pre-requisites: PHL110 / PHL120 / EPL107
Basic laws of electrodynamics; Wave propagation in dielectrics, semiconductors and conductors: attenuation, dispersion, phase and group velocities; Wave propagation in plasma: Basics of plasma, methods of plasma production, electron motion in E and B fields, plasma wave, ion acoustic wave, electromagnetic waves, ionospheric propagation; Surface wave propagation, medium frequency communication; Waveguides: rectangular and cylindrical, Resonators; Antenna: dipole antenna, antenna pattern, antenna array, radar; Instabilities: two stream instability Cerenkov free electron laser; Relativistic covariance of Maxwell's equations, Lienhard-Wichart Potentials, radiation from accelerated charges.

EPL211 Principles of Material Synthesis
4 credits (3-1-0)
Pre-requisites: PHL110 / PHL120
Overlaps with: PHL702
Thin films in solid state devices; Vacuum evaporation-Hertz-Knudsen equation, film thickness uniformity; Glow discharge and plasmas, DC, RF and microwave excitation; Sputtering processes- Sputtering of alloys; Reactive sputtering, Plasma chemistry, plasma etching mechanisms; CVD Deposition-Thermodynamics of CVD, gas transport, growth kinetics; Nucleation and Growth:models for 3D and 2D nucleation, grain structure and microstructure and its dependence on deposition parameters; Epitaxy: lattice misfit and imperfections; epitaxy of compound semiconductor, theories of epitaxy, Role of interfacial layer, Artificial semiconductors, Band-gap engineering; Stresses in thin films-internal stresses, Adhesion; Diffusion, Interdiffusion and Reactions in Thin Films: Electro-migration,

metal-semiconductor reactions, silicides, Diffusion barriers, Oxidation-basic models, impurity redistribution during epitaxial growth and oxidation; Ion implantation: profiles of implanted ions, Annealing mechanisms and their role in epitaxy and ion-implantation, Rapid thermal annealing; laser modification effects.

EPL213 Fundamentals of Semiconductors
4 credits (3-1-0)
Pre-requisites: PHL110 / PHL120
Overlaps with: EEL218
Motion of electron in periodic potential: Effective mass and Brillouin zone, Kronig Penney Model, Nearly free electron model, Energy band gap in semiconductors, Holes, Methods of calculating band structure; Density of States in intrinsic carrier concentration, Donors and acceptors, carrier-drift diffusion, band structure; Phonons and scattering mechanisms: Electron-Phonon, electron-electron interactions, Ionized Impurity scattering; Generation and Recombination Processes: Basic mechanisms- Thermal and Shockley-Read, Hall, Impact-ionization and its transition rate; Optical Absorption in Semiconductors: Optical constants, Kramer-Kronig relations, free carrier absorption, plasma and cyclotron resonance, fundamental absorption, direct and indirect transitions, exciton, impurity and lattice absorption; Photo-conductivity: traps, photoconductive gain, photovoltaic effect, photo magnetic effect, emission of radiation from semiconductors; Junctions: Homojunctions, heterojunctions, metal- semiconductor and MIS junctions in equilibrium; junctions under non-equilibrium, current flow.

EPP215 Physics Laboratory - II
3 credits (0-0-6)
Pre-requisites: EPP109
The experiments provide (i) measuring capability and feel of the functional behavior, and (ii) exposure to the practical aspects in the areas of Thermal and Statistical Physics, Solid State Physics, Superconductors, Vacuum Technology and Materials Science.

EPP216 Physics Laboratory - III
3 credits (0-0-6)
Pre-requisites: EPP110
The experiments planned will be such to (i) bring clarity of understanding of the concepts and mechanisms, (ii) provide measuring capability and feel of the functional behavior, and (iii) expose to the practical aspects in the areas of Thin Films, Semiconductors, Solid State Electronics, Plasma, Optoelectronics and Fiber Optics.

EPP301 Design Laboratory
4 credits (0-0-8)
Pre-requisites: EPP110 and EC 60
The course intends to go beyond the experience of the previous course and includes design of integrated physical systems involving various components on the lines of a mini project. About four such objectives to be attempted from different major areas.

EPR310 Professional Practices (PH)
2 credits (0-1-2)
Pre-requisites: EC 60
Spread over 5th and 6th semesters organization of Industrial tours/visits with on site demonstrations cum lectures (long duration tours during winter break between the two semesters), Lectures and discussion sessions by eminent personalities from Industry and R&D organizations.

EPS310 Independent Study (PH)
3 credits (0-3-0)
Pre-requisites: EC 80
The course details to be worked out by the faculty giving the course keeping in view the learning needs of the student.

EPD310 Mini Project (PH)
3 credits (0-0-6)
Pre-requisites: EC 80
The project details to be worked out by the faculty giving the project keeping in view the learning needs of the student.

EPL331 Vacuum Technology and Surface Physics
3 credits (3-0-0)
Pre-requisites: EC 60
Vacuum: its need in research and industry. Principles of low, high and ultra-high vacuum: production and measurement. Design aspects of vacuum systems for different applications, materials for vacuum systems.

Surface Properties: Structural-surface structure and reconstruction, Electronic-contact potential and work function, surface states and band bending, plasmas and surface optics; Atomic motion-surface diffusion, surface melting and chemisorption

Surface Analytical Techniques: Electron spectroscopic techniques (AES, XPS): Principles and applications in materials/devices; Imaging of atoms and nano-clusters using tunneling and ultra-low forces (STM and AFM); Surface structure by LEED.

EPL332 Nuclear Science and Engineering
3 credits (3-0-0)
Pre-requisites: EC 60
Basics of Nuclear Physics, Nuclear particle detectors, activation analysis, Carbon dating, fission and fusion, principle/design/types of nuclear reactors, effect of nuclear radiation on materials, radiation protection and environment, nuclear tracer techniques in industry, nuclear radiography, thickness, density and other gauges, applications of radioisotopes in agriculture and medical areas

Fusion Energy: Nuclear kinetics; reaction analysis, Coulomb scattering; field effect trajectories; magnetic field configurations; particle transport; energy viability; burn cycles.

EPL333 Computational Physics
4 credits (3-0-2)
Pre-requisites: EC 60
Overlaps with: MAL235
Introduction to Numerical Methods: Locating Roots of Equations, Interpolation and Numerical Differentiation, Numerical Integration, Systems of Linear Equations, Ordinary Differential Equations, Smoothing of data – Method of Least Squares, Fourier Transform Techniques; Simulation Techniques: Random Number Generation and Monte Carlo Methods, The Metropolis algorithm, Variational Methods and Optimization Techniques; Applications of Computer Simulations in Physics: Random Walk and its Applications to Polymers, Percolation and Fractal Phenomena, Aggregation Diffusion Models for growth, Chaos and Non-Linear Systems, Ising Model Simulations of Magnetic Solids and Phase Transitions, Simulations of simple Neural Network Models, Ray tracing algorithms in graded refractive index media.

EPL334 Lasers
3 credits (3-0-0)
Pre-requisites: EC 60
Overlaps with: PHL795
The Einstein coefficients, Spontaneous and stimulated emission, Optical amplification and population inversion; Lineshape functions: Homogeneous and inhomogeneous broadening, Natural, Doppler and Collision broadening; Laser Rate Equations: Two level, Three level and Four level laser systems, Gain saturation; Optical amplifiers: Rare earth doped fiber amplifiers; Optical Resonators: Fabry Perot cavity, Spherical mirror resonators, Stable and unstable resonators, Longitudinal and Transverse modes of the cavity, Threshold condition for laser oscillation, Optimum output coupling; Q-switching and mode locking in lasers, Single longitudinal and single transverse mode oscillation; Laser systems: Ruby, Nd:Yag, Nd: Glass lasers; Tunable lasers: Ti-Sapphire laser; He-Ne, Argon ion, Carbon dioxide and Excimer lasers; Fiber lasers; Semiconductor lasers: Fundamentals, Operation Characteristics.

EPL335 Low Dimensional Physics
4 credits (3-1-0)
Pre-requisites: EC 60
Overlaps with: PHL726
Concept of dimensionality of solids, 3D to 0D; Energy band structure in low dimensions, motion of electron in bands, Density of states, Quantum wells and low dimensional systems, Tunneling transport in low dimensional solids, Behaviour of low dimension solids under electric and magnetic fields, Quantum mechanical treatment of low dimensional solids, Photon and phonon transport, optical absorption, interband absorption, optical properties, inter sub-band transitions, Two dimensional electron gas.

EPL336 Semiconductor Optoelectronics
4 credits (3-1-0)
Pre-requisites: EC 60
Overlaps with: PHL793
Review of Semiconductor Device Physics: Fermi level and quasi Fermi levels. p-n junctions, Schottky junction and ohmic contact. Semiconductor optoelectronic materials, band gap modification, quantum well structures; Semiconductor Photon Sources: Interaction of photons with electrons and holes in a semiconductor, Rates of emission and absorption. Electroluminescence; the LED: materials, structure and device characteristics; Semiconductor Laser: basic structure, theory and device characteristics, DFB, DBR, Quantum well and VCSE Lasers, Laser diode arrays; Semiconductor Photodetectors: Types of photodetectors: photoconductors and photodiodes, PIN diodes and APDs. Detector characteristics and device performance, phototransistors, solar cells and CCDs; Photovoltaic Cells: Single junctions under illumination, photon and carrier loss mechanism, graded and tandem junction devices; Optoelectronic integrated circuits (OEICs)
.

EPL337 Materials Science and Engineering
4 credits (3-1-0)
Pre-requisites: EC 60
Overlaps with: PHL703
Elementary materials science concepts; Diffusion processes and their industrial applications; Phase diagrams: Gibbs phase rule, zone refining and pure Si crystals, First and Second order phase transitions; martensitic transformation and spinodal decomposition; Electrical and thermal behaviour; solid solutions and Nordheim's rule,Skin effect, thin metal films and integrated circuit inter-connections; thermoelectricity, seebeck, Thomson and Peltier effects, thermoelectric heating and refrigeration, thermoelectric generators, the figure of merit; Elastic behaviour of solids, Anelasticity, thermoelasticity, viscoelastic deformation, Corrosion and Degradation of Materials: Electrochemical considerations, corrosion environments, corrosion prevention, Materials Selection and Design Considerations; Economic, Environmental and Societal issues in Materials Science and Engineering.

EPL338 Non-linear Phenomena in Physics and Engineering
4 credits (3-1-0)
Pre-requisites: EC 60
The dynamical system and its mathematical model, classification of dynamical systems; Oscillatory system and its properties, illustrative examples; Linear Oscillators, damped and driven oscillators, phase portraits, examples of applications in physics and engineering; Nonlinear oscillators, fixed points, stability Bifurcation theory, applications to electrical circuits, chemical reaction dynamics, duffing oscillator, transmission lines; Period doubling bifurcations, strange attractor, chaos, applications to Lorentz model and Van der Pol oscillator; Linear waves, weakly nonlinear and dispersive waves, solitons, Kdv, NLS, Sine-Gordon systems, examples of applications in physics and engineering; Nonlinear optical phenomena: second harmonic generation, parametric processes, optical solitons, soliton-based all optical communication systems; Nonlinear phenomena in condensed matter physics: Phase transitions, quasi-crystals, symmetry-breaking.

EPC410 Colloquium (PH)
3 credits (0-3-0)
Pre-requisites: registered for EPT410
This course will cover the presentations of the work carried out by students during the Practical Training and will be attended by all students.

EPT410 Practical Training (PH)
Non credit
Pre-requisites: EC 90 at the end of 5th sem.
Practical Training of 50 working days in an Indian industry or R&D organization.

EPD411 Major Project Part 1 (PH)
3 credits (0-0-6)
Pre-requisites: EC 120
To set the objectives, deliverables, work plan, logistics planning and milestones with discernible outputs and then to demonstrate the feasibility through some initial work.

EPD412 Major Project Part 2 (PH)
7 credits (0-0-14)
Pre-requisites: EPD411
Working out the detailed work plan and implementation of the project.

EPV430 Special Topics in Nano-Technology
1 credit (1-0-0)
Pre-requisites: EC 90
Topics from the emerging areas of nano technology development will form the basis and the specialized/visiting faculty offering the course will provide the detailed course contents.

EPV431 Special Topics in Photonics and Optoelectronics
1 credit (1-0-0)
Pre-requisites: EC 90
Topics from the emerging area of photonics and opto-electronics development will form the basis and the specialized/visiting faculty offering the course will provide the detailed course contents.

EPV432 Special Topics in Emerging Processes
1 credit (1-0-0)
Pre-requisites: EC 90
Topics from the emerging area of process and technique development will form the basis and the specialized/visiting faculty offering the course will provide the detailed course contents.

EPV433 Special Topics in Emerging Materials
1 credit (1-0-0)
Pre-requisites: EC 90
Topics from the emerging area of materials development will form the basis and the specialized/visiting faculty offering the course will provide the detailed course contents.

EPV434 Special Topics in Emerging Devices
1 credit (1-0-0)
Pre-requisites: EC 90
Topics from the emerging areas of device development will form the basis and the specialized/visiting faculty offering the course will provide the detailed course contents.

EPL439 Microelectronic Devices
3 credits (3-0-0)
Pre-requisites: EC 90
Overlaps with: EEL218
Basic Semiconductor: energy bands, donors and acceptors, carrier concentration, carrier transport, generation-recombination, high field effects, basic equations for device operation; p-n junctions: electrostatics, space charge, abrupt and linearly graded, current-voltage and capacitance-voltage characteristics, junction breakdown, transient behaviour hetero-junctions; Bipolar Transistor: transistor action, current gain, static characteristics, frequency response, transient behaviour, junction breakdown, modelling-Ebers-Moll/Gummel-Poon, thyristor; Metal-Semiconductor contact: Schottky effect, metal-semiconductor contacts, current-voltage characteristics, ohmic contacts; Field Effect Transistor: Junction field effect, MESFET, metal-insulator-semiconductor

(MIS), MOS diode, MOSFET, characteristics, threshold voltage, frequency response, device scaling, modelling, charge couple devices (CCD).

Integrated Circuits: standard-bipolar/MOS/CMOS technology, circuit realization, semiconductor memories, RAM, ROM and PROMs, static and dynamic memories, design aspects, VLSI and ULSI.

EPL440 Quantum Electronics
3 credits (3-0-0)
Pre-requisites: EC 90
Overlaps with: PHL792
Propagation of light waves through bulk media, Review of electromagnetic waves, plane waves, Poynting vector, polarization, diffraction; propagation through anisotropic media, Nonlinear optical effects, Nonlinear polarization; Second order effects: Second harmonic generation, Sum and difference frequency generation, Parametric amplification, parametric fluorescence and oscillation, Periodically poled materials and their applications in nonlinear devices; Third order effects: Self Phase modulation, Temporal and spatial solitons, Cross Phase modulation, Four wave mixing, Phase conjugation; Quantization of the electromagnetic field; Coherent states and their properties; Squeezed states of light and their properties; Application of optical parametric processes to generate squeezed states of light; Optical resonance and two-level atoms, atom cooling and trapping; Ultra-intense laser matter interactions.

EPL441 Applications of Lasers in Technology
3 credits (3-0-0)
Pre-requisites: EC 90
Overlaps with: PHL752
Brief review of laser principles and operative mechanisms. Laser systems in Industrial research and development. CO_2 YAG, Excimer and Ruby lasers in material processing, Laser beam hardening; Lasers in material processing, thermal and non-thermal laser induced processes, laser applications in metal welding, cutting, drilling and nano-particle generation; Laser ablation and thin film deposition; Laser processing of semiconductors; Rapid thermal annealing and alloying; Production of nano-structured Si and compound semiconductors and their characterisation by laser Raman and photoluminesence spectroscopy; recent development in laser source technology; use of lasers in data storage, communication, information technology and medical instrumentation.

EPL442 Fiber and Integrated Optics
3 credits (3-0-0)
Pre-requisites: EC 90
Overlaps with: PHL790, PHL791
Propagation in planar optical waveguides-concepts of modes, prism film coupling, Effective index theory for 2-D waveguides, Coupled mode theory for directional couplers and periodic waveguides, I.O. devices, propagation in step and graded index fibers, pulse dispersion, Single-mode fibers and characteristics, Fiber technology and fiber characterisation, Optical communication system designs and recent trends, Non-linear fiber optics, Solitons, optical fiber sensors.

EPL443 Holography and Optical Information Processing
3 credits (3-0-0)
Pre-requisites: EC 90
Overlaps with: PHL756,PHL758,IDL734
Signals and systems, Fourier transform (FT), sampling theorem; Review of diffraction theory: Fresnel-Kirchhoff formulation and angular spectrum method, FT properties of lenses and image formation by a lens; Frequency response of a diffraction-limited system under coherent and incoherent illumination. Basics of holography, in-line and off-axis holography, plane and volume holograms, diffraction efficiency; Recording medium for holograms; Applications of holography: display, microscopy; memories, interferometry, NDT of engineering objects, etc.; Holo-optical elements. Analog optical information processing: Abbe-Porter experiment, phase contrast microscopy and other simple applications; Coherent image processing: vanderLugt filter; joint-transform correlator; pattern recognition, image restoration; Data processing from synthetic aperture radar (SAR), acousto-optic signal processing, discrete analog processors.

EPL444 Functional Nanostructures
3 credits (3-0-0)
Pre-requisites: EC 90
Overlaps with: PHL726
Basics of low dimensional (0D, 1D, 2D) structures, Quantum dots wires and wells, Nanoparicles-free and dispersed, Nanocrystalline and nanostructured films, Self organized structures; Nanostructures for optical and electronic applications, Quantum dot diodes, lasers and detectors, Single electron devices and logic applications, Optical computing and Information processing; Carbon based nanostructures, Electrical, mechanical and chemical properties of carbon nanotubes, Sensors and drug delivery vehicles, Data processing; Bulk nanostructured material and Photonic crystals; Nanostructures for Magnetic applications, Giant and Colossal Magnetoresistance. Nanostructured ferromagnetism, Random Access Memories; Nanostructures for catalysis and hydrogen storage, Nanoclays, colloids and hydrogen storage nano materials. Organic and Biological nanostructures. Nanomachines and supra molecular devices.

EPL445 Engineering Optics
3 credits (3-0-0)
Pre-requisites: EC 90
Overlaps with: PHL751, IDL731
Lens systems and basic concepts in their design; Optical components: Mirrors, prisms, gratings and filters; Sources, detectors and their characteristics; Optical systems:Telescopes, microscopes, projection systems, photographic systems, interferometers and spectrometers; Concepts in design of optical systems; Applications in industry, defense, space and medicine; LCD, CCD, compact disc, scanner, laser printer, photocopy, laser shows, satellite cameras, IR imagers.

EPL446 Spintronics and Data Storage
3 credits (3-0-0)
Pre-requisites: EC 90
Basic magnetism, Spin polarization, Magneto and magneto-optical transport, Magnetic storage devices and other means of data storage, Ferromagnetic semiconductors and their use in recording media, Basics of GMR in materials and its applications in read heads, Spin valve and spin-tunnel devices in data storage, Magnetic RAMs, Superparamagnetic limit, Magnetic nanostructures for very large density recording, Future directions in data storage.

EPV450 Selected Topics in Nano-Technology
2 credits (2-0-0)
Pre-requisites: EC 90
Topics from the emerging areas of nano technology development will form the basis and the specialized/visiting faculty offering the course will provide the detailed course contents.

EPV451 Selected Topics in Photonics and Optoelectronics
2 credits (2-0-0)
Pre-requisites: EC 90
Topics from the emerging areas of photonics and opto-electronics development will form the basis and the specialized/visiting faculty offering the course will provide the detailed course contents.

EPV452 Selected Topics in Emerging Processes
2 credits (2-0-0)
Pre-requisites: EC 90
Topics from the emerging areas of processes and techniques development will form the basis and the specialized/visiting faculty offering the course will provide the detailed course contents.

EPV453 Selected Topics in Emerging Materials
2 credits (2-0-0)
Pre-requisites: EC 90
Topics from the emerging areas of materials development will form the basis and the specialized/visiting faculty offering the course will provide the detailed course contents.

EPV454 Selected Topics in Emerging Devices
2 credits (2-0-0)
Pre-requisites: EC 90
Topics from the emerging areas of device development will form the basis and the specialized/visiting faculty offering the course will provide the detailed course contents.

PHL551 Classical Mechanics
4 credits (3-1-0)
Constraints, Newton's equation with constraints, virtual work, generalized co-ordinates, Lagrange's equation, cyclic co-ordinates, conservation laws. Basics of calculus of variations, Variational principles and Lagrange's equation.   Hamilton's equations, Liouville theorem. Canonical transformations. Poisson brackets, Liouville equation, Gibbs ensemble. Central force, Kepler's problem. Scattering of particles in a central force field, Rutherford formula.   Non-inertial frames, Coriolis force, rigid body motion, Euler angles, Euler's equations. Non-linear oscillations, Fourier series expansion and methods of perturbations, successive approximation, phase space analysis stability of fixed points, period doubling bifurcations and chaos. Continuous system. Lagrangian formulation, Stress-tensor, Hamiltonian formulation, Poisson brackets. Classical fields, Noether's theorem.

PHL552 Electrodynamics
4 credits (3-1-0)
Boundary value problems using Laplace's equation, Maxwell's equations for time varying fields, polarization and conductivity, plane waves in dielectrics and conductors, wave propagation in plasmas, reflection/ refraction, critical reflection, surface waves and medium frequency communication, wave-guides, transmission lines, dipole antenna, antenna array, Rayleigh scattering, Postulates of special relativity, Lorentz transformations, 4-vectors, interval, 4-momentum, mass-energy equivalence, relativistic covariance of Maxwell's equations, Lienard-Wiechert potentials, radiation from accelerated charges, applications to communication and radar.

PHL553 Mathematical Physics
4 credits (3-1-0)
Matrices, Eigenvalues and eigenvectors, Vector spaces, Group theory and its applications; Fourier transform, Discrete Fourier transform, Fast Fourier transform; Sturm-Liouville problem; Review of wave, heat and Laplace partial differential equations; Integral equations; Fredholm and Volterra equations; Green's functions, applications of Green's function in Quantum Mechanics and Solid State Physics; Conformal mapping and its applications; Cartesian tensors with applications in Physics.

PHL554 Concepts of Solids
4 credits (3-1-0)
Summary of crystal lattices, Reciprocal lattice, Bonding & packing in crystals, Point and space groups, Defects in crystals, Classical & quantum theory of harmonic crystal, Thermal expansion, Phonon collisions, Lattice thermal conductivity, Origin of bands, E-k diagrams, Band structure of semiconductors, Impurity levels in thermal equilibrium, Non-degenerate semiconductors, p-n junction, Drift and diffusion currents.

PHL555 Quantum Mechanics
4 credits (3-1-0)
State vector, Hilbert space, Dirac notation, basis in Hilbert space, operators. Schroedinger equation, pictures of quantum mechanics. Wave packet. Stationary states, eigenvalues and eigenfunctions, Born's interpretation, average values, Ehrenfest theorem. Uncertainty principle. Harmonic oscillator. Fock space. Two-body problem, hydrogen atom. Symmetries, conservation laws, angular momentum. Spin, addition of angular momenta.   Time-dependent perturbation theory, Stark and Zeeman effects.   WKB and variational methods.   Time dependent perturbation theory, Fermi Golden rule, periodic perturbation. Interaction of radiation with matter, radiation field quantization,

spontaneous emission, absorption, induced emission, dipole transitions, selection rules. Identical particles, scattering, cross-section, Born approximation, partial waves, optical theorem.

PHL556 Statistical Mechanics
4 credits (3-1-0)
Introduction to statistical methods, random walk and the binomial distribution, statistical properties of the random walk, relation to Gaussian and Poisson distributions, central limit theorem; statistical description of systems of particles –basic postulates and statistical ensembles,microcanonical, canonical and grand canonical ensembles; method of calculation using the ensemble approach and its applications to classical systems; density matrix formalism; quantum statistical mechanics and its applications to bosons and fermions; thermodynamics of phase transition in a Van der Waal system, statistical mechanics of magnetic phase transitions.

PHL557 Electronics
4 credits (3-1-0)
Thevenin and Norton's theorem, Hybrid- & r- parameters, Biasing, current mirror, Small signal Amplifiers, Feedback amplifiers, power amplifiers, JFET and MOSFET circuits, Operational amplifiers DC coupled pairs, Differential amplifiers, its parameter, basic applications, Sinusoidal oscillators, Multi vibrators, Schmitt trigger, 555 IC timer, Clipping and clamping circuit, Sample and hold circuit, Active RC filter, Butterworth and Chebyshev filter, Power supplies and regulators, Power electronic circuits, Basic logic gates, Boolean algebra, combinational logic gates, digital comparators, Flip flops, shift registers, counters, Analog to digital converters.

PHL558 Applied Optics
4 credits (3-1-0)
Scalar waves, Diffraction integral, Fresnel and Fraunhofer diffraction, Single slit-Multiple slits- Circular aperture diffraction, Zone plate, Resolving power, Gaussian beam, Coherence theory, Interferometry, Laser Speckles, Basics of Fourier transformation (FT) operation, definition of spatial frequency, Transmittance functions, FT operation, Definition of spatial frequency, Transmittance functions, FT by diffraction and by lens, Spatial filtering-basics, Types of filters, Abbe-Porter experiment, Phase contrast microscope, Matched filter, Holographic principles, On-axis and off-axis hologram recording and reconstruction, Hologram types, Few applications, Wave propagation in anisotropic media, Polarized light, Uniaxial crystals, polarizing components, Guided wave optics-basics, Fiber optics.

PHP561 Laboratory I
6 credits (0-0-12)
Experiments from the areas of Optics, Electrodynamics and Electronics will form the practical contents of this course.

PHP562 Laboratory II
6 credits (0-0-12)
Experiments from the areas of Solid State Physics, Spectroscopy and Nuclear Physics will form the practical contents of this course.

PHP563 Advanced Laboratory
4 credits (0-0-8)
Experiments from the areas of Thin Films, Solid State Devices, Holography, Fiber Optics and Analytical Methods will form the practical contents of this course.

PHL565 Cooperative Phenomena in Solids
4 credits (3-1-0)
Perturbation Theory and Weak Periodic Potentials, Wave packets of Bloch Electrons, Tight binding model, Polarizability, Local fields, Clausius-Mossotti relation, Peizo-, Pyro- and Ferro-electric crystals, Ferroelectric domains, Optical behavior of bound & free electrons, Kramer-Kronig relations, Optical absorption, Photo conductivity, Diamagnetism, Pauli paramagnetism, Curie's law, Adiabatic demagnetization, magnetic ordering, Ferro-and Antiferromagnets, Spin waves, Effects of Dipolar Interactions, Superconductivity, Energy gap, London equation, BCS

Theory, Ginzburg-Landau formalism, Josephson effect, High temperature superconductors.

PHL567 Atomic and Molecular Spectroscopy
4 credits (3-1-0)
Spectra of alkali metals, doublet fine structure, two electron atom, Zeeman and Paschen-Back effect, X-ray spectra, general factors influencing spectral line width and line intensities, Molecular symmetry, irreducible representation, Rotational and vibrational spectra of diatomic molecules, FTIR and Laser Raman spectroscopy, Electronic spectra, Franck-Condon principle, bond dissociation energies, Molecular orbitals and models, Fluorescence and phosphorescence.

PHL569 Nuclear Physics
4 credits (3-1-0)
Basic observations of nuclear physics: Nuclear radii and charge distributions, Nuclear binding energy, Electric and magnetic moments, Semi-empirical mass formula, Nuclear force and two nucleon system, Nuclear models, Gamow's theory of alpha-decay, Fermi's theory of beta-decay, Electromagnetic transitions in nuclei multipole radiation, Nuclear fission. Nuclear reactions, particle accelerators and detectors, Sub-nuclear degrees of freedom: Symmetries of elementary particle physics, Quark model, Bag model, Introduction to QCD and Quark-gluon plasma (Qualitative).

PHD651 Project I
3 credits (0-0-6)

PHD652 Project II
6 credits (0-0-12)

PHL653 Semiconductor Electronics
3 credits (3-0-0)
Semiconductors junction review; charge storage and transient behavior, equivalent circuit of diode, p-n hetero-structure: band discontinuity and its effect on junction properties; Junction breakdown mechanisms; Static characteristics of Bipolar transistor; Frequency response and switching behavior, Non-ideal effects: base width modulation, early effect, current crowding and high injection effect; Hetero-junction transistor; SCR, M-S junctions: Basic structure, Energy band relation, I-V characteristics; Ohmic contacts; MOS capacitors, JFET and MESFET basic principles, MOSFET: structure and operation, basic characteristics and analysis; linear quadratic models; equivalent circuit; Threshold voltage calculation; Substrate biasing effect; LED, Laser, Photodiode and solar cells, Tunnel, IMPATT & Gunn diodes and comparison of microwave devices.

PHL654 Experimental Methods
3 credits (3-0-0)
Optical Microscopy; Scanning Electron Microscopy; Scanning Tunneling Microscopy; Atomic Force Microscopy; X-ray diffraction; Transmission Electron Microscopy; Low Energy Electron Diffraction; Reflection of High Energy Electron Diffraction; Neutron diffraction; Electron Spectroscopy for chemical analysis; Auger Electron Microscopy; Secondary ion mass spectroscopy; Electron Energy Loss Spectroscopy; X-ray Fluorescence; Rutherford back scattering; UV-VIS-NIR spectro-photometer & Ellipsometry; Deep Level Transient Spectroscopy; Thermally Simulated Current; C-V and Admittance Spectroscopy; Hall effect and Time of Flight methods for charge carriers, Differential scanning calorimeter; Differential Thermal Analyzer.

PHL655 Laser Physics
3 credits (3-0-0)
Introduction. Physics of interaction between Radiation and Atomic systems including: stimulated emission, emission line shapes and dispersion effects. Gain saturation in laser media and theory of Fabry-Perot laser. Techniques for the control of laser output employing Q-switching, mode-locking and mode-dumping. Optical cavity design and laser stability criteria. Description of common types of conventional lasers. Physics of semiconducting optical materials, degenerate semiconductors and their Homojunctions and Hetrojunctions. Light emitting diodes (LED's), junction lasers. Characteristics of diode laser arrays and applications.

PHL656 Microwaves
3 credits (3-0-0)

Maxwell's equations, Wave equation, Boundary conditions, Ideal transmission line, Terminated line, Wave solutions, TEM, TE and TM waves, Rectangular and circular wave guides, power and attenuation, Smith chart, Impedance matching, Double and triple stub tuners, Quarter wave and half wave transforms, Equivalent voltage and currents, Impedance description, Impedance, admittance and scattering matrix formulation, Signal flow graph, Attenuators, Phase shifters, Directional couplers, Junctions, Power dividers, Isolators and circulators, Resonant circuits, Transmission line resonators, Rectangular and circular wave guide resonators, Electron beams, Velocity modulation, Klystron, Magnetron, Traveling wave tubes, Gunn oscillator, Transistor and FET amplifiers, biasing, stability, power gain, noise, Mixers.

PHL657 Plasma Physics
3 credits (3-0-0)

Introduction to plasma, Debye shielding, Single particle motion in E and B fields, Mirror confinement, Plasma oscillations, Waves in unmagnetized plasmas, Solitons, Two stream instability, Rayleigh Taylor instability, Vlasov equation and Landau damping, Waves in magnetized plasmas (fluid theory), Plasma production & characterization, Plasma processing of materials, Laser driven fusion, Cerenkov free electron laser, Applications to astrophysics and astronomy.

PHD658 Mini Project
3 credits (0-0-6)

To provide an opportunity to interested students to gain practical experience of a kind different than that of his major project, i.e. if the major Project is experimental than Mini Project should be theoretical or simulation OR vice versa. It will be available in 3rd semester only.

PHL661 Selected Topics
3 credits (3-0-0)

PHL662 Special Topics
3 credits (3-0-0)

PHL701 Electronic Properties of Materials
3 credits (3-0-0)

Drude and Sommerfeld theories of metals, Effect of periodic lattice potential, Magnetic behaviour-exchange interaction and magnetic domains, Ferrimagnetic order, ferrites and garnets, hard and soft magnets, single domain magnets, spin waves, surface magnetism, dielectric constants of solids and liquids, Claussius-Mossoti relation, dielectric dispersion and losses, piezo, ferro-and pyroelectricity, optical constants, atomistic theory of optical properties, quantum mechanical treatment, band transitions, dispersion, plasma oscillations.

PHL702 Science & Technology of Thin Films
3 credits (3-0-0)

Physical Vapor Deposition - Hertz Knudsen equation; mass evaporation rate; Knudsen cell, Directional distribution of evaporating species Evaporation of elements, compounds, alloys, Raoult's law; e-beam, pulsed laser and ion beam evaporation, Glow Discharge and Plasma, Sputtering–mechanisms and yield, dc and rf sputtering, Bias sputtering, magnetically enhanced sputtering systems, reactive sputtering, Hybrid and Modified PVD- Ion plating, reactive evaporation, ion beam assisted deposition, Chemical Vapor Deposition - reaction chemistry and thermody-namics of CVD; Thermal CVD, laser & plasma enhanced CVD, Chemical Techniques - Spray Pyrolysis, Electrodeposition, Sol-Gel and LB Techniques, Nucleation & Growth: capillarity theory, atomistic and kinetic models of nucleation, basic modes of thin film growth, stages of film growth & mechanisms, amorphous thin films, Epitaxy–homo, hetero and coherent epilayers, lattice misfit and imperfections, epitaxy of compound semiconductors, scope of devices and applications.

PHL703 Materials Technology
3 credits (3-0-0)

Phase diagrams : allotropic transformations, Vegard law, binary and ternary phase diagrams and non-equilibrium phase transformations, Purification of materials: theory for effective distribution coefficients and its determination, zone refining, Diffusion: Laws and mechanisms for surface, grain boundary and volume diffusion, Phase transformations: nucleation and growth, solid-solid transformation and spinodal decomposition, Growth of single crystals: growth from melt, vapor phase and solution, Deterioration of materials: Corrosion, galvanic cells, passivation, Oxidation: oxide growth mechanisms, oxidation control and oxidation resistance of alloys.

PHL704 Semiconductor Device Technology
3 credits (3-0-0)

Silicon wafer fabrication and oxidation techniques, Growth kinetics, Oxide growth measurements techniques, Defects in silicon, silicon dioxide, Interface defects, Point defect based model for oxidation, Polysilicon, Si_3N_4 and Silicide formation. UV, Electron, plasma and x-ray lithography techniques, Wet etching and plasma etching techniques. Diffusion and ion implantation, Diffusion in polycrystalline materials, Ion implantation techniques, Modeling and measurement of dopant profiles, Overview of process flow for IC technology.

PHL705 Physics of Semiconductor Devices
3 credits (3-0-0)

Review of Quantum Theory of Semiconductors, Semiconductors in Equilibrium, Carrier Transport in Semiconductors, Semiconductor Under Non-Equilibrium, Physics of Junction Devices, Metal-semiconductor & Semiconductor heterojunctions, Physics of bipolar devices, Fundamentals of MOS and Field effect Devices, Basics of Solar Cell.

PHL707 Characterization of Materials
3 credits (3-0-0)

Crystallography, X-Ray Diffraction Methods, Reitveld Refinement, Neutron Diffraction, X-Ray absorption, X-Ray Fluorescence spectroscopy, Electron Diffraction- diffraction pattern in specific modes, LEED and RHEED, Electron Optics, Electron Microscopy-Transmission and Scanning Electron Microscopy, STM and AFM, Compositional analysis employing AES, ESCA and Electron Probe Microanalysis.

PHP711 Solid State Materials Laboratory I
4.5 credits (0-0-9)

The experiments will be primarily on the preparation of Single crystals from melt, polycrystalline bulks by conventional sintering, and thin films by spray pyrolysis & spinning, and characterization of (i) Hall measurements, and optical properties of thin films by spectrophotometric and ellipsometric measurement, (ii) Thermal properties of alloys, (iii) Dielectric properties, dielectric dispersion and voltage dependent resistivity of certain electronic ceramics, (iv) structural determination of crystals, and (v) Estimation of dislocation density by chemical etching.

PHP712 Solid State Materials Laboratory II
4.5 credits (0-0-9)

The experiments will be primarily on the preparation of thin film by thermal evaporation and sputtering techniques, growth of SiO_2 on Si by oxidation, synthesis of polycrystalline samples of ferrites, high temperature super-conductors and electronic ceramics, and characterization of (i) electronic and optical properties of thin films, (ii) magnetic, thermo-resistive and superconducting properties of electronic ceramics.

PHL721 Electronic Ceramics
3 credits (3-0-0)

Bonding in ceramics and their structure including defects and nonstoichiometry; Development of microstructure in equilibrium and nonequilibrium phases, calcinations, grain growth and solid liquid phase sintering; Ceramic coatings and their deposition; Properties of valence controlled, photonic, electro-optic, magnetic and superconducting ceramics, nonlinear dielectrics and ferrites; Applications of electronic ceramics in various devices including sensors for gases, temperature, pressure and voltage, and in optical communication, magnetic and oxide electronics, and electric power and energy storage devices.

PHL722 Analytical Techniques
3 credits (3-0-0)
Mass Spectrometry, Thermal Characterization, Ultrasonic Nondestructive Methods, Spectrophotometry & Ellipsometry, Spectroscopic Techniques: Molecular spectroscopies including Microwave, FTIR, Raman and surface enhanced Raman Spectro-scopy; Resonance Spectroscopies, Mossbauer Spectroscopy, Magnetic & Dielectric Analysis.

PHL723 Vacuum Science and Cryogenics
3 credits (3-0-0)
Behavior of Gases; Gas Transport Phenomenon, Viscous, molecular and transition flow regimes, Measurement of Pressure, Residual Gas Analyses; Production of Vacuum - Mechanical pumps, Diffusion pump, Getter and Ion pumps, Cryopumps, Materials in Vacuum; High Vacuum, and Ultra High Vacuum Systems; Leak Detection. Properties of engineering materials at low temperatures; Cryogenic Fluids - Hydrogen, Helium 3, Helium 4, Superfluidity, Experimental Methods at Low Temperature: Closed Cycle Refrigerators, Single and Double Cycle He^3 refrigerator, He^4 refrigerator, He^3-He^4 dilution refrigerator, Pomeranchuk Cooling, Pulsed Refrigerator System, Magnetic Refrigerators, Thermoelectric coolers; Cryostat Design: Cryogenic level sensors, Handling of cryogenic liquids, Cryogenic thermometry.

PHL724 Magnetism and Super-conductivity
3 credits (3-0-0)
Demagnetisation factor, Antiferroma-gnetism, Neutron diffraction, Magnetism in Rare Earths and Antiferromagnetic Alloys, Helimagnetism, Ferrimagnetism, Spin Glasses, Magnetotstriction, Domains and magnetization process, Single Domain Particles, Coercivity in fine particles, Superparamagnetism, Spintronics, Magnetoresistance, ApplicationsType-I Superconductivity, London theory, Specific Heat and Thermal Conductivity, Intermediate State, Measurements of Critical currents and Magnetic Properties, Critical State Models, Ginzberg-Landau and BCS Theory, Josephson effects, SQUIDs, Type-II Superconductivity; Pinning of Vortices, High Temperature Superconductors, Flux Flow, Flux Creep, Fluctuation effects, Levitation and Electrical Power Applications of HTSC.

PHL725 Physics of Amorphous Materials
3 credits (3-0-0)
Types of amorphous solids, aspects of glass transition, structure, rcp and crn structures, EXAFS and Synchroton radiation, Molecular solids and Network dimensionality, network solids, 8-N rule, topological defects and valence alteration, Electronic structure of amorphous solids, localized and extended states, mobility edges, CFO model, Density of states and their determination, transport in extended and localized states, Optical properties of amorphous semiconductors, absorption edge and absorption tail, high absorption region, sum rules, Some case studies and applications of important amorphous materials, hydrogenated amorphous silicon, chalcogenide glass, metallic glasses.

PHL726 Nanostructured Materials
3 credits (3-0-0)
Physics of low-dimensional materials, 1D, 2D and 3D confinement, Density of states, Excitons, Coulomb blockade, Surface plasmon, Size and surface dependence of physical, electronic, optical, luminescence, thermo-dynamical, magnetic, catalysis, gas sensing and mechanical properties.

Physical and chemical techniques for nanomaterial synthesis, Assembling and self organization of nanostructures, Nanoscale manipulation, Nanotube and wire formation, Importance of size distribution control, size measurement and size selection.

PHL727 Quantum Heterostructures
3 credits (3-0-0)
Bandstructure modification by alloying and strain, Modulation doping, Lattice matched and lattice mismatched materials, Strained hetrostructures. Quantum confinements in 2D, Excitons, lattice vibrations and electron transport in quantum structures, Optical behavior and inter band transitions, Electro optic and quantum Hall effects. Motivation for using hetrostructures for devices, Schottky barrier and p-i-n photodetector, Charge coupled devices, Edge emitting, Surface emitting and Quantum well LED's and lasers. Hetro structure FET, Velocity modulation and quantum interference transistor, Hetrostructure bipolar transistor and Resonant tunneling devices.

PHS731 Independent Study
3 credits (0-3-0)
The contents would include specific advanced topics of current interest in Materials Synthesis, New Materials and their behavior and New Device structures and concepts. The contents would be announced every time the course is offered as a self study course

PHL741   Quantum Electrodynamics and Particle Physics
3 credits (3-0-0)
Dirac equation, plane wave solutions, Foldy-Wouthusen transformations, S-matrix, Classical fields, equations of motion, conserved quantities, Quantization of complex scalar, electromagnetic and spinor fields, The interaction Hamiltonian, normal and chronological products, Wick's theorem, Feynman's rules and diagrams: electron scattering by an external em field, electron-photon scattering, pair creation, current form factors, Cross-sections, traces, scattering of electrons and p-mesons of a nucleon, decay processes, Renormalization, one-loop correction, electron self-energy, vacuum polarization, Parity, Charge conjugation, Time reversal invariance, CP violation and CPT theorem, SU(2) of Isospin, SU(3) of color, Quark model of hadrons: SU(3) of flavor, Isospin and strangeness, baryon octet, meson octet, magnetic moments of baryons, electron-proton scattering – proton form factors, Inelastic e-p scattering – structure functions, partons and Bjorken scaling.

PHL742   General Relativity and Introductory Astrophysics
3 credits (3-0-0)
Tensors, definition; algebraic properties, orientation tensor, symmetrisation and antisymmetrisation. Affine transplantation of tensors, concept of the metric tensor and geodesics, Curvature, Reimann Tensor and its properties, Energy Momentum tensor, Ricci Tensor and Einstein tensor and the Einstein Equations. Newtonian limit. Schwarschild solution and its consequences. Experimental tests of the solution, Mercury's orbit, red shift, Shapiro Delay light deflection, Reissner Nordstrom and weak field solutions of the Einstein Equation. Homogeneous and isotropic universes. Freidman Cosmologies, Evolution of the Universe into its present state and experimental tests of the theory Gravitational lensing and experimental observations thereof. Gravitational waves, their physical properties and the motion of a test particle in a gravitational field. Gravitational wave detectors.

PHL743   Group Theory and its Applications
3 credits (3-0-0)
Concept of a group, multiplication tables, cyclic and permutation groups, subgroups, cosets, Isomorphism and Homomorphism, conjugate elements and classes, normal sub-groups and factor group, direct product of groups, Group representations, Unitary and Irreducible, representations, Schur's Lemmas, orthonormality theorems, Character tables, Basis functions for irreducible representations. Continuous groups, Lie groups, The rotation group, Special orthogonal and unitary groups, crystallographic point groups and their representations. Applications in quantum mechanics and solid state physics.

PHL744   Advanced Topics in Quantum Mechanics
3 credits (3-0-0)
Klein-Gordon equation, Dirac equation, Negative energy states, hole theory, angular momentum and spin, Coupling to an electromagnetic field, Non-relativistic limit, Hydrogen atom spectrum in Dirac theory, Non-relativistic propagator, Propagator in positron theory, Scattering of electrons and positrons in a Coulomb field, Strong interaction, Nucleon-Nucleon and meson-nucleon scattering. Second quantization of the electromagnetic, the mesonic and the fermionic fields, Microscopic theory of superfluidity. Interaction of electrons with phonons in a metal, pairing, Cooper pairs, BCS theory of superconductivity. Bose-Einstein condensation..

PHL751 Optical Sources, Detectors and Photometry
3 credits (3-0-0)

Eye and Vision: Visual system, accommodation, adaptation, sensitivity, acuity; Radiometry & Photometry: Radiometric quantities and their measurement, color and brightness temperature; photometric quantities, radiation from a surface; Brightness and luminous intensity distribution; Integrating sphere; Illumination from line, surface and volume sources; Illumination in images; Colorimetry: Fundamentals, trichromatic specifications, colorimeters, CIE system; Conventional light sources: Point and extended sources; Incandescent, fluorescent, arc and gas discharge lamps; LEDs; Illumination engineering: Lighting fundamentals, day lighting, examples of design, lighting of factories and streets: Optical Detectors: Photographic emulsion, thermal and photon detectors; Detector characteristics and figures of merit, noise considerations; Photoconductors and characteristics; Photomultiplier tubes, photodiodes; calibration of detectors; detector arrays, CCD.

PHL752 Laser Systems and Applications
3 credits (3-0-0)

Review of laser theory, properties of laser radiation, and laser safety; Common laser systems : Ruby-, Nd:YAG- and Nd:Glass lasers, diode-pumped solid state laser, Er-doped silica fiber laser, Ti:Sapphire laser, He-Ne, CO_2 and Ar-ion lasers, excimer-, dye-, X-ray- and free-electron lasers; Semiconductor lasers : Double heterostructure–and quantum-well lasers, VCSEL, DFB- and DBR lasers; Application of lasers in data storage, communication and information technology : CD players, DVDs, laser printers, bar-code scanners, and optical communication; Surface profile and dimensional measurements using diffraction and its variations; High-power laser applications: marking, drilling, cutting, welding, and hardening; laser fusion; Laser Doppler velocimetry, LIDAR, laser spectroscopy, medical applications of lasers.

PHL753 Optical System Design
3 credits (3-0-0)

Gaussian theory of optical system; Aberrations: Transverse ray and wave aberrations, chromatic aberration and third order aberrations; Ray tracing: paraxial, finite and oblique rays; Image evaluation; Geometric OTF. its computation and measurement; Strehl ratio; Variance of wave aberration function, RMS wave aberration function, spot diagram;Optimisation techniques in lens design, definition of merit function, commonly used optimisation methods, damped least square method, orthonormalization, and global search method; Tolerance analysis; Achromatic doublets, apochromats and aplanats; Cooke Triplet and its derivatives; Double Gauss lens, Introduction to zoom.

Lenses and aspherics; Examples of modem optical systems such as optical systems using aspherics, zoom lens, GRIN optics.

PHL754 Optical Instruments and Metrology
3 credits (3-0-0)

Spectroscopic instrumentation; Fabry-Perot interferometer, diffraction gratings, Fourier transform spectroscopy; Interferometric instrumentation for testing; shearing, scatter fringe, three-beam and polarization interferometers; Scanning microscopy: Imaging modes, depth discrimination, super resolution, practical aspects, measurements on semiconducting devices, near-field techniques; Displays : television optics, liquid crystal displays, video projectors; Adaptive optics : Wavefront sensing and correction, adaptive systems, reconstruction and controls; Opto-medical Instruments: Keratometers, opthalmoscopes, optometers, optical coherence tomography; Infrared instrumentation: I.R. telescopes, focal plane arrays, cryo-cooling systems, scanning and stabilization mechanisms, smart weapon seekers, forward look infrared, space-based sensors; Space optics: Satellite cameras,high-resolution radiometers, space telescopes; Optical metrology: Surface inspection, optical gauging and profiling, techniques for nondestructive testing, Moire self imaging and speckle metrology, sensing elements, instrumentation and applications in material science and biology.

PHL755 Statistical and Quantum Optics
3 credits (3-0-0)

Probability theory, generating function, characteristic function; Stochastic processes, spectral properties, correlation and convolution; Analytic signal and spatial frequency analysis; Temporal, spatial and partial coherence; Propagation of coherence, Van Cittert and Zernike theorem; Higher order correlations; Differential photo detection probability, joint probability of multiple photodetection, Mandel's formula; Intensity interferometry; Quantum theory of light, density operators and Wigner Ofunction; Coherent states and squeezed states; Photon statistics, nonclassical states and EPR paradox; Laser Doppler velocimetry, light beating and photon correlation spectroscopy; Doppler free spectroscopy, saturation spectroscopy; Laser speckle statistics.

PHL756 Fourier Optics and Optical Information Processing
3 credits (3-0-0)

Signals and systems, Fourier transform (FT), sampling theorem; Diffraction theory: Fresnel-Kirchhoff formulation and angular spectrum method, brief discussion of Fresnel and Fraunhofer diffraction, FT properties of lenses and image formation by a lens; Frequency response of a diffraction-limited system under coherent and incoherent illumination, OTF - effects of aberration and apodization, comparison of coherent and incoherent imaging, super-resolution; Techniques for measurement of OTF; Analog optical information processing: Abbe-Porter experiment, phase contrast microscopy and other simple applications; Coherent image processing: vanderLugt filter; joint-transform correlator; character recognition, invariant pattern recognition, image restoration; Data processing from synthetic aperture radar (SAR), acousto-optic signal processing, discrete analog processors.

PHL757 Optical Materials and Thin Films
3 credits (3-0-0)

Refractive index and dispersion; Transmission, reflection and absorption of light; Glass and amorphous materials; Optical material for UV and IR; Laser crystals: Spectroscopy of laser crystals, laser crystals for high gain, crystal growth and characterization; Optics of anisotropic crystals : biaxial, uniaxial crystals, double refraction, index ellipsoid, optical activity; Non-linear optical crystals; Liquid crystals; Photorefractive materials, theory of photorefractivity, application of photorefractive; Semiconductors : band gap modification by alloying optical properties of quantum well, quantum wire and quantum dot structures; Photonic band gap (PBG) materials, growth of PBG materials, light transmission in PBG materials, application of PBG materials; Optics of thin films: reflection, transmission and absorption in thin films; antireflection (AR) Coating : single layer AR coating, double layer AR coatings, multiplayer and inhomogeneous AR coatings; Reflection coatings : metal reflectors, all dielectric reflectors; Interference filters : edge filters, band pass filters, Fabry-Perot filters, multi-cavity filters; Thin film polarizers; Beam splitters; Thin film integrated optical structures and devices.

PHL758 Theory and Applications of Holography
3 credits (3-0-0)

Basics of holography, in-line and off-axis holography; Reflection, white light, rainbow and wave guide holograms; Theory of plane holograms, magnification, aberrations, effects of non-linearity, band-width and source size; Volume holograms: coupled wave theory, wavelength and angular selectivity, diffraction efficiency; Recording medium for holograms: silver halides, dichromatic gelatin, photoresist, phoconductor, photorefractive crystals, etc.; Applications : microscopy; interferometry, NDT of engineering objects, particle sizing; holographic particle image velocimetry; imaging through aberrated media, phase amplification by holography; optical testing; HOEs: multifunction, polarizing, diffusers, interconnects, couplers, scanners; Optical data processing, holographic solar concentrators; antireflection coatings; holo-photoelasticity; Colour holography: recording with multiple wavelength; white light colour holograms; Electron holography, acoustic and microwave holography and some typical applications, computer holography, digital holography.

PHL759 Selected Topics in Applied Optics
3 credits (3-0-0)
The course would cover topics of current interest, not covered in other courses.

PHP761 Optics Laboratory-I
3 credits (0-0-6)
Experiments involving testing and measurements with the following instruments : Strain viewer, higher precision spheroscope, micro-optic autocollimator, knife edge and star test apparatus, Fizeau interferometer, Twyman Green interferometer, multiple beam inter- ferometer, schlieren photography, Abbe refractometer, vacuum coating unit, various types of microscopes.

PHP762 Optics Laboratory-II
3 credits (0-0-6)
This courses designed to make the students familiar with modern measurement techniques. Typical exprements are in the following areas: Spatial filtering, Holography, Speckles, Fourier optics, Contrast enhancement, Displacement measurement, vision testing, O.T.F. measurements etc.

PHP763 Optical Workshop
3 credits (0-0-6)
Introduction to various types of glass, cutting, edging, grinding, smoothing and polishing. Polishing machines. Making of tools and test plates. Fabrication of optical components like flats, prisms, concave mirrors and lenses etc.

PHP764 Mechanical Workshop and Engineering Drawing
3 credits (0-0-6)
This course is so designed as to (i) give the student adequate practice of preparing drawings of simple instruments and their mountings, (ii) make the student familiar with the techniques employed in a mechanical workshop and some practice in fabrication of simple attachments for optical instruments.

PHL790 Integrated Optics
3 credits (3-0-0)
Planar waveguides :Step-index and graded-index waveguides, guided and radiation modes. Strip and channel waveguides, anisotropic waveguides, segmented waveguide; electro-optic and acoustooptic waveguide devices. Directional couplers, optical switch; phase and amplitude modulators, filters, etc. Y-junction, power splitters, Arrayed waveguide devices, fiber pigtailing, Fabrication of integrated optical waveguides and devices. Waveguide characterisation, end-fire and prism coupling; grating and tapered couplers, nonlinear effects in integrated optical waveguides.

PHL791 Fiber Optics
3 credits (3-0-0)
Fiber numerical aperture, Sources of signal attenuation and dispersion, Step and graded index multimode fibers, LP modes in optical fibers: Single-mode fibers, mode cutoff and mode field diameter, Pulse dispersion in single-mode fibers: dispersion-tailored and dispersion-compensating fibers. Birefringent fibers and polarization mode dispersion. Fiber bandwidth and dispersion management, Erbium-doped fiber amplifiers and lasers; Isolators, Fiber fabrication techniques. Fiber characterization techniques including OTDR, Connectors, splices and fiber cable.

PHL792 Optical Electronics
3 credits (3-0-0)
Wave propagation in anisotropic media, Electro-optic effect: phase and amplitude modulators. Electro-optics of liquid crystals; LCDs and SLMs. Acousto-optic effect: A.O. Diffraction: modulators, deflectors and tunable filters. Nonlinear Optics: SHG, sum & difference frequency generation, parametric amplification, Wavelength converters, Phase conjugation: Nonlinear effects in optical fibers: SPM, XPM and FWM, solitons, SRS & SBS.

PHL793 Semiconductor Optoelectronics
3 credits (3-0-0)
Review of semiconductor physics: energy bands, density of states, Fermi level, p-n junctions. Homo-and hetero-junctions, quantum wells, Semi-conductor materials Semiconductor optical amplifiers, LEDs and LDs: Device structure and Characteristics, DFB, DBR, and quantum well lasers, VCSELS & Laser diode arrays, Electroabsorption modulators and SEEDs, Semiconductor photodetectors; PINs and APDs, CCDs and OEICs.

PHL795 Optics and Lasers
3 credits (3-0-0)
Review of basic optics: Polarization, Reflection and refraction of plane waves: Diffraction: diffraction by single slit and circular aperture, Gaussian beams, Fourier optics: Interference: two beam and multiple beam interference, Fabry-Perot interferometer. Interaction of radiation with matter, light amplification and gain saturation. Laser rate equations, three level and four level systems; Optical Resonators: resonator stability; modes of a spherical mirror resonator, mode selection; Q-switching and mode locking in lasers: Properties of laser radiation and some laser systems.

PHL797 Selected Topics-I
3 credits (3-0-0)

PHL798 Selected Topics-II
3 credits (3-0-0)

PHL800 Numerical and Computational Methods in Research
3 credits (3-0-0)
Solution of polynomial and transcendental equations, ordinary differential equations with initial conditions, matrix algebra and simultaneous equations, eigenvalues and eigenvectors of a real symmetry matrix, least square curve fittings, numerical integration, integral equations, ordinary differential equation with boundary conditions, Monte Carlo methods and random numbers.

PHD801 Major Project Part I
6 credits (0-0-12)

PHD802 Major Project Part II
12 credits (0-0-24)

PHL810 Plasma Waves and Instabilities
3 credits (3-0-0)
Kinetic theory of plasma instabilities—unmagnetized plasma; magnetized plasma; Landau damping; cyclotron damping; bump- in-tail instability; beam driven instabilities; drift waves; temperature anisotropy driven modes; current drive instabilities; applications to RF heating in tokamaks and free electron laser.

PHD851 Major Project Part-I
6 credits (0-0-12)

PHD852 Major Project Part-II
12 credits (0-0-24)
This major project is for two semesters, but its allotted in the month of April, so that the students can use the summer vacation period for literature survey and preliminary studies. The projects end in May/June at the end of fourth semester. The evaluation of the Part-I and Part-II would be done independently at the end of third and fourth semesters, respectively. The project can be on any topic covered under applied optics and related subject.

PHP853 Advanced Optical Workshop II
3 credits (0-0-6)
Fabrication of precision optical components/instruments.

PHS855 Independent Study
3 credits (0-3-0)
Student, in consultation with the course coordinator, would select a

topic for the self-study and prepare seminars on the topic. In addition, experts may also be invited to give lectures on advanced topics, which would also form part of the curriculum of this course.

PHL891 Guided Wave Optical Components and Devices

Review of optical fiber properties: multimode, single mode, birefringent, photonic crystal and holey fiber: Directional couplers: Analysis, fabrication and characterization: application in power dividers, wavelength division multiplexing, interleavers and loop mirrors: Fiber Bragg grating: Analysis, fabrication and characterization: application in add-drop multiplexing, gain flattening, dispersion compensation and wavelength locking: fiber half-block devices and application in polarizers, modulators and wavelength filters, Fiber polarization components: polarization controllers and associated micro-optic components like isolators and circulators; Optical fiber sensors: Intensity, phase and polarization based sensors, applications in various disciplines.

Department of Textile Technology

TTN110 Introduction to Textile Technology
2 credits (0-0-4)

This course is an introduction to second year level courses in the department. The students are encouraged to self learn basic principles of relevant technology and its technical jargon by conducting simple experiments, making observations and reading brief handouts. This includes learning the importance of textile materials and structures in comparison to other known structural materials such as metals, ceramics, concrete, etc. Introduction to development of various structures of textile, such as fibres, yarn, fabric and their conversion into everyday to technically critical applications. A trip to a textile industry and short seminar series by students will make an integral part of this course.

TTP200 Design of Textile Products and Processes
2 credits (0-0-4)
Pre-requisites: TTN110 / MEL110 / MEL120

Individual or group of students would be offered predefined product or process design project under the guidance of a faculty members. Emphasis of the projects set should be on achieving set objectives using known technological components, rather than new or fundamental research.

TTP211 Introduction to Fibres
2 credits (1-0-2)
Pre-requisites: PHL110 / MAL110 / CYL120

Classification of fibres-natural and manmade; Basic structure of a fibre; General properties of a fibre such as moisture absorption, tenacity, elongation, initial modulus, yield point, toughness, elastic recovery; Detailed chemical and physical structure of natural fibres- cotton, wool and silk, their basic properties; Introduction to important bast fibres. Laboratory exercises would include experiments on fibre identification through physical appearance, microscopic- optical, SEM and burning behaviour; Chemical identification through solvent treatment and FTIR; Identification using DSC (melting point and glass transition temperature), density measurement.

TTL211 Structure and Physical Properties of Fibres
3 credits (3-0-0)
Pre-requisites: PHL110 / MAL110 / CYL120

Molecular architecture, configuration, conformation, amorphous and crystalline phases, glass transition, plasticization, crystallization, melting, factors affecting Tg and Tm; Basic structure of a fibre-one dimensional oriented, semicrystalline, structure of fibrils; Role of molecular entanglement on fibre formation; Formation of structure in viscose and thermoplastic fibres i.e. PET, nylon, PP and acrylic; Methods of investigating physical structure of fibres such as WAXD, SAXD, DSC, DMA/TMA, FTIR, birefringence and sonic modulus; Moisture absorption properties, Rate of moisture absorption, Heat of sorption, water retention and swelling; Theories of moisture absorption- general view, absorption in crystalline and amorphous regions, quantitative theories; Theories of mechanical properties of natural and man-made fibres, viscoelastic behaviour, comparison of properties of various fibres; Fibre friction, Optical properties, Introduction to electrical properties such as dielectric properties and static charge generation; Thermal properties – heat-setting.

TTL212 Manufactured Fibre Technology
4 credits (3-1-0)
Pre-requisites: CYL120 / MAL110 / PHL110

Polymerization of nylon-6, nylon-66, poly(ethylene terephthalate) and polyacrylonitrile; Important reactions and their kinetic rate equations. Batch versus continuous reactors; Modification of PET and nylons; Introduction to polymer transport phenomena, Polymer rheology, Shear flow through a capillary, elongational flow in a spinning line; Melt instabilities; Melt spinning lines; stress induced crystallization in high speed melt spinning; Characteristic features of PET, polyamide and polypropylene spinning; Spin finish and its components; Wet and dry spinning processes; Effect of parameters on fibre breakage and fibre structure; Importance of dry jet wet spinning of PAN; Introduction to drawing and heatsetting in thermoplastic fibres.

TTP212 Manufactured Fibre Technology Laboratory
1 credit (0-0-2)
Pre-requisites: CYL120 / MAL110 / PHL110 / TTL212
(Concurrent registration with TTL212 permitted)

Experiments related to fibres production processes, for example, determination of moisture in chips. Effect of moisture and temperature on MFI of PET and PP, Melt spinning of PET, nylon-6 filament yarn on laboratory spinning machines, Single and two stage drawing of the as spun yarns and POY, Demonstration of high speed spinning machine; Heat setting of PET and nylon drawn yarns on heaters, in oil bath and steam. Effect of temperature, slack/taut condition on heatsetting; Determination of structure and mechanical properties of as spun, POY, drawn and heat set yarns using DSC, x-ray, FTIR, density, sonic modulus; Determination of polymer solution rheology using Brookfield rheometers and ball-fall method; Effect of shear rate, temperature on viscosity of solutions; Wet spinning or dry jet wet spinning of PAN copolymers; Demonstration of false twist and air jet texturing processes; Determination of structure of textured yarn under microscope.

TTL221 Yarn Manufacture - I
4 credits (3-1-0)
Pre-requisites: CYL120 / MAL110 / PHL110

Impurities in natural fibres. Separation of trash and lint. Pre-baling operations for wool. Purpose of opening, cleaning, mixing and blending of fibres. Opening elements. Principles of fibre opening in blow room and card. Sequence of opening machines. Principles of cleaning. Influence of process parameters on opening and cleaning. Analysis of opening and cleaning processes. Principles and methods of fibre mixing and blending. Mass transportation. Collection of waste. Objectives and principles of drafting. Purpose and principle of condensation of fibres. Causes of mass variation of fibrous assembly and control. Automation and recent developments.

TTP221 Yarn Manufacture Laboratory - I
1 credit (0-0-2)
Pre-requisites: CYL120 / MAL110 / PHL110

Practicals related to the theory course TTL211.

TTL222 Yarn Manufacture - II
4 credits (3-1-0)
Pre-requisites: TTN110

Fibre fractionation and combing. Sequence of operations in a rectilinear comber. Comber machine elements. Preparation of fibre assembly for combing. Theory of fibre fractionation. Twist and yarn strength. Flyer twisting; types and design aspects of flyers. Principles of ring twisting; design aspects of spindles, rings and travellers. Doubling and twisting of yarns. Twist insertion using rotors. Yarn formation using air-jets. Twisting by friction drums. TFO and three for one twisting. Formation of laps. Packing of slivers in cans. Winding of rovings; Principle and design aspects of builder motion in roving frame. Formation of cop build packages in ring frame. Package formation in rotor, air-jet, friction spinning and TFO twisting machines. Automation and recent developments in spinning machinery .

TTP222 Yarn Manufacture Laboratory - II
1 credit (0-0-2)
Pre-requisites: TTN110

Practicals related to the theory course TTL222.

TTL231 Fabric Manufacture - I
4 credits (3-1-0)
Pre-requisites: CYL120 / MAL110 / PHL110

Introduction to various fabric manufacturing methods. Yarn preparation for fabric formation. Winding: objectives, types, basic features, and automation. Different types of packages. Pirn winding: objectives, types, basic features and automation. Warping: Objectives, comparison of various types of warping machine, basic features, creels and control devices. Sizing: Objectives, features of sizing machine, machine elements and process parameters, sizing materials, size preparation and application, size fibre interaction. Drawing-in and knotting.

Weaving: Loom elements, classification of looms, primary, secondary and auxiliary motions of loom, multiple boxes, over and under picking, beat-up, take up, let-off, weft stop and warp stop motion, weft feeler, warp protecting device and box motion. Cam design for shedding and picking. Dobbies and Jacquards: classification, mechanism and design developments. Automatic loom, basic features, pirn changing and shuttle changing mechanism. Loom winder and box loader.

Fabric structure: classification, notation of weave, draft and peg plan, plain weave with its derivatives and ornamentation, basic twill and satin weaves. Analysis of simple fabrics and calculations pertaining to yarn requirements.

Calculation for production and efficiency related to winding, warping, sizing and weaving.

TTP231 Fabric Manufacture Laboratory - I
1 credit (0-0-2)
Pre-requisites: CYL120 / MAL110 / PHL110
Experiments related to TTL231.

TTL232 Fabric Manufacture - II
4 credits (3-1-0)
Pre-requisites: TTN110
Shuttleless Looms: Principles of weft insertion, power of picking, velocity and acceleration and picking elements, energy consumed, timings, drive to sley and healds, fabrics quality and productivity of projectile, rapier, air-jet and water-jet looms. Comparison of various weft insertion systems. Theoretical analysis of weft insertion in shuttle less looms. Principles of fabric formation on two phase, multiphase, circular and narrow fabric weaving. Carpets: basic features and manufacturing process of hand/machine knotted, woven (Brussel, Wilton, Axminster) and Tufted carpet. Leno weaving, Triaxial weaving. Multiphase weaving. Denim manufacturing.

Basic weft and warp knitted constructions; primary and secondary knitting elements; sequence of loop formation on warp and weft knitting machines; relation between machine gauge and yarn count; productivity of knitting machines; geometry of a loop in plain knitted fabric; control of loop length, fabric weight and dimensions. Properties of knitted fabric. Nonwoven fabrics: Definitions and classifications; production technology, selection criteria and important properties of fibres used. Different types of webs and bonding techniques. Production and properties of needle punched, stitch bonded, adhesive bonded, spunlaced, spun bonded and meltblown fabrics

TTP232 Fabric Manufacture Laboratory - II
2 credits (0-0-4)
Pre-requisites: TTN110
Experiments related to TTL232.

TTL241 Technology of Textile Preparation and Finishing
3 credits (3-0-0)
Pre-requisites: CYL120 / MAL110 / PHL110
Natural and added impurities in textiles; Singeing, desizing, scouring, bleaching, mercerisation and optical whitening of cotton; Combined preparatory processes Carbonisation, scouring and bleaching of wool, degumming of silk; Preparation of synthetic fibres and blends; heat setting; Machinery for preparation of textiles; Surfactants and their application; Introduction to chemical and mechanical finishes; Chemical finishes for hand modification; Biopolishing; easy care; oil, water and soil repellent finishes; Fire retardancy; antimicrobial finishes; Finishes for wool; Mechanical finishes like shrinkproofing and calendering; Raising, sueding and emerising; Low liquor application techniques and machinery; Stenters and dryers.

TTP241 Technology of Textile Preparation and Finishing Laboratory
1.5 credits (0-0-3)
Pre-requisites: CYL120 / MAL110 / PHL110
Practicals dealing with desizing, scouring and whitening of cotton textiles; Combined preparatory processes; Carbonising, scouring and

bleaching of wool and desizing of silk; Finishes for handle modification; functional finishes such as crease recovery, flame retardant, rot proofing of cotton and milling of wool.

TTL242 Technology of Textile Coloration
4 credits (3-1-0)
Pre-requisites: TTN110
The principles of dyeing and printing of textile; Basic characteristics of dyes, chemical structure of dyes and classification of dyes; Dyeing equipment and the specific dyes and procedures used to dye textiles; Evaluation of Fastness; Methods of printing namely, roller, screen, transfer, ink jet and the preparation of printing paste; Direct, discharge and resist printing styles; Physical chemistry of fibre/fabric dyeing; Physicochemical theories of the application of dyestuffs to textile and related materials, including the thermodynamics and kinetic principles involved; Discussion of colour science and computer match prediction in dyeing fibres, yarns and fabrics; Objective specification of colour, colour difference measurements and various colour spaces; Based on colour theory and numerical analysis, computer match prediction algorithms; Setting of Pass/Fail criterion and shade sorting; Colour communication; Using computer colour matching software.

TTP242 Technology of Textile Coloration Laboratory
1.5 credits (0-0-3)
Pre-requisites: TTN110
The principles of dyeing and printing of textile material; Dyeing equipment and the specific dyes and procedures used to dye textiles; Evaluation of Fastness; Methods of printing namely, roller, screen, transfer, ink jet and the preparation of printing paste; Direct, discharge and resist printing styles.

TTV301 Special Module in Yarn Manufacture
1 credit (1-0-0)
Pre-requisites: TTN110 and EC 60
The course aims at introducing new or highly specialized technological aspects in yarn manufacture. The course topic and content is likely to change with each offering depending upon the current requirement and expertise available with the department including that of the visiting professionals.

TTV302 Special Module in Fabric Manufacture
1 credit (1-0-0)
Pre-requisites: TTN110 and EC 60
The course aims at introducing new or highly specialized technological aspects in fabric manufacture. The course topic and content is likely to change with each offering depending upon the current requirement and expertise available with the department including that of the visiting professionals.

TTV303 Special Module in Textile Chemical Processing
1 credit (1-0-0)
Pre-requisites: TTN110 and EC 60
The course aims at introducing new or highly specialized technological aspects in textile chemical processing; The course topic and content is likely to change with each offering depending upon the current requirement and expertise available with the department including that of the visiting professionals.

TTV304 Special Module in Fibre Science
1 credit (1-0-0)
Pre-requisites: TTN110 and EC 60
The course aims at introducing new or highly specialized technological aspects in fiber science. The course topic and content is likely to change with each offering depending upon the current requirement and expertise available with the department including that of the visiting professionals.

TTV305 Special Module in Textile Technology
1 credit (1-0-0)
Pre-requisites: TTN110 and EC 60
The course aims at introducing new or highly specialized technological aspects in textile technology. The course topic and content is likely to

change with each offering depending upon the current requirement and expertise available with the department including that of the visiting professionals.

TTD310 Mini Project (TT)
3 credits (0-0-6)
Pre-requisites: EC 80
Project type design/fabrication work under the guidance of a faculty member. Prior to registration, a detailed plan of work should be submitted by the student(s) to the head of the department.

TTL310 High Performance Fibrous Structures and Composites
3 credits (3-0-0)
Pre-requisites: EC 60
Introduction to fibres for high performance composites; Different fibre architectures used for composites and their characteristics and properties; Influence of fibre architectures on the properties of composites; Unidirectional, planar, 3D and net-shaped performing; Introduction to matrix types and their properties, Polymeric matrices for rigid and flexible composites; Reinforcing materials and the effect of their geometry on the properties of composites; The fibre-matrix interface; role of coupling agents; Mechanism of stress transfer; Toughness and thermal behaviour of composites; Various techniques of composites design and fabrication; Composites for structural engineering, electrical, civil, aerospace, defense, automobile, sporting goods and other applications; Design and analysis of textile structural composites.

TTR310 Professional Practices (TT)
2 credits (0-1-2)
Pre-requisites: EC 60
Overview of the state of art technology and practices in the industry presented by senior professionals from the industry.

TTS310 Independent Study (TT)
3 credits (0-3-0)
Pre-requisites: EC 80
Research oriented activities or study of subjects outside regular course offerings under the guidance of a faculty member. Prior to registration, a detailed plan of work should be submitted to the head of the department for approval.

TTL311 High Performance and Specialty Fibres
3 credits (3-0-0)
Pre-requisites: TTL211 / TTL212 / TTP211
Polymerization, spinning and properties of aromatic polyamides, high molecular weight polyester, rigid rod and ladder polymers such as BBL, PBZT, PBO, PBI; Manufacturing of carbon fibres from PAN precursors, viscose and pitch fibres; Glass fibres; Liquid crystal fibres; Gel spinning of polyethylene; Hollow and profile fibres, design of spinnerette for such fibres; Membrane technology; Blended and bicomponent fibres; Medical textiles; Superabsorbent fibres; Plasma modification; Radiation processing; Industrial tapes; Biaxially oriented films and fibres therefrom; Barrier films and coatings.

TTP311 Simulation of Fibre Production Processes
3 credits (1-0-4)
Pre-requisites: TTL212
Reaction rate equations for condensation polymerization, radical polymerization for batch and continuous stirred tank reactors; application of generating functions for formation of differential equations for infinite number of chains, analytical and numerical solutions of equations; force balance in melt spinning line; formation of differential equations on force dynamics; solutions using computational methods; modeling of coagulation process in wet spinning and other fibre forming processes.

TTL321 Mechanics of Spinning Machinery
3 credits (2-1-0)
Pre-requisites: TTL211 & TTL222
Types of gears. Nomenclature of spur and helical gears. Conjugate action and involute tooth profile. Interference. Force analysis in gear drives. Thrust loads. Bevel and worm gears. Velocity ratio of epicyclic gear trains. Differential gearing in roving frame and comber. Design of cone drums for scutcher and roving frame. Flat, V, round and timing belts. Tape drives. Belt drives for special purposes. Adjustment of belt tensions. Chain drives and polygonal effect. Analysis of tensions, torque, bending forces and power transmission in drives. Jaw, friction, cone and centrifugal clutches. Block and other brakes. Force analysis in clutches and brakes. Sliding contact bearings, friction in journal bearings. Classification and use of ball and roller bearings. Equivalent bearing load and load-life relationship. Design of transmission shaft and drafting rollers: Safety factor, tensile, compressive, shear, bending and torsional stresses. Design for static load, lateral and torsional rigidities. Balancing of machines and vibrations, flexible spindles.

TTL322 Mechanics of Spinning Processes
3 credits (3-0-0)
Pre-requisites: TTL221 & TTL 222
Forces acting on fibre during opening and cleaning processes. Carding process. Analysis of cylinder load and transfer efficiency. Fibre configuration in card and drawn sliver. Fibre straightening and hook removal. Sliver irregularity. Fibre movement in drafting field. Suppression of drafting wave. Drafting force. Roller slip, roller eccentricity and vibration. Fibre fractionation in comber. Analysis of forces on yarn and traveller. Spinning tension in ring and rotor spinning. Twist flow in ring and rotor spinning. End breaks during spinning. False twisting principles. Blending of fibres. Evaluation of blending efficiency.

TTL323 Process Control in Spinning
3 credits (3-0-0)
Pre-requisites: TTL221 & TTL222
Importance of process control. Control of mixing quality and cost using LP. Bale management. Control of cotton contamination. Control of cleaning efficiency and waste in blow room and card. Control of waste in comber. Control of neps in sliver. Control of imperfections and faults in yarns. Control of yarn count and count CV%. Control of strength, and strength CV%. Control of periodic mass variations. Machine and energy audit. Analysis and interpretation of statistical data. Total quality control.

TTL324 Spinning of Man-made Fibres and Blends
3 credits (3-0-0)
Pre-requisites: TTL221 & TTL222
Significance of manmade fibre sector. Fibre characteristics and spinnability of manmade fibres. Fibre properties and end uses. Relationship between fibre properties and yarn quality and yarn characteristics. Role of spin finish and fibre crimp in processing. Blending and its objectives. Estimation of blend intimacy and blend irregularity and factors affecting them. Migration. Selection of blend constituents. Rotor, Friction and Air-jet spinning. Process changes for spinning of dope-dyed and fibre-dyed fibres. Effect of blend composition on yarn properties. Processing of man-made fibres and blends on cotton and worsted system of spinning. Production of bulk yarn.

TTL331 Fabric Structure and Analysis
3 credits (2-0-2)
Pre-requisites: TTL231 / TTL232 / TTL221 / TTL222
Introduction to various conventional fabrics like poplin, sheeting, cheese cloth, damask, denim, drill and jean, and gabardine etc. Characteristics and building up of granite weaves. Diamond and diaper weaves. Geometric patterns in checker board weaves. Colour effects in woven fabrics. Honeycomb and huckaback weaves. Leno and gauge structure. Study of whipcord and Bedford cord. Pique. Wadded structure. Extra

warp and extra weft figuring. Detailed treatment of backed and double clothes. Interchanging warp and weft structure with figure effects. Center stitched double fabrics. Warp and weft pile fabrics. Velvet and velveteen. Analysis of fabrics referred to above for constructing weave (with draft and peg plan), constructional details and loom particulars etc. Computerized designing. Overview of Indian traditional woven textile designs.

TTL332 Computer Aided Fabric Manufacturing
3 credits (2-0-2)
Pre-requisites: TTL231 & TTL232
Electronic Dobby: Working principle, machine parameters, microelectronics electronics, design features, drive arrangement, systems for pattern data transfer and design development. Electronic Jacquard: working principle, constructional variants, various electronic jacquard systems, selection system, pattern data, transfer and management. CAD for dobby, jacquard, label and carpet: Design algorithm, development of Jacquard designs, process of drafting and sketch design, development of figures, composition of design, geometric ornamentation, arrangement of figures, weave simulation.

Practicals: Working on electronic dobby and electronic Jacquard, working on CAD, development of various designs for Jacquard, level and carpet. Development of design samples.

TTL333 Process Control in Weaving
3 credits (3-0-0)
Pre-requisites: TTL231 & TTL232
Importance and consideration for evolving a system for process control. Machine and energy audit. Housekeeping and material handling. Statistical interpretation of data on waste and quality. Controls for quality, machine stoppage and productivity in winding, warping, sizing, drawing, prin winding and weaving. Standard norms for settings speeds and production rates. Fabric defects and their control. Control and norms of hard waste in various processes. Care, selection and consumption norms of accessories. Importance and types of maintenance, maintenance schedule in winding, warping sizing and loom shed. Machine audit: Energy norms in winding, warping sizing and loom shed and scope of its control. Calculations pertaining to production, efficiency and machine allocation in winding, warping, pirn winding, sizing and loom shed.

TTL341 Polymers and Surfactants for Textiles
3 credits (3-0-0)
Pre-requisites: CYL230 / TTL241 / TTL242
Surfactants, Classification and organic chemistry of surfactants, micellization; Application of surfactants in textiles-emulsification, foams, wetting, solid dispersions in liquids, solubalization, detergency, etc; Applications of polymers in textiles; Properties and requirements for polymers for sizes, thickeners, binders, adhesive, coating polymers and finishing agents; Chemistry of following polymer/copolymer systems – preferred polymerization technique, desirable comonomers); Commercial process, properties and specific applications: Modified natural polymers-starch/ cellulose/ Guar gum based polymers, poly acrylic/ methacrylic acid, poly (vinyl acetate) and Poly (vinyl alcohol), polyurethanes, Poly (vinyl chloride)/ PVDC/ Fluoro polymers, rubbers/ styrene based polymers,poly (siloxanes) and other related polymers.

TTL351 Apparel Technology
3 credits (2-0-2)
Pre-requisites: TTL231 / TTL232 / TTL241 / TT242
Concept of clothing design and proportion. Fabric properties and their effect on garment properties, production and quality. Anthropometrics; Clothing sizes. Pattern making and grading. Principles of marker making; spreading and cutting. Cutting methods. Quality control in the cutting room. Stitch classification, seam types and their applications. Sewing faults, their causes and remedies. Choice of sewing needles and threads. Principles and comparison of machines available for a variety of sewing operations. Work aids-folders, special presser feet, feeding systems. Interlinings-classification and application. Fusing and pressing machines. Garment breakdown analysis. Clothing production systems and material handling. Garment dyeing and finishing.

TTL352 Clothing Science
3 credits (3-0-0)
Pre-requisites: TTL211 / TTL232 / TTL231
Factors involved in the study of clothing. General functional description of clothing. Physiological and psychological aspects of fabric comfort. Heat and moisture relations in clothing. Physical properties of clothing and clothing materials in relation to comfort; thermal resistance, water vapor resistance, wicking and air-permeability. Influence of environmental conditions of the protective performance of garments. Field studies on the thermal protection of clothing. Bending and shear properties, clothing fit and drape. Fabric friction, static electricity and comfort. Aesthetic aspects of clothing. Influence of fiber yarn characteristics and fabric construcution parameters on clothing comfort. Current trends and new developments in the study of clothing. New materials and finishes, new techniques, new concepts.

TTL361 Textile Testing
3 credits (3-0-0)
Pre-requisites: TTL211 / TTL212 / TTL221 / TTL232
Introduction to textile testing. Selection of samples for testing. Random and biased samples. The estimation of population characteristics from samples and the use of confidence intervals. Determination of number of tests to be carried out to give chosen degree of accuracy. Significant testing of means and variance. Quality control charts and their interpretation. Standard tests, analysis of data and test reports.

Measurement of length, fineness and crimp of fibres. Determination of maturity, foreign matter, and moisture content of cotton. Measurement of twist, linear density and hairiness of yarn. Evenness testing of silvers, rovings and yarns. Analysis of periodic variations in mass per unit length. Uster classimat. Spectrogram and V-L curve analysis. Tensile testing of fibres, yarns and fabrics. Automation in tensile testers. Tearing, bursting and abrasion resistance tests for fabrics. Pilling resistance of fabrics. Bending, shear and compressional properties of fabrics. Fabric drape and handle. Crease and wrinkle behaviour. Air, water and water-vapour transmission through fabrics. Thermal resistance of fabrics. Testing of interlaced and textured yarns. Special tests for carpets and nonwoven fabrics.

TTP361 Textile Testing Laboratory
1 credit (0-0-2)
Pre-requisites: TTL211/TTL212/TTL221/TTL232.
Experiments related to course TTL361.

TTL362 Theory of Textile Structures
5 credits (3-2-0)
Pre-requisites: TTL211 / TTL221 / TTL222 / TTL232
Types of yarn, Consolidation mechanism, Influence of fibre parameters on yarn structure, Coaxial helix model, Significance of twist, Yarn contraction, Influence of fibre properties and process parameters on yarn diameter and density, Packing of fibres in yarn, spinning–in coefficient, fibre migration, stress–strain behaviour of filament and staple yarns, Failure mechanism of staple yarn, Geometry folded yarn Elements of fabric geometry. Flexible and rigid thread models. Crimp interchanges in woven fabrics and crimp balance of elastic threads. Practical applications of cloth geometry. Fabric sett, cover and areal density. Fabric deformation in tension (uniaxial and biaxial). Bending behaviour of fabric: bending hysterisis, clustering ratio, bending of set and unset fabric, bending in bias direction. Shear, drape, buckling and compressional behaviour, mechanical properties of knitted fabric. Fabric mechanical property in relation of making up.

TTL363 Technical Textiles
4 credits (3-1-0)
Pre-requisites: TTL211 / TTP211 / TTL222 / TTL232
Growth of industrial textiles; Engineering textile structures for industrial purposes; Properties and use of textiles in the design of flexible composites like tyres, hoses and belts; Use of textiles in rigid composites, properties and applications; Textiles in filtration; Agricultural application of textiles; Textiles in civil engineering applicaitions; Design, production, properties and application of coated fabrics; Flame retardant fibers and fabrics and their use in protective clothings. Textiles in miscellaneous industrial applications.

TTL364 Intelligent and Functional Textile
2 credits (2-0-0)
Pre-requisites: TTL211 / TTP211 / TTL232 / TTL222
Definition of smart and intelligent textiles; Passive and active functionality; Textile with high protection and comfort properties; Extreme winter clothing with low heat transmission, heat absorbing, heat storing systems; Phase change materials, incorporation of PCMs in fibres and fabrics; Breathable textile; Multifunctional textiles with incorporated electronics for integrated communication, music, health monitoring, defence support functions, wearable computers; Environmentally sensitive textiles- photochromic and thermochromic (chameleonic) fabrics, camouflage (radar shielding) fabrics, variable heat absorption surfaces, stimuli sensitive polymers such as temperature, pH, ionic, magnetic sensitive materials, design and their applications to textile; Fibres as solar cells; Recent advances in multifunctional textiles.

TTL365 Costing and its Application in Textiles
4 credits (3-1-0)
Pre-requisites: EC 60
Costing as an aid to management. Cost terms related to income measurement, profit planning and cost control for textile industry. Costing of materials, labour and factory overheads and their control; methods of inventory costing for textile industry, accounting of labour, factory over head absorption rate, overhead cost allocation in a composite mill. Job-order costing for a garment industry. Batch costing. Process costing; waste cost and its control in a textile mill. Joint and by-product costing. Unit cost; costs of yarns and fabrics, fabric processing cost. Absorption and variable costing; short-term decision making. Profit planning; cost-volume-profit-analysis, break-even point, contribution margin, margin of safety and capital budgeting. Cost control; standard costs, cost and revenue variances. Financial information; balance sheet and profit and loss account. Statement of changes in financial position. Ratio analysis.

TTC410 Colloquium (TT)
3 credits (0-3-0)
Pre-requisites: Registered for TTT410
Evaluation will be based on practical training and presentation.

TTT410 Practical Training (TT)
Non credit
Pre-requisites: EC 90 at the end of 5th sem.
Fifty (50) working days or 400 hours of practical training and presentation

TTD411 Major Project Part 1 (TT)
4 credits (0-0-8)
Pre-requisites: EC 120
Formation of project team (up to two students and up to two faculty guides); formulation of work plan; completing targetted work for the semester and presentation of complete work of progress for award of grade.

TTD412 Major Project Part 2 (TT)
8 credits (0-0-16)
Pre-requisites: TTD411; with B Grade
Continuation of planned tasks started in Project Part 1, TTD411, to completion, thesis writing and presentation of complete work for the award of grade.

TTV700 Special Module in Selected Topics
1 credit (1-0-0)

TTL711 Polymer and Fibre Chemistry
3 credits (3-0-0)
Introduction to natural and synthetic polymers;Terms and fundamental concepts; Step-growth polymerization, Carother's equation, Functionality, Crosslinking; PET manufacturing; Chain growth polymerization, Free radical polymerization, Kinetics of free-radical initiation, termination, chain transfer, Mayo's equation, cage effect, auto-acceleration, inhibition and retardation; Polypropylene manufacturing; Acrylic manufacturing; Atom transfer radical polymerization, ionic polymerization, ring opening polymerization; Nylon-6 manu-facturing; Co-polymerization and its importance. Copolymer equation, reactivity ratio, tailor making of copolymer properties; Techniques of chain polymerization; Bulk, solution, emulsion, microemulsion and suspension polymerization; Chemical Modification of fibres; Polymer solution, Flory's theory; Interaction parameter; Molecular weight and its distribution by: End group analysis, osmometry, light scattering, ultra centrifugation, gel permeation chromatography, intrinsic viscosity; Spectroscopic methods of polymer characterization such as, FTIR. UV, NMR.

TTP711 Polymer and Fibre Chemistry Laboratory
1.5 credits (0-0-3)
Identification of fibres by chemical and burning tests; polymerization of vinyl monomers such as styrene, acrylamide using bulk polymerization, solution polymerization, emulsion polymerization, radiation induced polymerization. Condensation polymerization; Molecular weight measurement; Intrinsic viscosity and end group analysis; Analysis of chemical structure by FTIR, UV spectroscopy.

TTL712 Polymer and Fibre Physics
3 credits (3-0-0)
Molecular architecture in polymers, Configuration and conformation; Nature of molecular interaction in polymers, Cumulative interaction, Entanglement, Random chain model and rms end-to-end distance; Glass transition temperature (Tg), Factors affecting Tg; WLF equation; Rubber Elasticity; Melting and Crystallization; Models describing fibre structure, Fringed fibrillar and fringed micellar model, One phase model; Requirement of fibre forming polymers; Crystallinity and orientation; X-ray diffraction measurement of crystallinity, orientation, crystal size, small angle X-ray scattering; Measurement of density of fibres, Density crystallinity, Infrared spectroscopy for determination of orientation, crystallinity etc; Optical microscopy for measurement of birefringence; Internal and surface structure by electron microscopy; Thermal methods DSC TGA and TMA for structural investigation; Morphological structure of Cotton, Wool, Silk, Regenerated Cellulose, Polyester, Nylon, Polypropylene, Polyacrylonitrile.

TTP712 Polymer and Fibre Physics Lab
1.5 credits (0-0-3)
Characterization of fibres by Infrared spectroscopy, Density measurements; Thermal analysis such as Thermogravimetric Analysis (TGA), Differential Scanning calorimetry (DSC) and Thermo-Mechanical Analysis (TMA); Dynamic Mechanical Analysis (DMA); Sonic modulus ; X-ray diffraction studies; Birefringence measurement; Optical microscopy studies; Scanning Electron Microscopy (SEM) of fibres.

TTL713 Technology of Melt Spun Fibres
4 credits (3-1-0)
Transport Phenomena in Fibre Manufacturing; Polymer rheology-Newtonian and non-Newtonian fluids, shear flow, elongational flow; Heat transfer operations, Mass transfer operations, diffusion in polymers; Necessary conditions of fibre forming polymer, Melt instabilities, Necking and stress induced crystallization in high speed melt spinning, Effect of process parameters on fibre spinning and structure of polymide 6 and 66, polyethylene terephthalate and polypropylene fibers/filament. Force balance in a spinning line, Simulation of melt spinning process, Drawing Process and its necessity, Neck or flow deformational drawing, Natural draw ratio, Drawing machines, Effect of parameters on structure development in nylon, polyester and PP, Types of heat setting, Effect of setting parameters on structure and properties of polyester, nylon, polypropylene fibres, Zone drawing and annealing, Concept of bulking, Process of false twist, air-jet and stuffer box texturing processes and machines

TTL714 Physical Properties of Fibres
3 credits (3-0-0)
Introduction to fibre structure and requirements of fibre forming polymers; Moisture Relations: Moisture sorption and desorption in fibres Sorption isotherms, Heats of sorption, Swelling and theories of moisture sorption; Mechanical properties: Mechanism of deformation in fibres; Principles of elasticity and viscoelasticity; Creep and stress relaxation; Boltzmann

superposition principle; Dynamic mechanical properties; Model theory of viscoelasticity; Time- temperature superposition principle; Stress- strain relations, Yield and fracture; Fibre friction: its nature, theory, application and measurement; Optical properties: Polarizability and refractive index. Birefringence and its measurement; Thermal Properties: Thermal expansion, Thermal conductivity; Electrical Properties: Dielectric properties, effect of frequency and temperature on dielectric constant, Electrical resistance and its measurement, Static electricity and measurement of static charge in fibres.

TTL715 Technology of Solution Spun Fibres
3 credits (3-0-0)
PAN properties; Solution rheology and its dependence on parameters. Effect of parameters on entanglement density, fibre spinning and subsequent drawing; Various solvent systems; Dope preparation; Wet and dry spinning processes; Effect of dope concentration, bath concentration, temperature and jet stretch ratio on coagulation rate, fibre breakage and fibre structure; Modeling of coagulation process; properties and structure of dry and wet spun fibres; Dry jet wet spinning of PAN and its advantages; Gel spinning; Melt spinning of PAN; Bicomponent and bulk acrylic fibres. Acrylic fibre line, crimping and annealing, tow to top conversion systems; Viscose rayon process, wet spinning, Zinc sulfate spinning; Polynosics and high performance fibre; Lyocell process, structure and properties; Gel spinning of PE, introduction to high performance fibres and their spinning systems such as rigid rod polymer, liquid crystalline polymers, polylactic acid and spandex fibre manufacturing.

TTP716 Fibre Production and Post-spinning Operations Laboratory
2 credits (0-0-4)
Experiments related to fibre production processes; Effect of moisture and temperature on MFI of PET and PP; Melt spinning of PET, PP & nylon-6 filament yarns on laboratory spinning machines; Single and two stage drawing of the as-spun yarns or industrial POY; Demonstration of high speed spinning machine; Wet and dry heat setting of PET and nylon drawn yarns; Effect of temperature and tension on heat setting; Determination of structure and mechanical properties of as spun, POY, drawn and heat set yarns using DSC, X-ray, PTIR, density, sonic modulus; Effect of shear rate, temperature on polymer solution viscosity using Brookfield Rheometer and ball-fall method; Wet spinning or dry jet wet spinning of PAN copolymers. False twist and air jet texturing processes; Determination of structure of textured yarn under microscope.

TTL717 Advances in Manufactured Fibres
3 credits (3-0-0)
Profile fibres, hollow & porous fibres, spandex fibres; Biodegradable fibres, polyglycolic acid fibres, polylactic acid fibres, chitosan fibres, their preparation properties and applications; Bicomponent fibres, blended fibres; Fibres in medicine and biotechnology; Aesthetic fibres, bio-mimicking fibres; Membranes; Smart fibres; Comfort fibres; Fibres for Ballistic protection; Microdenier fibre; Spun Bonded and Melt blown nonwovens; Photochromatic fibres; Plasma processing of textiles; Processes for manufacturing of tapes and films.

TTL718 High Performance Fibres and Composites
3 credits (3-0-0)
Production and properties of aromatic polyamides & polyesters, Rigid rod and ladder polymers such as Kevlar, Nomex, BBL, PBZT, PBO, PBI, Manufacturing of carbon fibres from PAN precursors, viscose and pitch fibres, Liquid crystal fibres, High performance polyethylene fibres, Ceramic fibres, Definition of composites, Resins for composites, Fibre architecture- short and long, Interfaces, Composite theory, Fabrication of composite materials, Case studies on composites.

TTL721 Theory of Yarn Structure
3 credits (2-1-0)
Types of yarn. Role of yarn structure on yarn and fabric properties. Structural parameters of yarn. Twisting forms and yarn contraction. Morphology of staple yarns. Fibre characteristics in sliver, roving and yarns. Comparative analysis of structural characteristics of various types of spun yarns. Influence of fibre characteristics on yarn structure. Tensile behaviour of filament, spun, core spun and elastic yarns. Bending behaviour of yarns. Frictional behaviour of yarns. Rupture behaviour of filament and spun yarns. Geometry of plied structure. Tensile properties of plied structures.

TTL722 Mechanics of Spinning Processes
3 credits (3-0-0)
Cotton fibre selection through bale management. Forces on fibres during opening and cleaning processes and it's effect. Carding process. Analysis of cylinder load and transfer efficiency. Technological considerations in the design of high production card. Card wire geometry, Fibre configuration in card and drawn sliver. Hook removal and it's significance. Sliver irregularity. Fibre movement in drafting field. Suppression of drafting wave. Drafting force. Roller slip. Roller eccentricity and vibration. Fibre fractionation in comber. Combing performance. Principles of autolevelling. Blending of fibres, evaluation of blending efficiency. Analysis of forces on yarn and traveller. Spinning tension in ring and rotor spinning. Spinning geometry, Twist flow in ring and rotor spinning. End breaks during spinning. False twisting principles.

TTL723 Selected Topics in Yarn Manufacture
3 credits (2-1-0)
Spinning of micro denier fibre. Synthetic fibre spinning on cotton spinning system. Spinning of dyed fibres. Principle of woollen and worsted spinning systems. Influence of high draft on yarn quality. Optimization of production speeds. Production of core and elastic yarns, sewing thread, acrylic bulk yarn, carpet yarn and fancy yarns. Waste fibre spinning. Mechanical and electrical drives. Energy conservation and saving through process optimization. Yarn conditioning. Yarn clearing devices. Selection criteria for aprons, cots and top rollers. Design of bottom drafting rollers. Future expected innovations. Control systems in spinning machinery.

TTL724 Textured Yarn Technology
3 credits (3-0-0)
Pre-requisites: EC 90
Principles of texturing and modern classification; False twist texturing process- mechanisms and machinery, optimization of texturing parameters, barre', structure-property correlation of textured yarns; Draw-texturing- the need and fundamental approaches; Friction texturing- the need and development, mechanics of friction texturing, latest development in twisting devices, optimization of quality parameters. Noise control in texturing.

Air jet texturing - Principle, mechanisms, development of jets and machinery, process optimization and characterization, air jet texturing of spun yarns.

Air interlacement - Principle and mechanism, jet development and characterization.

Bulked continuous filament yarns - Need, principle, technology development.

Hi-bulk yarns - Acrylic Hi-bulk yarn production, mechanism and machines involved, other such products.

Solvent and chemical texturing - Need, texturing of synthetic and natural fibres.

TTL731 Theory of Fabric Structure
3 credits (2-1-0)
Engineering approach to fabric formation. Fibre, yarn and fabric structure- property relationships. Crimp interchange in woven fabric. Elastica model for fabric parameters and crimp balance. Concept of fabric relaxation and set. Practical application of geometrical and elastica models.

Uniaxial and biaxial tensile deformation of woven fabric. Bending deformation of woven fabric, bending behaviour of set and unset fabrics and bending in bias direction. Bending, Shear and drape properties of woven fabric. Buckling and compressional behaviour of woven fabrics. Mathematical models and their application in the study of tensile, bending, shear, compressional and buckling deformation of woven fabrics.

Structure and properties of knitted and nonwoven fabrics.

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TTL732 Computer Aided Fabric Manufacturing
3 credits (2-0-2)
Electronic Dobby: Working principle, constructional variants, design of the electronic dobby, drive arrangement, systems for pattern data transfer.

Electronic Jacquard: Working principle, constructional variants, various electronic jacquard systems, selection system, pattern data transfer and management.

CAD for dobby, jacquard, label weaving and carpet: Development of Jacquard designs, process of drafting and sketch design, development of figures, composition of design, geometric ornamentation, arrangement of figures, weave simulation.

Laboratory: Working on electronic dobby and electronic Jacquard, working on CAD, development of various designs on CAD and development of design samples.

TTL733 Selected Topics in Fabric Manufacture
3 credits (2-1-0)
Development trends in winding, warping and sizing machines for improving quality of preparation and cost, reduction with specific reference to shuttleless weaving machines. Tension control and automation in sizing.

Loom development trends and objectives. Single phase and multiphase looms. Kinematics of sley and heald motion with reference to shuttleless looms. Theoretical analysis of weft insertion in shuttleless looms. Mechanism of warp breakage; Cloth fell position, beat up force and pick spacing. Analysis of let off mechanism, electronic let off and take up. Electronic jacquards. Developments with reference to energy saving, noise reduction and waste control. Electronic data acquisition in a loom shed.

Knitting: Dynamics of knitted loop formation. Design and performance of high speed knitting cams. Developments in knitting machines. Developments in processing machineries for knitted fabrics. Yarn feeding devices on circular knitting machines and design features of positive feeders.

Nonwovens: Fibre/filament arrangement in web and its effect on mechanical properties of nonwoven fabrics. Failure mechanism in different nonwoven fabrics. Effects of machine, fibre and process variables on properties of nonwoven fabrics. Production of spun bonded and melt blown fabrics.

TTL740: Science and Applications of Nanotechnology in Textiles
3 credits (3-0-0)
Pre-requisites: EC 90
Introduction to Nanoscience and Nanotechnology; Synthesis of Nanomaterials used in Textiles; carbon nanofibers, carbon nanotube, fullerenes, metal and metal oxide nanoparticles, such as nano silver, nano silica, nano titania, nano zinc oxide, nano magnesium oxide; Size and surface dependence of their physical and chemical properties such as mechanical, thermo-dynamical, electronic, catalysis; Surface functionalization and Dispersion of Nanomaterials; Nanotoxicity concerns; Nanomaterial applications in textiles and polymers; Nanocomposites: definition and types, synthesis routes, characterization techniques; nanocomposite fibers, coatings, their application e.g., gas barrier, antimicrobial, conducting; Nanofibers: preparation, properties and applications such as filtration, tissue engineering, Nanofinishing: water and oil-repellent, self-cleaning, antimicrobial, UV protective, Nanocoating methods on textile substrates: Plasma Polymerization, Layer-by-layer Self Assembly, Sol-Gel coating.

TTL741 Coloration of Textiles
3 credits(3-0-0)
Developments in dyes and dyeing processes for the dyeing of various textile substrates with various dye classes; Dyeing of blends; Mass coloration of man-made fibres; Development in printing methods and machines; Direct, resist and discharge styles of printing; Printing of blends; Transfer printing; Physicochemical theories of the application of dyestuffs to textile and related materials, including the thermodynamics and kinetic principles involved; Dye-polymer interactions; Role of fibre structure in dyeing.

TTL742 Theory and Practice of Textile Finishing
3 credits(2-0-2)
General overview of the recent technological developments in the area of textile finishing; Special emphasis will be on formaldehyde free finishes for wash-n-wear and durable press applications; fire retardants for apparel and industrial textiles; silicon and amino silicon softeners; fluoro-chemicals for water repellency and soil release functions; water proof breathables- principles and technology involved in their production; surface modifications of textiles and their impact on various functional properties; antistats for synthetic fibres / fabrics; micro-encapsulation and its relevance in textile finishing application; new finishes for different functional and aesthetic requirements.

TTL743 Principles of Colour Measurement and Communication
3 credits (2-0-2)
Physical, physiological and psychophysical aspects of colour, colour perception, colour specification, colour measurement and colour control, Basis of modern techniques for colour specification, measurement, control and communication, Applications of colour science to textiles, colour reproduction, computer-based imaging and display systems, Basic concepts of computer colour graphics.

TTL744 Environment Management in Textile and Allied Industries
3 credits (3-0-0)
Pre-requisites: EC 90
Importance of ecological balance and environmental protection; Definition of waste and pollutant; Pollutant categories and types; International and Indian legislation and enforcing agencies in pollution control; Waste management approaches; Environmental Management Systems – ISO 14000; Environmental impact along the textile chain from fibre production to disposal: Toxicity of intermediates, dyes and other auxiliaries etc.; Pollution load from different wet processing operations; Textile effluents and their characterisation; Technology and principles of effluent treatment; Advanced colour removal technologies, Recovery and reuse of water and chemicals; Air and noise pollution and its control; Eco labelling schemes; Industrial hygiene and safe working practices; Analytical testing of eco and environmental parameters; Eco friendly textile processing: waste minimisation, standardisation and optimisation, process modification; safe and ecofriendly dyes and auxiliaries; Industrial hygiene and safe working practices; Solid waste (fibre and polymer) recycling; Fibre waste modification; Environmental management systems: ISO 14000; Certification and criteria; case studies.

TTL746: Medical Textiles
3 credits: (3-0-0)
Pre-requisites: EC 90
Polymers and Textile-based techniques used for medical applications, Cell-Polymer interaction, Non-implantable materials: Wound-dressing, related hydrogel and composite products, Bandages, Gauges, Implantable biomedical devices: Vascular grafts, Sutures, Heart valves, Extra-corporeal materials: Scaffolds for Tissue engineering, Rapid prototyping , Cartilages, Liver, Blood Vessel, Kidney, Urinary bladder, Tendons, Ligaments, Cornea, Healthcare and hygiene products: Surgical Gowns, masks, wipes, Antibacterial Textiles, Super absorbent polymers, Dialysis, Soluble factor release, Safety, Legal and ethical issues involved in the medical textile materials.

TTL750: Science of Clothing Comfort
3 credits: (3-0-0)
Pre-requisites: EC 90
Introduction to Clothing Comfort: Definitions, Brief introduction to the various processes related to comfort, Application of science of clothing comfort. Psychology and Comfort: Introduction and basic concepts, Psychological research techniques, General aspects and measurement of aesthetic properties, change in aesthetic behaviour. Neurophysiological Processes of Clothing Comfort: Neurophysiologic basis of sensory perceptions, Perceptions of sensations related to mechanical stimuli, Perceptions of sensations related to thermal and moisture stimuli. Thermal Transmission: Thermoregulatory Mechanisms of human body, Heat Transfer Theories, Thermal Conductivity of Fibrous

Materials, Steady state measurement techniques for heat transfer, Transient heat transfer mechanism: the warm-cool feeling, Moisture Transmission : Liquid and Vapour, Liquid Moisture transfer through fibrous materials, Relationship of moisture and heat : basic concepts, Multiphase flow through porous media, Moisture exchange between fibre and air, Temperature and moisture sensations: theories and objective measurement techniques, Impact of microclimate Tactile Aspects of Clothing Comfort, Fabric mechanical properties and tactile-pressure sensations like Fabric Prickliness, fabric itchiness, fabric stiffness, fabric softness, fabric smoothness, roughness and scratchiness, Fabric hand value, Clothing comfort aspects in relations with garment size and fit.

TTL751 Apparel Engineering and Quality Control
3 credits (2-0-2)

Mechanics of sewing operation: Feeding mechanism, mechanism of generation of needle thread tension, feed dog setting mechanism, stresses and heat generated during sewing, interaction of feed and pressure, sewing dynamics. Measurement and controls in sewing operation: Pressure, sewing speed, thread tension, needle temperature, needle penetration force. Automation in sewing operation.

Fabric quality assessment for clothing industry: Fabric quality requirement for high quality garments, low stress fabric mechanical properties and their effect on sewing operation. Use of FAST and KES system. Fabric mechanical properties and sewing operation interaction: Tailorability and formability. Lindberg theory, optimization of sewing parameters by using fabric mechanical property, optimization of finishing parameters such as steam, pressure, vacuum, for getting desired effect.

Fabric defect analysis for clothing industry: Defect identification, bow and skewness, correlating defect with back process, valueloss.

Quality control in apparel manufacturing: Determination of sewability, seam pucker, seam slippage and needle cutting index, evaluation of cutting defect, fusing defect, sewing defect, inspection of dimension, appearance, drape, change in color, shape and spots.

Measurement and selection of sewing thread properties for different fabrics: Optimization of sewing parameters such as ticket number, needle number, yarn tension, stitch density and stitch type for desired sewability.

Selection of lining and interlining fabrics for various shell fabric: Evaluation of lining and interlining fabric, determination of compatibility.

Packaging of finished garment, final random inspection of finished garments, packaging method, safety norms.

Accessories: Buttons, hook and eye, jips, velcro.

TTL752: Functional Textile Envelopes
3 credits: (2-0-2)
Pre-requisites: EC 90

Introduction to and classification of Functional clothing envelopes: definition and terminology, Principles of Ergonomics and Human factors engineering: their application in design of functional clothing envelopes, Principles and practice of Anthropometrics, Biomechanical considerations in design of envelopes for specific applications, Comfort in 3D assemblies, Principles of optimal design approach and application to Functional envelope design. Techniques and tools for testing and performance evaluation: trials on thermal manikins and humans for effect on physiological parameters and performance efficiency. CAD/CAM for design of design templates, 2D and 3D visualization, simulation and modeling on human bodies, Case studies, testing and analysis of existing functional envelopes with a view to study specific design and manufacturing considerations.

TTL761 Costing, Project Formulation and Appraisal
3 credits (2-1-0)

Cost Concepts: Direct/indirect, Fixed/variable, Total cost. Inventory costing : FIFO, LIFO, Weighted average methods. System of costing: Job, order, batch, process, unit & operating cost joint & byproduct. Cost Standards in Textiles : Cost structure in textile industry, Cost of raw material/labour/utilities. Cost Control : Standard costs, variance analysis, determination of cost per kg of yarn, per kg

(metre) of fabric, measures for cost reduction, selling price decision for yarn/fabric. Profit planning : Cost volume - profit analysis, Break Even point. Budgeting, Definition, purpose, types. Financial Statement & Investment Analysis : Profit & Loss account and Balance sheet analysis, Fund flow statement, Ratio analysis, Concept of cost of capital, IRR, DRC, DSCR, ERR, payback period and techniques for calculation.

Project Cycle: Phases of project cycle identification, preparation evaluation, documentation & Supervision. Various functions in project cycle - Technical, commerical, financial, economic, managerial.

Project formulation and Appraisal: Appraisal concept, Need for appraisal, Methodology, Various aspects - market, management, technical, financial and economic, Key financial indicators in appraisal, Investment decision from appraisal report, Post-project appraisal.

Evaluation of Technological Content of Textile Projects: The choice of Technology and their assessment, operating constraint, appropriateness of technology, factors influencing selection, various aspects of technology transfer.

Project Utilities and Environmental Aspects for Textile projects: Power, Steam, Fuel, Water, Compressed air, Air conditioning, Pollution (air, water, ground noise).

Special Appraisals: For Modernisation projects, balancing equipment, expansion and diversification projects (including backward & forward integration).

TTP761 Evaluation of Textile Material – I
1 credit (0-0-2)

Characterization of Fibre : Birefringence, sonic modulus, density measurements, thermal analysis, X-rays (orientation and crystallinity); Yarn Testing : Tensile properties, hairiness, cross-sectional studies and yarn preparation.

TTL762 Management of Textile Production
3 credit (3-0-0)
Pre-requisites: EC 90

Indian textile industry senario, production and exports, handloom sector. Textile Policy. Sickness in Textile industry, analysis and options. Production planning and control; product mix linear programming concepts. Inventory control models. Replacements and maintenance problems. Techniques of project evaluation. Mill planning. Forecasting, concept and time series models. Management information systems. Sequencing. Assignment techniques. Method study. Marketing management research and planning. Zero defect concept. Modernization.

TTP762 Evaluation of Textile Material – II
1 credit (0-0-2)

Evaluation of spliced yarn and sized yarn. Testing of technical textile; coated fabrics, geo-textiles, filter fabrics. Simulation of knitted and woven structure, comfort properties of fabric, water repellency. Computer colour matching, measurement of UV protective character of textile material.

TTL763 Technical Textiles
3 credits (2-1-0)

Definition, classification, products, market overview and growth projections of technical textiles. Fibres, yarns and fabric structures in technical textiles and their relevant properties. Filtration: Textile and other filter media for dry and wet filtration. Mechanisms of separation. Requirements for good filter media and filtration. Fibre and fabric selection for filtration.

Geotextiles: Types and application of geosynthetics. Functions and application areas of geotextiles. Fibres and fabric selection criteria for geotextile applications. Mechanics of reinforcement, filtration and drainage by geotextiles. Soil characteristics. Methods of long term prediction of geotextile life and survivability in soil.

Automotive Textiles: Application of textiles in automobiles. Requirement and design for pneumatic tyres, airbags and belts. Methods of production and properties of textiles used in these applications.

Sewing threads, cords and ropes: Types, method of production and applications. Functional requirements, structure and properties.

Miscellaneous: Functional requirements and types of textiles used for paper making, agricultural, architectural, packaging and footwear.

TTL764 Process Control in Spinning & Weaving
3 credits (3-0-0)
Optimum fibre-mix for various end use requirements. Yarn realization. Waste control in blowroom and card for all types of fibres spun on cotton system. Minimising lea count variation. Controlling yarn irregularity, imperfections and faults. Yarn tenacity and elongation. Hairiness. Machinery audit. Indices of productivity. Production of high quality export yarns. Trouble Shooting, some case studies.

Role of ambient temperature and humidity. Life of accessories. Workload.

Principles for control of productivity in different sections, Contribution of control in yarn, winding, warping, sizing & weaving to the cost of production in fabric manufacture.

Splicing, machine allocation and load distribution, Control of migration in sizing, size droppings, sizing materials.

Loom allocation. Control of value loss in fabrics through evaluation & grading of fabric defects. Temperature and humidity control & its effect on performance. Control of loom accessories. Control of loss of efficiency by snap study. Controls in the process of high twist yarns, blended yarns, filament yarns in warp and weft.

Controls in the winding for processing yarns for dyeing & knitting.Controlling sloughing off during winding, warping & weaving. on-line data system and its use in controls.

TTL765 Product Development
3 credits (2-1-0)
Pre-requisites: EC 90
Overview of developments. Scope of product development in textiles and clothing. Designing for functions aesthetics. Designing for apparel, clothing and industrial applications. Product improvement and product innovations in textiles. Demand estimation and product development objectives. Interaction between- properties of fibre, yarn, fabric and garments properties. The product development process - requirements, key characteristics, recourses, conceptual design, technology selection, material selection, sampling, design and evaluation. Design logic, specifications, costing, manufacturing strategies and evaluation of new products. Standards, testing and specifications for new products. Case studies from the point of view of developing textile products for selected end use applications.

TTL771 Electronics and Controls for Textile Industry
4 credits (3-0-2)
Overview of electronics and controls in modern textiles equipments and machines. Overview of basic analog electronics: Elements (R, L, C, V, I), circuit laws and theorems. Overview of basic digital electronics: Gates and ICs. Sensors and transducers (displacement, position, force, temperature, pressure, flow). Signal Conditioning. Control elements, systems and examples. Data acquisition, analysis, control and automation by microprocessors and micro controllers. Motor and power drives. Power control devices. Some applications of data acquisitions and control systems in textiles and case studies.

Laboratory: Experiments on sensors and transducers (displacement, position, strain, temperature, rotational speed). Basic analog circuits with diodes and transistors. Basic digital Gates. SCR and TRIAC control of motor speed. Data acquisition and control with micro processors/ micro contollers.

TTL772 Computer Programming and its Applications
3 credits (2-0-2)

Fundamentals of Computer Programming, Programming Methodology: Structured Programming and concepts of Object-Oriented Programming.

Programming in C++ - Statements and Expressions, Control statements. Structure, Functions: Function Overloading etc.

C++ as Object-Oriented Programming Language- Classes and Objects, Data Abstraction, Inheritance - Multilevel and Multiple inheritance etc., Polymorphism - operator overloading and virtual functions, file handling.

Application development using C++.

TTL773 Design of Experiments and Statistical Techniques
3 credits (3-0-0)
Pre-requisites: EC 90
Objectives and principles of experimental design. Experimental design terminology. Increasing accuracy of experiments. Completely randomized designs. Blocking designs Latin square designs. Analysis of variance (ANOVA). Two-level and three-level factorial designs. Complete 2n factorial and fractional factorial designs. Response surface designs. Central composite and Box-Behnken designs. Use of statistical packages. Fitting data. Linear regression with one and more variables. Polynomial models. Correlation and coefficient of determination. Partial correlation. Rank correlation Coefficient of concordance. Acceptance sampling by attributes and variables. OC curves. Average run length. Control charts. Choice of sample size.

TTL782: Nonwoven Science and Engineering
3 credits (3-0-0)
Pre-requisites: EC 90
Introduction to nonwovens, Materials used in nonwovens, Principles of nonwoven processes: web formation processes, bonding processes, spunmelt processes, and chemical processes, Testing and evaluation of nonwovens: international standards, structure of nonwovens, and properties of nonwovens, Scientific analysis of structure and properties of nonwovens: fibres and their arrangement, pores and their organization, mechanics of nonwovens, fluid flow and fluid absorption, filtration, barrier and breathability, thermal insulation, and acoustic absorption, Engineering of advanced nonwoven products: medical nonwovens, nonwoven wipes, nonwoven filters, automotive nonwovens, and home furnishing nonwovens, Design and development of new nonwoven products: theories, market study, product costing, case studies, and intellectual property rights.

TTL830: Modeling and Simulation in Fibrous Assemblies
3 credits: (2-0-2)
Introduction of Textile Modeling and Simulation, Stochastic and Stereological Methods: Random fibrous assemblies, anisotropy characteristics in fibrous assemblies, two and three dimensional fibrous assemblies, neural networks: biological neural system, Mathematical models of artificial neurons, Artificial Neural Networks (ANN) architecture, Single and multilayer perceptrons, Learning rules, Back propagation algorithm, Applications of ANN; Fuzzy Logic: Introduction of crisp and fuzzy sets, Concepts of uncertainty and imprecision, Operations of classical and fuzzy sets, Membership functions, Fuzzification, Fuzzy rule generation, Defuzzification Applications of fuzzy logic; Genetic Algorithm (G.A): Basics of G.A, Implementation of G.A in fabric engineering; Computational Fluid Dynamics: Newtonian and Non-Newtonian Fluids and their applications in extrusion processes, Computer simulation of fluid flows through porous materials, heat and mass transfer in fibrous assemblies; Statistical Mechanics: Monte Carlo simulation of random fibrous assemblies, Application of Ising Model and fluid transport phenomenon through textile structure; Multiscale Modeling: Geometrical modeling of textile structures, modeling of properties of fibrous assemblies using object oriented programming techniques; Curve Fitting Techniques: Prediction of mechanical properties of fibrous assemblies, process-structure-property relationship of fibrous structures.

TTL866 Functional and High Performance Textiles
3 credits (2-1-0)
Protective clothing: Clothing requirements for thermal protection, ballistic protection, UV-protection, protection from electro-magnetic radiation and static hazards, protection against micro-organisms, chemicals and pesticides. Design principles and evaluation of protective clothing; Medical

Textiles: Textiles in various medical applications, Application oriented designing of typical medical textiles, Materials used and design procedures for protecting wounds; cardiovascular application, sutures etc; Sportswear: Clothing requirements for different sports. Development of highly functional fibres, yarns and fabrics for temperature control and moisture management.; Stretch, bulky and light weight fabrics; Composites: Two and three dimensional fabrics and triaxially braided materials for composites; Production and properties of preforms and composites; Properties and uses of rigid composites; Stimuli sensitive intelligent textiles - their production, properties and applications; Smart textile incorporating functional devices; Miscellaneous: Glass, ceramic and metallic fibres and their textile products.

TTS890 Independent Study (Fibre Science & Technology)
3 credits (0-3-0)
Student should undertake a research oriented activity including software development, machine design and development, instrumentation, product and process development or indepth study of a subject of outside the regular courses offered in the programme. This study should be carried out under the guidance of a faculty member. The subject area chosen by the student should be sufficiently different from the area of major project being persued by the student. The student must submit a detailed plan of work for the programme coordinator before approval of registration for the course.

TTD891 Major Project Part-I (Fibre Science & Technology)
6 credits (0-0-12)

TTS891 Independent Study (Textile Engineering)
3 credits (0-3-0)
Student should undertake a research oriented activity including software development, machine design and development, instrumentation, product and process development or indepth study of a subject of outside the regular courses offered in the programme. This study should be carried out under the guidance of a faculty member. The subject area chosen by the student should be sufficiently different from the area of major project being persued by the student. The student must submit a detailed plan of work for the programme coordinator before approval of registration for the courses.

TTD892 Major Project Part-II (Fibre Science & Technology)
12 credits (0-0-24)

TTD893 Major Project Part-I (Textile Engineering)
6 credits (0-0-12)

TTD894 Major Project Part-II (Textile Engineering)
12 credits (0-0-24)

Centre for Applied Research in Electronics

CRL702 Architectures and Algorithms for DSP Systems
4 credits (2-0-4)

Introduction to Digital Signal Processing System (DSP tasks; DSP processors and embodiments; Numeric Respresentation and Arithmetic Operation Format (Fixed point and floating point representations; Extended precision; Floating point emulation; Q notation; Fixed point and floating point arithmetic operations). Architecture of Programmable Digital Signal Processors (Central processing unit- Data and program memory features; Peripheral interfacing/Execution control). Digital signal Processor specific Assembly language programming (Instruction types; Addressing modes. Assembly language programming for specific fixed / floating points DSP processor; Pipelining). DSP Algorithms (Convolution and FFT; Methods for generation of elementary functions; Pseudo-random number generation.) Software Design for Low power (Sources of power consumption in a programmable DSP;/Software power estimation; Software optimization techniques for low power).

Practicals: Familiarization with assembly language programming tools of chosen DSP Processor, Number representation formats and arithmetic operations, Basic DSP operations: Filtering, FFT, Random Number and other function generation algorithms, Laboratory Project.

CRL704 Sensor Array Signal Processing
3 credits (3-0-0)

Representation of Space- Time Signals (Coordinate systems; propagating waves; wave number-frequency space; random fields; noise assumptions). Signal Modeling and Optimal Filters (Auto-regressive (AR), Moving average (MA), ARMA models; Autocorrelation and power spectral density (PSD) of random processes; linear minimum mean square and linear least squares error estimator; solution of normal equations; optimum filter; matched filters.) Adaptive Filter Theory (Motivation and applications; method of steepest descent; least mean squares adaptive filters; recursive least squares adaptive filters; Convergence issues and performance analysis.) Power Spectrum Estimation (Nonparametric methods; Estimation of autocorrelation function and PSD using periodogram; Blackman-Tukey and Welch- Barlett methods; Parametric methods; Model order selection; PSD estimation using rational spectral models; MUSIC ESPRIT).Signal Shaping for Transmission (Representation of band pass signals; band pass sampling theorem; Complex Envelope; Ambiguity function and its properties; Considerations in signal shaping.) Array Processing (Array signal modeling; sensor array/ geometries; spatial/sampling; beam forming- spatial and space-time filtering; array aperture; delay and sum beam forming; frequency domain beam forming; optimum beam forming: MVDR beam former, Generalized side-lobe canceller; Adaptive beam forming).

CRL705 Advanced Sensor Array signal Processing
3 credits (3-0-0)

Introduction: Motivating examples, history of array signal processig, wave propagation, mathematical model, basic notations, assumptions, and problem formulation. DOA Estimation Problem: Basic estimation methods, beamforming techniques, subspace techniques, ML techniques (Deterministic and stochastic), some special techniques for ULAs, coherent, wideband, nearfield, spread etc, sources, Beamforing: Classical methods, subspace techniques, space time beamforming. Special techniques for ULA, wideband etc, sources. Detection of number of signals, Classical methods, subspace methods, Array design techniques.

CRL707 Human and Machine Speech Communication
3 credits (3-0-0)

Introduction; (Human-machine speech communications aspects; speech chain, digital representations of speech; intensity level of sound). Speech production (anatomy and physiology of speech organs; articulatory phonetics; acoustic phonetics; phonetics transcription; universal speech production model.) Speech signal analysis (Time domain methods; Frequency domain methods; Pitch estimation spectrogram analysis; Cepstrum analysis;). Linear prediction coding (Least squares autocorrelation and covariance methods; Line spectral frequencies). Psychoacoustics and auditory perception (Hearing; critical bands; phenomena of masking; Mel scale; perceptually important features of speech; prosodic features). Speech signal coding (Speech coder

attributes; Coding rates; PCM; ADPCM; CELP;Harmonic coding of speech; Coding standards). Evaluation of speech quality (Dependancies of quality; Objective and subjective quality evaluation measures; Objective evaluation of subjective quality). Speech synthesis (Limited and unrestricted text to speech synthesis; Articulatory synthesis; Concatenative synthesis; Incorporation of prosody). Automatic Speech recognition (Pattern recognition approach; Dynamic time warping; Feature extraction; HMM; Language models). Speaker recognition (Verification vs. recognition, recognition techniques; features that distinguish speakers).

CRL711 CAD of RF and Microwave Circuits
4 credits (3-0-2)

Review of basic microwave theory: Transmission Lines and waveguides - Concepts of characteristc impedance, reflection coefficient, standing and propagating waves. Modes and evanescent waves, Network analysis: S,Z, and other multi-port parameters, impedance matching and tuning. Implementation in simulators. Planar transmission lines: Quasi-static analysis, full wave analysis, and numerical techniques. Discontinuties, equivalent circuits, use of simulators. Simple printed couplers, filters, power dividers. Implementation with lumped elements at RF. Simulation of structures on HFSS, and optimization.

Practicals : Design and fabrication of band pass filter using SERENADE. Design and fabrication of wilkinson power divider using SERENADE. Design and fabrication of ring coupler using SERENADE. Design and fabrication of NRD guide band pass filter using HFSS.

CRL712 RF and Microwave Active Circuits
3 credits (3-0-0)

Small signal amplifiers- low noise, maximum gain, stability, Broad band amplifiers- matching circuits, travelling wave amplifiers. Power amplifiers- Efficiency, CAD, device modeling, measurement. Mixers-Single ended, balanced, double balanced, different configurations for microstrip, waveguide etc., noise properties, simulatiion using harmonic balance, Osillators- various configurations depending on active device, stability and noise, resonators, VCO, transient analysis using SPICE, harmonic balance analysis, frequency synthesis using DDS, PLL.

CRL713 Fundamentals of RF Electronics
3 credits (2-0-2)

Mathamatical foundation in understanding of signal, mocrowave crcuits, and devices: Phase diagrams, duality, superposition, miller, Thevenin and Norton Theorems, instantaneous, average, complex power their representation nomenclature, Fourier series, Laplace, Fourier and Z transforms, convolution, correlation and basic properties of Fourier transforms, transimssion line theory, T and IT equivalent circuit, behavior of transmission line at radio frequency. Physcis and operation of bipolar, and MOS structures. DC and Low Frequency Circuit Concepts: BJT Biasing, mode of operation small signal AC analysis. FET circuits at DC, AC analysis, first and scond order AC models of FETs, high frequency models of BJT and FETs, single pole approximation, differential amplifiers, and frequency response, Circuit Representation of Two Port RF/ Microwave Networks. :Impedance, Admittance, Hybrid, Transmission Matrix, Generalized S parameters, Reciprocal Networks, Loss less Networks, Signal Flow graphs and its Applications, Gain Consideration in Amplifiers, Impedance Matching and network selection: power gain concept, mismatch factor, return loss, input/output VSWR, maximum gain, constant gain design, figure of merit, matching network design using lumped and distributed elements, stability consideration in active networks. Base-band and Pulse Signaling: Sampling, quantizing and encoding, digital Signal formats: binary coding, differential coding, bit synchronization, multilevel signaling, intersymbol interference, differential pulse code modulation, delta modulation time division multiplexing, pulse time, pulse width, pulse position modulation, Amplitude and Frequency Modulation: Amplitude modulation, Double sideband suppressed carrier, Asymmetric sideband sigals, phase/ frequency modulation, narrowband angle modulation wideband frequency modulation. Band pass Digetal Signaling: (OOK, BPSK, DPSK), multilivel signaling (QPSK, MPSK, QAM), minimum-shift keying (MSK) and comparison of band pass digital signaling systems, band pass sampling, filtering and linear distortion.

Practicals: Design, simulation (P spice), realization and characterization of high gain differential amplifier used in the first stage of an operational amplifier. This will involve design and simulation of a current source, extraction spice parameters, gain characterization etc., Comparison of coding schemes, self-correcting codes, assembly language programming, operation a system in a closed loop for investigating the matched filtering performance, detecting the signal in a noisy environment. The already developed for RF Identification will be used for this experiment, Design fabrication and characterization of an RF antenna.

CRL715 Radiating System for RF Communication
3 credits (3-0-0)
Antennas: radiation concepts, diploes, monopoles, Antenna parameters (gain, efficiency etc.)- theory, comparison with simulators, and measured data for simple antennas. Analysis and synthesis of simple linear arrays. Optimizers. Equivalence theorems and application to horns and reflectors, comparison with simulations. Active and passive electronic scanning antennas. Microstrip and other printed antennas, analysis using equivalent circuit, numerical techniques. Broad band printed antennas, and other broad-band antennas for ESM. Scattering by wedge GTD, and application to short-range communications.

CRP718 RF and Microwave Measurement laboratory
3 credits (0-0-6)
Experiments based on measurement and instrumentation techniques using: oscilloscopes, spectrum analyzers, network analyzers, lock-in-amplifiers, waveform generators, bit-error rate and S/N measurement, antenna characterization, telemetry, data recorders and display, etc, Experiments based on various sensors used in characterization of RF materias, devices, circuits and systems: acoustic, ultrasonic,magnetic, electrical, thermal, optical, radiation, and smart sensors, etc.

CRL720 Surface Acoustic Wave Devices and Applications
3 credits (3-0-0)
Prerequisite : Elementary Background in Signal Processings.
Signal Processing fundamentals. Surface wave propagation in anisotropic materials. Excitation and detection of Rayleigh waves in piezoelectric materials. Analysis of interdigital transducers. Mason's equivalent circuit. Delta function model. Cross field model. Impulse response model. Sampling and surface wave transducers. Band pass filter : Amplitude/phase weighting, Building block, Ramez exchange and optimization design techniques. Filter banks. Chirp filters: linear/non-linear frequency modulation schemes, reflective dot/array compressors phase coded devices, pulse compression modules and their application in radars. Realization of spectrum analyzers, frequency hopping and FFT processors using the chirp transducers. Propogation effects in materials : diffraction and beam steering, formulation using angular spectrum of plane waves, diffracted fields in the parabolic approximations.

Charge transport by Surface Acoustic Waves in GaAs. Acoustic charge transfer device structure, operation and applications.

CRL721 Analog/RF IC Modeling and Design
3 credits (2-0-2)
Amplifier fu ndamentals in CMOS, Bipolar and BiCMOS technologies. SiGe- Heterojunction Bipolar Transistors for RF applications and their noise performance, Trans-receiver building blocks for CMOS, Bipolar and BiCMOS. Low voltage, Low noise, Low power techniques in RF CMOS sub micron design receiver Architecture, RF/ Base band filtering and compensation. LNA's and VCOs at RF-Design and Limitations, Direct conversion, Image rejection, sub sampling mobile and cellular communication. Multimode, multi-band communication 3G communication.

Practicals: Design and characterization of a high gain (20,000) differential Amplifier, Design and Simulation of high gain high frequency SiGe Double Hetero Structures Transistors, Characterization and simulation of a communication link, coding schemes, self correcting

codes and auto-correlation process, Design and characterization of an intergrated transmit receive module, Sampling, sub sampling, band pass sampling and spectrum characterization.

CRL722 RF and Microwave Solid State Devices # 3
3 credits (3-0-0)
Review of basic concepts in semiconductor device operation ; energy-band diagram, drift and diffusion current, generation recombination excess carriers, and p-n junction theory. Schottky barrier diode: formation of metal-semiconductor barrier, Schottky-Mott theory and modification, metal-semiconductor interface, silicides-Si interface, effect of interface states, current flow through barrier, forward and reverse bias I-V, C-V characteristcs, measurement of barrier height. Schottky diode device structures and technology Ohmic contact formation. Varactor diode, equivalent circuit, C-V characteristics for linearly graded, abrupt, and hyper abrupt p-n junction, cut-off frequency. P-I-N diode general considerations, I-V and C-V characteristics. IMPATT diode, principle of operation, small signal impedance, power conversion efficiency, diode structure and fabrication. Transferred electron devices, differential negative resistance effect, Gunn diode. GaAS MESFETs, basic device structure, theory of operation equivalent circuit and analysis. Silicon MOSFETs: brief review of MOSFET theory, Passive design and operation, high frequency structures SOI based MOSFETs. Passive components in RF technology (inductors, capacitors), MMICs.

CRP723 Fabrication Techniques for RF & Microwave Devices
3 credits (1-0-4)
Concept of process flow in IC fabrication, representative process flow for diode/MOSFET. High temperature processes; oxidation, diffusion, and annealing. Use of "masks" in IC fabrication, mask design and fabrication., Photolithography processes. Chemical etching processes: dry and wet etching. Vacuum and vacuum systems. Thin films in IC processing, resistive evaporation, e-beam, RF and DC sputtering processes. Concept of test chip design and process parameter extraction.

Practicals: Vacuum system, Thermal evaporation, DC/RF sputtering, Mask making techniques: Coordinatograph/Photo-plotter first Reduction Camera, Step and Repeat process, Photolithography process, Etching techniques, Oxidation/ diffusion processes, Diode fabrication, Band Pass filter fabrication, Measurement equipment calibration.

CRL724 RF and Microwave Measurement System Techniques
3 credits (3-0-0)
Review of measurement and instrumentation basics. Principles and applications of various sensors used in charaterization of RF materials, devices, circuits and system: acoustic, ultrasonic, magnetic, electrical, thermal, optical, radiation and smart sensors., Mechanical and thermal enginering issues for RF modules/ instruments. Instrumentation concepts and measurement techniques in: Oscilloscopes, Spectrum analyzers, Network analyzer, Lock-in-amplifiers, Waveform generators, Bit-error rate measurement, S/N measurement Talemetry, Data recording and display, Recent advances in RF and Microwave measurement Techniques.

CRL725 Technology of RF and Microwave Solid state Devices
3 credits (3-0-0)
Review of semiconductor device processing technologies: process sequence development for a representative MOS technology, overview of oxidation, diffusion, mask making, pattern transfer, etching, metallization etc., process integration. Techniques of metallization: Introduction to vacuum systems. Sputtering (DC,RF and magnetron), e-beam evaporation for ohmic amd Schottky. Contact formation, silicides for gate and interconnect. Fine line lithography process: optical lithography, x-ray and e-beam lithography, lift-off techniques. Wet and plasma assisted etching techniques, RIE, RIBE. Introduction to

Ion Implantation, Molecular Beam Epitaxy. Chemical Vapour Deposition (epitaxial growth, polycrystalline, silicon, dielectric films, flow pressure and plasma chemical deposition). GaAs MESFET technology. Introduction to MEMES technology.

CRL726 RF MEMS Design and Technology
3 credits (3-0-0)
Introduction and origin of MEMS, driving force for MEMS development, fabrication process. MEMS fabrication technologies: Conventional IC fabrication processes,bulk micro machining, surface micro machining, LIGA process, anodic and fusion bonding, packaging techniques for MEMS. Sensors, Classification and terminology of sensors, evolution of semiconductor sensors, sensor characterization basic concept of acoustic, mechanical, magnetic, radiation, thermal sensors and intergratd sensors. Actuation in MEMS devices, electrostatic actuation, parallel plate capacitor-cantilever beam based movement, comb-drive structures. The MEM switch; Cantilever based MEM switch, Membrane based switch design microwave material and mechanical considerations. The MEMS switch; cantilever based MEMS switch, membrane based switch design, microwave, material and mechanical considerations. Microwave transmission lines, membrane supported micro-strip line, coplanar waveguide, micro-machined waveguide, inductors, capacitors and tunable capacitors. MEMS based RF and microwave circuits: phase shifter, resonators, filters, oscillators.

CRL728 RF and Electronic System Design Techniques
3 credits (3-0-0)
Economics of Wireless and Fixed Communication systems, Building Blocks of RF Systems, super component design. Spread Spectrum Communication and Channel Modeling. Advanced Receiver Algorithms., Reed Solomon codes and Modulation., Wireless Application Protocols. WAP Services and Applications. Personal Communication Systems and Global Positioning Systems. CDMA and Bluetooth system Simulation. systems on Chip. 3 G Systems.

CRL731 Selected Topics in RFDT- I
3 credits (3-0-0)
Lecture course for covering special topics in the area of relevance to a group of students attending the RFDT programme.

CRL732 Selected Topics in RFDT- II
3 credits (3-0-0)
Lecture course for covering special topics in the areas of relevance to a group of students attending the RFDT programme.

CRL733 Selected Topics in RFDT- III
3 credits (3-0-0)
Lecture course for covering special topics in the areas of relevance to a group of students attending the RFDT programme.

CRS735 Independent Study
3 credits (0-3-0)
Interactive course offered by faculty to specific students for carrying out in-depth study in certain areas of technology.

CRL737 Selected Topics in Radars and Sonars
3 credits (3-0-0)
The Radar and Sonar Equations: Basic System parameters; Radar and Sonar Applications. High resolution imaging sonars: Sidelook sonar, Sector-scan sonar, Modulation scanning techniques, synthetic aperture sonar, CTFM/FMCW principle. Modern Navigation and positioning techniques. The Doppler Effect, FM-CW Radar, MTI Radar, Pulse Doppler Radar, tracking and Monopulse radar, Scattering and radar cross- section, radar clutter and combating clutter.

CRD802 Minor Project
3 credits (0-0-6)
Interactive course offered by faculty to specific students for carrying out in-depth study in certain areas of technology.

CRD811 Major Project-I
6 credits (0-0-12)
Laboratory-based project to demonstrate and develop advanced skills for technology development in a specified area.

CRD812 Major Project-II
12 credits (0-0-24)
Laboratory-based project to carry out original research and advanced design/development in a specific technology area.

National Resource Centre
for Value Education in Engineering

The following two courses are offered by the Centre for postgraduate students.

VEL700 Human Values and Technology
3 credits (2-1-0)

Present state of society-achievements and maladies. Notions of progress, development and human welfare. Distinction between 'pleasure' and 'happiness', 'good' and 'pleasant', 'needs' and 'wants'. Are there any universal human values? Complementarity of values and knowledge. Typical modern technologies- their impact on mankind. Fundamental characteristics of modern technology-their relationship to values. Sustainability of modern technology. Values for harmonious and sustainable development. Rationales behind universal human values. Values and humanistic psychology. Practical difficulties in living upto these values typical Dilemmas. Need for inner transformation. Various approaches towards purification of mind. Concept of holistic development and holistic technology. Integrating scientific knowledge and human values, understanding Engineering ethics.

VEL710 Traditional Knowledge and Values
3 credits (2-1-0)

Some of the values inherent in these TKS are respect for all life and non-life, respect for diversity, awareness of social and ecological impact of activities, self-sufficiency, sustainability, socially appropriate, use of local natural and knowledge resources, decentralized, aesthetically pleasing, wealth distributive etc. It would be emphasized that these values are inherently present in the framework of knowledge systems and are not add-ons. Traditional Technologies which are developed as part of the TKS framework are invented and tested in the field, where all environmental and social interaction, in particular its effect on other life-forms known and unknown are allowed to play their part. This non-fragmented approach makes such knowledge holistic and avoids the errors and pitfalls when technologies are applied on the basis of incomplete or inadequate theories.

VED750 Minor Project
3 credits (0-0-6)

To carry out detailed studies (under the guidance of a faculty member) on issues like Science, Technology and Human Values, Engineering Ethics, Sustainable Development, Scientific basis of human values etc.

Amar Nath and Shashi Khosla
School of Information Technology

SIL765 Network & Systems Security
4 credits (3-0-2)
Pre-requisites: CSL374 / CSL672 or equivalent, CSL373 / CSL633 or equivalent
The goal of this course is to introduce challenges in securing computer systems and networks. We will discuss various types of vulnerabilities in existing software interfaces, such as buffer overflows, unsafe libc functions, filesystem design issues, etc. We will also discuss modern-day defenses against attacks exploiting these vulnerabilities. In network security, we will discuss security problems in network protocols and routing, such as sniffing, denial of service, viruses, worms, and defenses against them. The course will involve reading research papers on relevant topics, programming assignments, and projects.

SIL769 Internet Traffic – Measurement, Modelling & Analysis
4 credits (3-0-2)
Pre-requisites: CSL374 / CSL672 or equivalent
Internet architecture: Overview of TCP/IP protocol stack. Mathematics for studying the Internet: Review of basic probability and statistics, analytic modeling approaches. Practical issues in Internet Measurements: Challenges, tools and techniques for measuring performance. Internet Traffic Characterization: Poisson models for Internet traffic, self – similarity in network traffic. Web Performance: workload characterization, caching, content distribution networks. Multimedia Systems: Video- on- Demand, IP-TV, Peer-to-Peer file sharing, Peer-to- Peer Streaming. Social Networks. Network Security.

SIL801 Special Topics in Multimedia Systems
3 credits (3-0-0)
Pre-requisites: Course Co-ordinator's permission
Objective of the course is to expose students to the advanced concepts in Multimedia Systems. Content of this course, depending upon the teacher, will be focused on some aspect(s) of multimedia systems like content based retrieval, multimedia communication, compression, techniques, speech and audio technology, etc.

SIL802 Special Topics in Web Based Computing
3 credits (3-0-0)
Pre-requisites: Course Co-ordinator's permission
Objective of the course is to expose students to the advanced concepts in Web Based Computing. Content of this course, depending upon the teacher, will be focused on some aspect(s) of web based computing like sematic web, web based distributed computing, search methods, etc.

SIV813 Applications of Computer in Medicine
1 credit (1-0-0) Pre-requisites: None
This course will consist of 14 lecture-hours that focus on information and communication technologies(ICT) that are being developed and used in medical education and clinical practice today. Various technologies ranging from computer aided instruction (CAI), simulations and networked applications at one end to electronic medical records (EMR), telemedicine and robotic surgery at the other end will be described. The process of research, development and evaluation in the designing and making of these applications and tools will be detailed. Writing assignments, creative thinking and interactive discussions will form an integral part of this course.

SIV861 Information and Communication Technologies for Development
1 credit (1-0-0) Pre-requisites: None
ICT for development is an emerging area of research that combines high-tech CS/IT skills, and put them to uses to solve social development problems. Some of the topics we will explore include the design of low-cost communication technologies for rural areas, agriculture consultancy systems, techniques for surveys and data collection to maintain health records, artifical intelligence to guide farmers on cropping patterns, and security schemes for financial inclusion and branchless banking.

SIV864 Special Module on Media Processing and Communication
1 credit (1-0-0) Pre-requisites: None
Communication today has rich multimedia contents. Under the varying bandwidth attention is required for appropriate processing of the media contests satisfying desired quality of service. This course will focus on bringing the two broad areas of multimedia processing and communication together. In media processing fundamental concepts of media processing and compression will be introduced with exposure to current techniques and standards. In communication protocols and algorithms for both wired and wireless networks will be discussed in relation to multimedia communication.

SID880: Minor Project in Information Technology
3 credits (0-0-6) Pre-requisites: Course Co-ordinator's permission
Objective of the course is to provide an opportunity to the students to work on development/research project in his/her area of specialization as part of M.S. degree.

SID890: Major Project for M.S. (Research)
40 credits (0-0-80) Pre-requisites: Course Co-ordinator's permission
Objective of the course is to provide an opportunity to the students to work on development/research project in his/her area of specialization as part of M.S. degree.

SIV895: Special Module on Intelligent Information Processing
1 credit (1-0-0) Pre-requisites: None
This course will focus on presenting conclave of methods which are being practiced for intelligent computing-learning techniques, classification methods, embedding intelligence, neural network, soft computing and evolutionary methods. Emphasis will also be given on the variety of multidisciplinary applications of such techniques.

School of Biological Sciences

SBL101 Modern Biology for Engineers
3 credits (3-0-0) Pre-requisites: None
Darwinian evolution & molecular perspective; Conventional species classification & Genomic view of evolution tree; Commonalities among life forms; Cell physiology, multi-cellular assemblies – superorganisms; Organismal physiology; Infectious diseases, Immunology, Stem cells, Cancer biology, Molecular interventions to improve nutritional content and survival of Plants & Animals. Design activities – Random pattern generation and morphogenesis.

SBP200 Introduction to Practical Modern Biology
2 credits (0-0-4) Pre-requisites: SBL 101
Biosafety lab practices – use of lab coats, gloves, safety goggles, eye wash, shower, chemical and biological waste disposal; Buffers in biology – Preparation of standard biological buffers, buffering capacity and pKa of buffers, biomolecules such as enzymes, whole cells and plant tissues in different buffering conditions; Observing cell surface and intracellular contents using light and fluorescence microscopy, "autofluorescence" of cells, real-time video microscopy of motile cells, cell growth and division; Plant genomic DNA isolation; Protoplast isolation and viability; Computer Modeling-From Genome Sequence to Protein Sequence and structure to screening for a "Hit" Molecule.

SBL201 High-Dimensional Biology
3 credits (3-0-0) Pre-requisites: SBL101
Introduction to Genomics, proteomics, Metabolomics & Cellomics; Size vis-à-vis packaging and replication challenges, Biomolecular architecture and assemblies leading to function, Immortal cells and aging, Minimalist Genomes & Designer Genomes; Molecular Engines; Proteins as nano-biomachines; network circuits for genome organization and protein-protein interactions, date hubs, party hubs, structure-function axioms, Biochemical cycles and feedback loops, Omics Applications, forensics, drug targets.

SBD301 Mini Project
3 credits (0-0-6) Pre-requisites: SBL101 and EC80
Systems Biology, Plant Molecular Biology, Bioprospecting, Tissue culture and Developmental Biology, Virology, Structural Biology, Cell Biophysics, Cellular Signalling, Protein folding and misfolding, Computational Biology.

SBL701 Biometry
3 credits (3-0-0) Pre-requisites: EC 90
Probability and Set theory: Application to biological data, Random variables: Individuals vs. populations in biological systems, Classification of data: "Discreteness or Continuity" in biological evolution, Distributions, Descriptive statistics, Inferential statistics, Analysis of variance (ANOVA), ANOVA-advanced concepts, Power analysis of variance, Regression and Correlation, Count/Frequency data. MATLAB based assignment activities will be designed for data simulation and analysis corresponding to the covered lecture material.

SBL702 Systems Biology
3 credits (3-0-0) Pre-requisites: EC 90
Overview and history of systems biology; Basic elements of molecular biology – DNA and protein, the genetic code, transfer RNA and protein sequences and control of gene expression; Signal transduction – signaling pathways and cascades, information processing and transmission, pathway dynamics; Trees and sequences – graphs, connectivity, trees, flows in networks; Elements of process control – feedback, feed forward and cascade control, dynamics of closed loops, analogies with control of gene expression; Examples of transcription networks, determination of simple motifs that are repeated in genetics; guidelines for analyzing genetics circuits, layouts and representations, circuit dynamics; modeling, simulation and prediction of cellular events, micro-macro relations; Experimental methods in systems biology, creation of directed information, existing databases; platforms and applications; Case studies from literature – circadian clock, metabolic networks, gene circuit design; New frontiers.

SBL703 Advanced Cell Biology
3 credits (3-0-0) Pre-requisites: EC 90
Chemistry of biological structure, function and information flow, Cellular compartmentalization and molecular organization of organelles, Properties and growth of HeLa, Jurkat, SF9 etc.; De-novo synthesis of organelles versus templated replication, Microtubule, microfilament and intermediate filaments; Transport of biomolecules; Nuclear structure, chromatin packing and transport; Microtubule, actin and filament based motile systems, cell-cell recognition and adhesion; Fluorescence, phase constrast, confocal and AFM; Molecular basis of cancer, oncogenes and tumor suppressor genes; cell growth and differentiation.

SBL704 Human Virology
3 credits (3-0-0) Pre-requisites: EC 90
Introduction, overview and history of medical Virology; Virus structure, classification and replication – symmetries, replication, maturation and release; Principles of viral pathogenensis- entry, cell tropism. Cellular pathogensis, clearance and persistence; Respiratory viruses – Influenza, paramyxoviruses, adenonviruses, SARS, RSV; Viral gastroenteritis – causative agents, epidemiology; Hepatitus viruses – food borne and blood borne; Herpes viruses – infections in immunocompetent and immunocompromised individuals, latency; Enteroviruses – Polio, ECHO, coxsackie viruses; Congenital viral infections – effects on foetus, prevention; Retroviruses – HIV, AIDS; Arboviruses and Viral zoonoses – arthropod vectors, vertebrate hosts, transmission cycles, rabies and viral haemorrhagic fevers; Tumour viruses – oncogenic mechanisms of viruses; Strategies for control of viral infection – active and passive immunoprophylaxis, antiviral agents; Safety precautions – lab acquired infections, hazard groups and containment levels; Case studies from literature, evolving and emerging areas of interest.

SBL705 Biology of Proteins
3 credits (3-0-0) Pre-requisites: EC 90
Over-view of protein preparation, modification, maturation; protein-protein interactions in cells, Heat shock proteins and their structure and functions in cells, protein mimicry, assisted protein maturation processes in cells, Protein trafficking and dislocation, protein secretion from cell, kinetics and thermodynamics of protein folding and unfolding reations, biomarker discovery, ribosome profiling.

SBL706 Biologics
3 credits (3-0-0) Pre-requisites: EC 90 and BEL 110 or CYL 110 or CYL 120 or Equivalent
Definition and classification of biologics, Biologics, Biopharmaceuticals Vs. conventional drugs, Biosimilars, Role of rDNA technologies, transgenics (animal and plant), obligonucleotides, peptide, PNAs mediated therapeutics, drug delivery systems (lipids, cell penetrating peptides), vaccine, monoclonal antibodies produced by and in the living organisms, nanobiopharmaceutics, overview of the technologies employed for identification, characterization and production of biologics, Bioprospecting for novel drug discovery and development, Gene prospecting, plant bioprospecting, marine bioprospecting Phytomedicines, plant secondary metabolites, herbal drugs, edible vaccines, Bioresource based alternative medicine systems - AYUSH, Southeast Asian medicine system, PIC, MAT and ABS, assessing the role of biomimetics, system biology, synthetic biology in biologic production, GMPs, legislations, Safety Regulations associated with biologics in biopharmaceuticals.

SBL707 Bacterial Pathogenesis
3 credits (3-0-0) Pre-requisites: EC 90 and BEL110 or CYL110 or CYL120 or Equivalent
Common features of bacterial pathogens, structural features, capsules and cell walls, Pathogenicity islands, types of toxins produced, effect of toxins on host cells, secretion systems, production and function of adhesions, attachment to host cells, mechanisms of cellular invasion, extracellular and intracellular invasion, intracellular survival and multiplication, virulence factors, mechanisms of antibiotic resistance, interaction with the host immune system- innate and adaptive, evasion strategies, Immunocompromised individuals and opportunistic pathogens, specific examples such as Listeria, Mycobacterium, Shigella, Yersinia etc., strategies for prevention and cure, drug designing and scope for future studies, emerging infectious bacterial pathogens.

SBL708 Epigenetics in Human Health and Disease
3 credits (3-0-0) Pre-requisites: EC 90 and BEL 110 or CYL 110 or CYL 120 or Equivalent

Introduction – overview of epigenetics in human health and disease; Epigenetic mechanisms – basic mechanisms: DNA methylation and genome imprinting –role of DNA methylation; Epigenetics in cancer Biology – global and region specific changes and effects on transcription; DNA methylation and repeat instability diseases; Epigenetic reprogramming and role of DNA methylation in mammalian development –role in embryogenesis; Epigenetics in pluriprotency and differentiation of embryonic stems cells; MicroRNA in carcinogenesis – mechanisms and potential therapeutic options; Epigenetic regulation of viruses by the host –role in pathogenesis; methods in epigenetics-methylation patterns and histone modifications; Case studies from literature, evolving and emerging areas of interest.

SBL709 Marine Bioprospecting
3 credits (3-0-0) Pre-requisites: EC90 and BEL110 or CYL110 or CYL120 or Equivalent
Significance, Overview of Marine Bioresources, Marine Biomedical Research and Development; Drug discovery continuum in Marine Biotechnology, Omics, Biosensors, Biomaterials, Bionanotechnology, Bioactive compounds, Nutraceuticals, Pharmaceuticals, Cosmeceuticals, Novel Technologies in Marine Research, Sustainable development, Case studies, Emerging issues and challenges; IPRs, Marine Biodiversity and Traditional Knowledge (medicine)

SBL710 Chemical Biology
3 credits (3-0-0) Pre-requisites: EC90 and BEL110 or CYL110 or CYL120 or Equivalent
Chemical modifications of proteins, protein and nucleic acid immobilization; The Organic Chemistry of Biological Pathways; cross linking in biomolecules; Physical Chemistry of proteins; fluorescent labeling of proteins and nucleic acids, sequencing of proteins and amino acids, radio labeling of proteins and nucleic acids, chemistry of glycosylation, phosphorylation, sulphonylation, methylation, of proteins and nucleic acids, non-ribosomal peptide synthesis, nano particles mediated monitoring of protein conformational transition, folding and unfolding processes; surface properties of proteins and subsequent implications in cellular processes, solubility of proteins, physical basis for biomolecular structure formation, environmental effects on structure-function of biomolecules, chemistry of enzymatic digestion of nucleotides and proteins, role of metal ions in the cellular function, metallo-enzymes and their biosynthesis, Hydrogen/Deuterium exchange reaction and its application in monitoring biological processes, basic concept of chemical synthesis of life.

SBC795 Graduate Student Research Seminar-I
0.5 credit (0-0-1) Pre-requisites: EC 90
The course is aimed at giving the student a forum to periodically present their research, to critique the research of colleagues and learn about the best research in their fields. Discussions will be held on scientific methodology and inculcated with a value system for pursuing a career in science. Activities will be carried out in workshop mode.

SBC796 Graduate Student Research Seminar-II
0.5 Credits (0-0-1) Pre-requisites: EC 90
Special topics in research will be assigned by Coordinator; results of the research of each student registered for the course will be discussed; Discussions on scientific material from recently published papers in areas related to their research; The "Laboratory" activities will include delivery of seminars on their research and participation in the seminars and critique.

SBS800 Independent Study
3 credits (0-3-0) Pre-requisites: EC 120
The course is aimed at providing the student an opportunity to pursue a special research topic. A research topic assigned and mutually agreed upon by the faculty and student. Registration will require the submission of a proposal through the research committee on the topic clearly delineating the objectives to be achieved.

SBL801 Signal Transduction and Drug Target Identification
3 credits (3-0-0) Pre-requisites: EC120
Eukaryotic cellular communications, importance of signal transduction, principles of signaling, recurring themes of signal transduction, reception, transduction, response, signal amplification, coordination of signaling, cascade formation, structure to function, anchors, adaptors, scaffold, recruitment of signaling proteins, topology and functional domains, dual specificity, modules, convergence, divergence, cross talk, receptors, G-protein coupled signal transduction, growth factors and tyrosine kinases, mitogen activated protein kinases, insulin signal transduction, critical nodes, protein phosphorylation, drug target identification, mechanism of drug action against signal transduction, antagonists of cell surface receptors and nuclear and receptors, ion channel blockers, transport inhibitors, targeting protein kinases and phosphatases, inhibitors of kinases and phosphatases, pseudosubstrates, examples of clinical drugs against protein kinases/ phosphatases, new and emerging technologies to identify drug target like antisense , omics, RNAi, high content screening, target hopping, combination of mutations, systems approach, complexity in signaling, techniques in signal transduction.

SBL802 Macromolecular Structure and Data Processing
3 credits (3-0-0) Pre-requisites: EC120
Treatment of macromolecules to generate suitable crystals, hanging drop and sitting drop techniques, seeding, cryopotecting and freezing crystals, acquisition of diffraction data, synchrotron radiation, indexing and scaling data, space group identification, symmetry elements, Fourier transformation and structure factors, the phase problem, heavy atom methods, molecular replacement, anomalous X-ray scattering, calculation of electron density, model building and phase refinement, co-crystallography, small angle X-ray scattering, preparing samples for transmission electron microscopy, negative staining, cryo-techniques for freezing grids, manual vs. automated data collection, cryotomography, software packages for data collection and processing, generating a model, refinement and validation, time resolved cryoEM.

SBV881 Advances in Chemical Biology
1 credit (1-0-0) Pre-requisites: EC 120
Structural aspects of proteins and nucleic acids, Mechanism of action of biological molecules, Chemical approaches to solve biological problems, Designing chemical tools for addressing problems in biology, Bioconjugate chemistry, Recent developments in these areas.

SBV882 Biological Membranes
1 credit (1-0-0) Pre-requisites: EC 120
Introduction to the hydrophobic effect, Phospholipid model systems, Cellular membrane asymmetry, Membrane dynamics, Membrane trafficking, Membrane fusion, Membrane proteins (Form and function), Small molecule permeability, Pores channels and transporters, Lipid systems for drug delivery.

SBV883 Chaperone and Protein Conformational Disorders
1 credit (1-0-0) Pre-requisites: EC 120
Molecular mechanism of protein misfolding, fate of agrregated proteins in the cell, various protein misfolding disorders in humans, mechanism of action of molecular chaperones in various cells, chaperone assisted suppression of protein misfolding.

SBV884 Elements of Neuroscience
1 credit (1-0-0) Pre-requisites: EC 120
Introduction to cell biology of neurons; presynaptic and post synaptic mechanisms; signal transduction cascades; neural integration; Hodgkin-Huxley experiments; Na and K pumps; physiological significance of pump modulation; Na and K channels; type and function of different Ca activated K channels; structure function and inactivation; tools for studying Ca signalling; caging and releasing Ca in the neurons; role of nitric oxide; Long term potentiation.

SBV885 Protein Aggregations and Diseases
1 credit (1-0-0) Pre-requisites: EC 120
Introduction to protein aggregation (amorphous and amyloid), types of aggregates, difference between aggregation and precipitation; External and internal factors for protein aggregation, pH, temperature and protein concentration effects; hydrophobicity, discordant helices; Structural and conformational prerequisites of amyloidogenesis, predominance of beta-sheet, alpha-helices or random coils of native protein; generic nature of protein folding and misfolding, Cytotoxic intermediates in the fibrillation pathway, Oxidative stress and protein

deposition disease, Protein aggregation, ion channel formation, and membrane damage, Recent trends in prevention of amyloidosis; drugs, antibodies, combination therapy.

SBV886 Signaling Pathway Analysis
1 credit (1-0-0) Pre-requisites: EC 120
Introduction to modelling of biological systems – history, types of models, macroscopic phenomena, modelling of cellular systems; hierarchy in information transmission and utilization, interaction between different levels of information leading complex behaviour; robustness of cellular systems and its significance; molecules that transmit signals, role of signaling in regulation of cellular functions, gene regulation; signal transduction – evolution and history; first messengers and receptors, GTP-binding proteins; Calcium Signaling – free, bound and trapped calcium, mechanisms regulating calcium concentration, calcium changes in single cells; protein phosphorylation as a switch, protein kinase A, protein kinase C, structure of signaling pathways, extracting motifs from pathways, relating motifs to observations; dynamics and periodicity in signaling pathways.

SBV887 Current Topics in Computational Biology
1 credit (1-0-0) Pre-requisites: EC 120
Bring about awareness of the challenges in Genomics, Proteomics, Metabolomics and Structural Biology.

SBV888 Current Trends in Computer Aided Drug Discovery
1 credit (1-0-0) Pre-requisites: EC 120
Teach students various methods for target identification, and applications QSAR and molecular modelling in drug discovery.

SBV889 Diagnostic Virology
1 credit (1-0-0) Pre-requisites: EC 120
Introduction to diagnostic virology – direct and indirect methods, specimens and window period; Microscopy – light microscopy, electron microscopy, and fluorescence microscopy in virus identifications; Methods of virus isolation – cell culture, embryonated egg inoculation and animal inoculation; Viral antigen detection – methods, assay characteristics, rapid antigen identification techniques; Detection of viral antibodies – methods, role of quantitative measurements, class-specific immunoglobulin detection; Viral nucleic acids – amplification, detection and quantitation methods; Molecular epidemiology of viral infections – high throughput methods; Identifying antiviral resistance – genotypic and phenotypic approaches; Quality control in diagnostic virology – internal and external quality control, international standards, and Shewhart control charts.

SBV890 Kinetoplastid Parasites and Novel Targets
1 credit(1-0-0) Pre-requisites: EC 120
Kinetoplastid diseases, transmission, clinical features, immune evasion, treatment, antimicrobial chemotherapy, drug resistance, cross – resistance, Leishmania, promastigotes and amastigotes, procyclic and metacyclic, macrophage, interaction with sand fly, cytokine response, transmission, syndromes associated with leishmaniasis, microtubules in kinetoplastida, dynamics and posttranslational modifications, drug interactions, resistance against tubulin binding agents, arsenite resistance in Leishmania, transporters in kinetoplastid protozoa and drug targets, leishmanial glucose transporters, function of histone deacytylases in kinetoplastid protozoa, DNA – topoisomerases in Leishmania, a possible therapeutic target, exoproteome of leishmania, importane and its application in Leishmania.

SBV891 – Virus Host Interactions
1 credit (1-0-0) Pre-requisites: EC 120
Introduction to the virus life cycle; host cell surface molecules utilized as virus receptors, mechanism of cellular membrane penetration for enveloped and non-enveloped animal viruses, cellular entry of bacteriophages and plant viruses; icosahedral and helical capsids, disassembly and transport of genome to the replication site, process of replication, modification of cellular organelles and hijacking of host cell resources ; site and manner of progeny virus assembly ; lytic and lysogenic viruses; virus egress and involvement of the host secretory pathway; host defence mechanisms, virus strategies to evade host immune system, antiviral therapies and drug discovery.

Centre for Atmospheric Sciences

ASL310 Fundamentals of Atmosphere and Ocean
4 credits (3-0-2)
Pre-requisites: EC 60
Composition of atmosphere and ocean, Thermodynamic state: distribution of temperature, density, pressure, water vapour, salinity, etc., Equations of state, Fundamental forces in the atmosphere and ocean; Pressure gradient, gravitational, Coriolis and frictional forces, Atmospheric chemistry: gas phase chemical reactions, tropospheric and stratospheric chemistry, Laws of motion in the rotating earth, geostrophic and hydrostatic balances, Thermodynamic laws and energy cycle: Radiation, conduction, convection and advection; adiabatic and diabatic cooling and warming, thermodynamic diagrams, General circulation in the atmosphere, Monsoons, Global ocean currents, unique characteristics of Indian Ocean circulation, Wave propagation: Gravity waves, Oceanic Tides, Surges and Tsunamis, Atmosphere-Ocean interaction: some examples of air-sea interaction.

ASL320 Climate Change: Impacts, Adaptation and Mitigation
4 credits (3-0-2)
Pre-requisites: EC 60
Elements of physical climatology, climate variability; anthropogenic causes of climate change; concepts of radiative forcing climate feedbacks and climate sensivity; Observed climate record and paleo reconstruction, modeling aspects of the climate system; Carbon emission pathways, scenario development, climate simulations of the future; Socio-economic impacts, quantifying uncertainties, tipping points and irreversible changes; Observed and projected changes in weather, monsoons, teleconnections, extreme weather events, see level in India; Climate hot spots, sector wise vulnerability and adaptation; Reducing greenhouse gas emissions, clean energy technologies, geoengineering options.

ASL410 Numerical Simulation of Atmospheric and Oceanic Phenomena
4 credits (3-0-2)
Pre-requisites: EC 90
Density stratification in atmosphere and ocean, static stability, equations of motion of a rotating fluid, scale analysis, hydrostatic approximation, vorticity and divergence, a coordinate system for planetary scale motion, Saint-Venant (shallow-water) equations; meteorologically important waves, Rossby and vertically propagating waves; basic concepts of barotropic and baroclinic instability.

Numerical methods: (a) Finite difference methods - advection equation, stability analysis, oscillation equations, (b) Galerkin Methods - transform method, application of spectral and finite element methods to barotropic vorticity equation. Time integration schemes for the advection equation. Introduction to consequences of sound waves, surface gravity waves, internal gravity waves in weather prediction models. Boundary layers: Prandtl layer, Ekman layer, Monin-Obukhov similarity theory and surface layer, closure assumption, eddy diffusion and K-theory, one-dimensional models of boundary layer. Objective analysis and initialization: data preparation, need for initialization of numerical models; introductory dynamic and normal mode initialization, variational and 4-dimensional data assimilation.

ASL701 Dynamics of Atmosphere and Ocean
3 credits (3-0-0)
Overlaps with: ASL710, ASL840
Basic hydrodynamic equations in a rotating frame of reference, geostrophic balance; basic laws of conservation, hydrostatic balance, gradient and thermal winds, dimensional analysis, simplified equations for ocean and atmosphere in motion; shallow water equations, potential vorticity conservation; barotropic and baroclinic instabilities; acoustic, gravity, Rossby and Kelvin waves; horizontal and transverse waves, vertically propagating waves; large-scale atmospheric circulations, available potential energy; equatorial dynamics, heat-induced tropical circulations, Gill's solution; mid-latitude circulations; planetary waves and stratosphere.

Ocean Dynamics: thermohaline and wind-driven ocean circulations; Ekman layers, Sverdrup transport, western boundary currents; ocean circulation variability; oceanic mixed layer; response of ocean to a moving storm or hurricane.

ASL703 Physics of Atmosphere and Ocean
3 credits (3-0-0)
Overlaps with: ASL710, ASL830
Thermodynamics of dry and moist air: atmospheric stability and dry adiabatic lapse rate, Clausius-Clapeyron (C-C) equation, moist processes in the atmosphere, saturated and unsaturated accent, moist adiabatic and saturated adiabatic processes in the atmosphere, saturated adiabatic lapse rate, pseudo adiabatic processes and equivalent potential temperature, conditional instability of second kind, thermodynamic diagrams; moist convection, condensation processes, formation of cloud droplets, precipitation.

Ocean physics: thermodynamics of seawater, observed temperature, salinity, and density in the ocean; density stratification, water mass distribution, coastal currents and upwelling; thermohaline circulation, The Gulf Stream and its rings; ocean currents, The Great Ocean Conveyor Belt, coupling of surface and deep ocean waters; basic foundation of turbulence, turbulent flows, turbulent vorticity, turbulent pressure, eddy diffusivity, and coherent structures; surface fluxes, air-sea interaction, mixing processes in the ocean.

Radiative transfer in atmosphere and ocean: Sun and climate, Planck function, black-body radiance, local thermodynamic equilibrium, radiometric quantities, absorption and emission, Schwarzchild's equation, radiative equilibrium in a grey atmosphere, balance between incoming solar and outgoing thermal radiation; More complex radiative transfer: integration over frequency, single lines, average transmission over a spectral interval, absorption by atmospheric gases, Heating rates, net radiative heating; a simple model of scattering in the atmosphere; Radiative transfer in atmosphere-ocean system.

ASL705 Boundary Layer Meteorology and Air Pollution
3 credits (3-0-0)
Overlap with: ASL831
Boundary layer processes, atmospheric boundary layers, bulk and gradient Richardson numbers, shear and buoyant production of turbulence, organized large eddies, boundary layer wind and thermodynamic profiles, convective and stably stratified boundary layers; surface layer; similarity theory, conservation equations for covariances, Reynolds stresses; turbulent fluxes; equations of atmospheric turbulence and closure assumption, TKE budget equation, observational techniques; Ekman boundary theory, oceanic boundary layers; parameterization and models of turbulent transport. Air pollution meteorology: sources of air pollution, Gaussian plume models, diffusion from point, line and area sources; urban air pollution.

ASL706 Parameterization of Physical Processes
3 credits (3-0-0)
Parameterization of subgrid-scale processes; one-dimensional PBL model; parameterization of subgrid orographic processes, gravity-wave (GW) drag; parameterization of dry adiabatic and moist convective processes, cloudiness parameterization in numerical models; cloud microphysics in numerical models; radiative transfer, band and emissivity models, multi-level longwave and shortwave radiation computations; surface and atmosphere interaction, land surface parameterizations, surface hydrology modelling, energy balance at the surface, surface albedo and vegetation cover.

ASL707 Mathematical & Statistical Methods in Atmospheric Sciences
3 credits (3-0-0)
Initial and boundary value problems, ordinary differential equations, orthogonal functions; partial differential equations: solving them through variational and numerical methods. Review of probability, discrete and continuous distributions, multivariate probability distributions, assessing goodness of fit, hypothesis testing, regression, time-series analysis, principal component/ empirical orthogonal function analysis.

ASL710 Atmospheric Physics
3 credits (3-0-0)
Overlap with: ASL701
Structure and thermodynamics of atmosphere: composition of air, stratification of the atmosphere, moist adiabatic processes, stability of the atmosphere, thermodynamics of dry and moist air. Atmospheric radiation: the radiation balance of the earth: Atmospheric system. Basic

equations governing atmospheric circulations: effects of rotation of the earth, scale analysis, hydrostatic and geostrophic approximations; circulation and vorticity. Waves in the atmosphere: sound waves and gravity waves, inertial oscillations, Rossby gravity waves. Planetary boundary layer: influence of obstacles on wind, mixing length theory, Ekman layer equations, the inversion layer. Weather prediction and climate studies: general circulation of the atmospheric, introducing different numerical techniques and physical parameterization schemes, the monsoon and its simulation by numerical models.

ASL712 Air Sea Interaction
3 credits (3-0-0)
Ocean-atmosphere system, transfer properties between atmosphere and ocean, oceanic absorption of solar energy, fluxes in the surface boundary layer over the sea, marine boundary layer, ENSO, variability of the ocean parameters in relation to Indian monsoon, physical parameterizations of the air-sea interaction, coupled ocean-atmosphere modeling.

ASL715 Science of Climate Change
4 credits (3-0-2)
Description of the climate system, natural greenhouse effect and the effect of trace gases and aerosols, feedbacks in the climate system, climate change in the past, ice ages, proxy records, abrupt climate change, Instrumental record of climate, climate variability on various time-scales, simple models of climate, General Circulation Models, natural and anthropogenic climate change: detection and attribution, impacts and mitigation of climate change.

ASL718 Tropical Meteorology
3 credits (3-0-0)
Tropical Weather Systems: Wind systems and general circulation in the tropics. Distribution of temperature, moisture and radiation; precipitation and evaporation in the tropics. Convective systems, Intertropical convergence zone (ITCZ), trade wind inversion. Diurnal and local controls: diurnal variations of rainfall, wind, temperature and pressure. Scale analysis for the tropics. Theory and observation of the tropical waves, heat induced tropical circulations. Tropical Cyclones: Structure and Mechanism of the formation and movement, prediction of the track and intensity of tropical cyclones by objective techniques. Monsoon meteorology : summer and winter monsoon circulation features, onset, withdrawal and maintenance of monsoon, monsoon depression, Somali jet and tropical easterly jet; simulation of monsoon phenomena; energetics of monsoon circulation.

ASL720 Satellite Meteorology and Remote Sensing
3 credits (3-0-0)
Satellite Meteorology, satellite observing system; retrieval of clouds, winds, temperature, humidity, trace gases and aerosols, rain; Image interpretation and analysis with ERDAS, ocean colours, SST, scatterometer studies, energy budget, Microwave soundings from satellites. Remote sensing of oil slicks, vegetation, Radar equation, Doppler and other polarization techniques, measurement of precipitation, severe storm detection, cyclonic storm detection and track prediction, hail detection and prediction, Lidar, acoustic radar and its principles

ASL722 Biological Oceanography
3 credits (3-0-0)
Oceanic life and ecosystems, biological productivity of ocean, biological exploitation of ocean, uses and problems of ocean, theories of population in marine ecological communities, mathematical models, ecological fluxes, scale analysis, effects of marine pollution on living resources. Physico-biological models, estuarine biological modelling, coastal ecosystem modeling

ASL724 Atmospheric Diffusion and Air Pollution
3 Credits (3-0-0)
Various sources and types of pollutants in the atmospheric environment, Reynolds averaging,closure problem, atmospheric diffusion, types of boundary conditions for modelling dispersion. solution of diffusion equation for instantaneous and continuous sources; dispersion from ground and elevated sources; long and short range dispersion, removal mechanism; dry and wet deposition, chemical removal, atmospheric

surface boundary layer, similarity theory. Wind rose, dispersion parameters and plume rise. Gaussian and box models, optical stack height; case studies for the despersion of pollutants.

ASP751 Simulation Lab I: Weather Analysis and Forecasting
2 credits (0-0-4)
Note: This Course is not open to Undergraduate Students.
Programming languages, Unix & shell programming, data formats: ASCI, GRIB, NetCDF. Introduction to Fortran 95, programming in Fortran 95; Examples for converting and reading ASCI, GRIB, NetCDF data files; graphical display of meteorological fields. Visits to observation facilities of IMD: meteorological instruments workshop; radiosonde and radar installations; forecasting for aviation and air pollution, meteorological parameters, GTS, weather codes and decoding of weather observations; visits to IMD for map discussion participation; thermodynamic diagrams, tropical weather systems, tropical cyclones; synoptic features during different seasons, western disturbances, monsoon circulation and its climatology at surface, 850 hPa and 200 hPa; sea-level pressure distribution on the globe; ø and ÷ fields. Mass and wind field balance, synoptic forecasting from analysis of weather maps; satellite image interpretation, cloud classifications ERDAS software, Introduction to numerical methods used in weather prediction, quasi-geostrophic and balance models, omega equation.

ASP752 Simulation Lab II: Objective Analysis & Data Assimilation
3 credits (0-0-6)
Observed meteorological / oceanographic parameters and their interpretation; Numerical mathematics of weather prediction: space discretizations, Arakawa's staggered and non-staggered schemes, Arakawa Jacobians; time integration schemes. Objective analysis: interpolating polynomials and function fitting for a triangular, rectangular and polygonal geometry; preparation of initial conditions from observations using method of successive correction and spline interpolations; Initialization: mass and wind field balance, Rossby adjustment theory, introductory dynamic and normal-mode initialization; initial model grid data preparation and forecast / hindcast experiments with a limited area model. Variational data assimilation: variational methods, variational assimilation basics; Examples of 3D-/4D-VAR with shallow water model and its adjoint; Experience with meteorological / satellite data assimilation; Simple oceanographic data assimilation at mesoscale and assimilation of altimetry data and ARGO data.

ASP801 Simulation Lab III: Ocean-Atmosphere Forecast Methodology
3 credits (0-1-4)
Design of horizontal and time differencing schemes, discrete analogues of basic governing equations, discrete formulations of horizontal and vertical mixing; preparation of model initial and boundary conditions from meteorological analyses and climatological data; Limited-area modelling, short-range forecast experiments with limited area model; medium and long range weather prediction experiments with a GCM; experience with different convection schemes in thunderstorm/ cyclone modelling with a fine resolution hydrostatic/ non-hydrostatic model. Image analysis of simulated fields with ERDAS.

Data studies: Madden-Julian oscillation, El niño and Southern Oscillation, Gill's barotropic model, computation of heat-induced tropical circulations; ocean analysis from ARGO data; ocean circulation models, computation of air-sea fluxes using meteorological and oceanographic data.

ASL803 Advanced Ocean Dynamics
3 credits (3-0-0)
Western boundary intensification, barotropic currents, baroclinic transport over topography. Mesoscale eddies and variability. Indian Ocean dipole circulation, linear waves, wave spectra, wave propagation. Wave energy equation, breaking waves, reflection and dissipation, theory of tides, tidal currents. Tidal processes in embayment and estuaries, wind and buoyancy driven currents, Near-shore circulation, alongshore and rip currents, littoral drift, sediment transport, coastal ocean response to wind forcing, storm surges, coastal upwelling and fronts, Kelvin, Yanai, Rossby, inertia-gravity waves.

ASL804 Air Quality Monitoring and Health Risk Assessment
3 credits (2-0-2)
Short and long range transport and diffusion; Model Evaluation and Uncertainty analysis; Dispersion of toxic substances, Nomograms for safe distance estimation, Risk assessment techniques; Case studies, air pollution measurement techniques: High, low volume sampling, aerosol samplers, Ozone and CO analyzers, indoor air monitoring, Wind rose, air quality and associated health effects, Spirometer measurements, dose response relationships for health risk assessment.

ASL808 Atmospheric Chemistry and Aerosols
3 credits (3-0-0)
General characteristics of atmospheric composition, ozone layer, stratospheric and tropospheric chemistry; principles of chemical kinetics; gas-phase and aqueous-phase reactions in the atmosphere; chemistry and physics of the polluted atmospheres, photochemical reactions and smog; monitoring techniques, organic pollutants in the atmosphere; atmospheric aerosols, impact of aerosols and clouds on climate; Montreal and Kyoto protocols, major fire emissions, greenhouse effect, climate change and green chemistry.

ASL813 Climate Variability
3 credits (3-0-0)
Global distributions of temperature, precipitation, etc.; Koppen¼s classification of climates, climate variability as estimated from observations and paleoclimatic proxy data; natural (internal) and externally forced climate variability; modeling climate and its variability using simple energy balance climate models, atmospheric and oceanic general circulation models, and coupled ocean-atmosphere models. Global efforts in understanding and predicting climate change, Impacts of climate change.

ASL814 Modelling of Dynamic Processes of Oceans and Atmosphere
3 credits (3-0-0)
Overlap with: ASL850
Finite difference approximations, Discrete analogues of differential equations in meteorology, relaxation methods, advection equations, Time differencing schemes, stability analysis, shallow-water models and filtering, Integral invariants, enstrophy and energy conserving schemes, Matsuno, leap-frog schemes, geostrophic adjustment, spectral methods, semi-implicit formulation, Non-linear instability, vertical coordinates, vertical discretization, Limited area models, Ocean mixing and ocean wave modelling.

ASL815 Marine Pollution and Costal Zone Management
3 credits (3-0-0)
Hydrodynamics of coastal zone, wave dynamics, coastal engineering, offshore backwater system, alongshore and waste water transport, sediment suspensions, offshore ocean dumping, impact of coastal ocean on living resources, petrochemical exploitation, wave power extraction, tidal energy, offshore thermal energy conversion, impact of salt water intrusion, sea level rise and impact on coastal zone, management of estuaries, sustainable development of the coastal zone, health related problems of coastal zone.

ASL816 Advanced Dynamic Meteorology
3 credits (3-0-0)
Quasi-geostrophic analysis, circulation and vorticity theorems, Ertel-Rossby invariants, Ertel's PV conservation theorem, Thomson's and Bjerkness baroclinic circulation theorem, barotropic and baroclinic instabilities, symmetric instabilities; quasi-geostrophic motion in equatorial area, heat induced tropical circulations; Rossby waves, internal gravity waves, vertically propagating waves, Rossby adjustment theory; middle atmospheric dynamics, sudden stratospheric warming, QBO; general circulation of the atmosphere.

Turbulence in the atmosphere: ensemble-averaged equations, space-averaged equations, conservation equations for covariances, large-eddy simulations, atmospheric surface layer, convective boundary layer, stable atmospheric boundary, statistical representation of trubulence, quasi-geostrophic turbulence.

ASL817 Mesoscale Meteorology
3 credits (3-0-0)
Circulation systems related to orography, valley winds, energy budgets, cloudiness, precipitation, evaporation, fog, lightening, snow avalanches and valley air pollution; general properties of mountain perturbations, adiabatic mesoscale perturbations in a straight atmospheric flow, adiabatic synoptic scale perturbations, dissipation of mechanical energy, mountain drag, modelling aspects of mountain waves, mountain generated momentum fluxes, theory of linear gravity waves, orographic gravity-wave drag, its parameterization and influence in general circulation models.

ASL819 High Performance Computing in Atmospheric Science
3 credits (2-0-2)
Basic ideas on multitasking and massively parallel processing, different architectures, application of HPC in global and regional models, parallelism in weather and climate models, domain decomposition method, 1D, 2D and 3D parallelization of GCMs, MPI, PVM, SHMEM, message passing libraries, high performance compilers, load balancing, inter-processor communication, network communication, graphical user interface, data formats, local and wide area networking, data flow and data mining.

ASL830 General Meteorology
3 credits (3-0-0)
Overlap with: ASL703
Basic concepts, thermodynamics of dry and moist air, thermodynamic diagrams, hydrostatic equilibrium, hydrostatic stability and convection, clouds and precipitation; Physics of radiation: solar and terrestrial radiation, mean annual heat balance.

ASL831 Introduction to Micrometeorology
3 credits (3-0-0)
Overlap with: ASL705
Effects and sources of air pollutants, air quality standards; solar radiation, wind system, stability conditions, mixing height, heat Island effect, land-sea breeze, puffs and plumes; atmospheric surface boundary layer; momentum and heat exchanges with homogeneous surfaces; building wakes and other topographical effect; drag and heat transfer coefficients; sampling and standardization techniques, dispersion of air pollutants. Eddy diffusion models, Gaussian models; evaluation of dispersion parameters, optimal stack height by using Nomograms; short- and long-term dispersion models; dry and wet deposition, precipitation chemistry; Monin- Obukhov similarity theory; Statistical analysis of meteorological and air quality data; Modern automatic air sampling and monitoring techniques; site location criteria for meteorological instruments and tracer techniques for air pollution impact studies.

ASL832 An Advanced Course in Micrometeorology and Risk Assessment Techniques
3 credits (3-0-0)
Planetary boundary layer modelling, observed characteristics of the atmospheric boundary layer, upper air measurements, theoretical treatments of the diffusion of material, dispersion during calm winds, numerical models for dispersion of pollutants, complex terrain modelling, long range transport and diffusion; risk assessment techniques for accidental release of toxic and inflammable materials, hazard analysis, potential risk, conceivable release mechanisms and release rates, dense gas dispersion, merits and demerits of various models, nomograms for determination of safe storage quantities and safe distances, estimation of vulnerable zones, model evaluation and uncertainty.

ASL840 Dynamic Meteorology
3 credits (3-0-0)
Overlap with: ASL701
Fundamental forces, equations of motion in rotating and non rotating coordinate frames, scale analysis, basic conservation laws, spherical coordinates, thermodynamic equation, geostrophic approximation, hydrostatic balance, static stability, circulation and vorticity, conservation of potential vorticity; Rossby adjustment theory, atmospheric waves, quasi-geostrophic equations, omega equation, hydrodynamic instability, available potential energy.

ASL850 Numerical Modelling of the Atmospheric Processes
3 credits (3-0-0)
Overlap with: ASL814
Equations governing the atmospheric motion, equations in different coordinate systems, atmospheric waves, scale analysis, hierarchy of balanced models, primitive equation models, numerical solution of atmospheric model equations, finite difference and spectral methods, various time integration schemes, conservation properties, some examples of numerical solutions. Numerical weather predictions with limited area and global models. Cloud-radiation interaction, convective adjustment processes, cumulus convection and large scale atmospheric variables, land surface processes and surface fluxes, parameterization of physical processes, design of optimal parameterization schemes, interaction of sub-grid scale processes with environment.

ASL860 Synoptic Meteorology
3.5 credits (3-0-1)
Introduction, meteorological charts and diagrams, map projections, plotting of synoptic maps, synoptic cross sections, time sections. Theory and practice of scalar analysis: analysis of sea level pressure patterns; analysis of pressure tendency fields; surface temperature and dew point. Kinematic analysis: streamline analysis, isotach analysis, analysis of upper-level wind and temperature. Analysis of the vertical structure of the atmosphere: vertical time section. Survey of analysis in the tropics.

ASC 861 Atmospheric Science Colloquium
1 credit (0-1-0)
Students give weekly seminar on the topics in ocean and atmospheric sciences given by the teacher and also attend all seminars held in the Centre. The students present their understanding of the topic covered under the weekly seminars.

ASL870 Physical Oceanography
3 credits (3-0-0)
Ocean in perspective, early exploration and a brief history of physical oceanography; Physical and chemical properties of ocean water: composition of sea water, salinity, density, thermal expansion of sea water, viscosity, surface tension, heat conduction, adiabatic temperature changes, optical properties, osmotic pressure, electrical conductivity, suspended and dissolved substances. Temperature- salinity (T-S) relationship, formation of characteristics water masses; salinity and temperature of the surface layers. Circulation and stratification of the Ocean: General surface circulation, deep-water movement, and major ocean currents. Thermohaline circulation and 'core' analysis, temperature and density inversion in the ocean, the role of bottom topography in determining temperature and salinity distribution. Regional Oceanography: Criteria for a regional classification, regions of equatorial currents, regions of monsoon currents, Oceanography of Indian Ocean: Exploration, major current systems-Somali current, equatorial and monsoonal gyres, water masses and water types, climate, pressure field and wind systems, cloud cover and precipitation.

ASL871 Special Topics in Storm Surges
3 credits (3-0-0)
To be given by the interested faculty

ASV872 Special Module in Storm Surges
1 credit (1-0-0)
To be given by the interested faculty

ASL875 Special Topics in Air Pollution
3 credits (3-0-0)
To be given by the interested faculty

ASV876 Special Module in Air Pollution
1 credit (1-0-0)
To be given by the interested faculty

ASL877 Special Topics in marine and Water Pollution
3 credits (3-0-0)
To be given by the interested faculty.

ASV 878 Special Module in marine and Water pollution
1 credit (1-0-0)
To be given by the interested faculty

ASL879 Special Topics in Remote Sensing
3 credits (3-0-0)
To be given by the interested faculty

ASV880 Special Module in Remote Sensing
1 credit (1-0-0)
To be given by the interested faculty

ASL880 Dynamic Oceanography
3 credits (3-0-0)
Basic hydrodynamic equations of motion and continuity; mass transport and free surface equation; steady motion in the sea; unsteady motions and their solutions. Application of the transport equations; analytical modelling of the tropical ocean circulation; use of tracers in circulation studies; storm induced upwelling in the open ocean. One-dimensional models of the Upper Ocean and seasonal thermocline; numerical models of ocean tides; two and three dimensional models of ocean currents; models of equatorial currents; numerical models for computing currents from the observed density fields; numerical models of alongshore current; application of hydrodynamic numerical models of coastal upwelling. Numerical simulation of storm surges by stair-step model, shear coordinate model, coastal zone model, inland inundation model, multilevel coastal zone model, refined grid model and the river-ocean coupled model; tide-surge interaction model.

ASL881 Special Topics in Objective Analysis
3 credits (3-0-0)
To be given by the interested faculty

ASV882 Special Module in Objective Analysis
1 credit (1-0-0)
To be given by the interested faculty

ASL883 Special Topics in Clouds and Aerosols
3 credits (3-0-0)
To be given by the interested faculty

ASV 884 Special Module in Clouds and Aerosols
1 credit (1-0-0)
To be given by the interested faculty

ASL885 Special Topics in Lake Circulation Modelling
3 credits (3-0-0)
To be given by the interested faculty

ASV886 Special Module in Lake Circulation Modelling
1 credit (1-0-0)
To be given by the interested faculty

ASV887 Special Module in Numerical Weather Prediction
1 credit (1-0-0)

ASL888 Special Topics in Atmospheric Sciences
3 credits (3-0-0)
To be given by the interested faculty

ASL890 Special Topics in Geophysical Fluid Dynamics
3 credits (3-0-0)
Inviscid shallow water theory: small amplitude motion (linear wave theory). Plane waves in a layer of constant depth, Poincare and Kelvin waves; Rossby waves; quasigeostrophic scaling in shallow water theory; quasigeostrophic Rossby waves; Rossby waves in a zonal current, Resonant interaction and multiple scale analysis; a brief review of viscous flows; Quasigeostrophic motion of a stratified fluid on a sphere; geostrophic approximation and its limitations, Quasigeostrophic potential vorticity equation for the atmospheric synoptic scales, Rossby-wave normal modes- The vertical structure Equation; Instability theory: The linear stability problem: condition for instability, Baroclinic Instability, the basic mechanism, Eddy's model, Charney's model-critical layers; Instability in the two layer model -Barotropic Instability.

ASS 800 Independent Study
3 credits (0-3-0)
To be given by the interested faculty

ASD891 Major Project –I
6 credits (0-0-12)

ASD892 Major Project-II
12 credits (0-0-24)

Centre for Biomedical Engineering

BML330 Topics on Safety Principles for Engineers
4 credits (3-0-2)
Pre-requisites: EC 60
Value theory-Risk and Reliability-Decision theory. Injury and damage control. Epidemiology of accidents. Human tolerance to energy inputs. Biomedical/biomechanical aspects of long term exposure to hazardous environment. Socio-technical aspects of safety standards. Case studies of well known disasters.

BML700 Introduction to Basic Medical Sciences for Engineers
3 credits (3-0-0)
Anatomical and physiological study of different human systems. Cell and tissue organization and metabolism Cardiovascular System; hemodynamics, blood, conduction system in the heart.   Soft and hard tissues and joints endocrine and nervous system and their role in homeostasis; Respiratory physiology; kidneys and the urinary system.

BML710 Industrial Biomaterial Technology
3 credits (3-0-0)
Good Manufacturing practice regulations, biomedical materials, quality assurance and quality control Labeling, Device failure, synthetic and biopoloymers Bioerodible materials, Host reactions to biomaterials. Sterilization of Medical devices, Advances in Sterilization Technology of clean room, Polymeric materials for drug delivery systems, active and passive targeting, intelligent materials.

BML800 Research Techniques in Biomedical Engineering
3 credits (3-0-0)
Simulation and analysis of physiological systems by up to date computer techniques and development of physical models; Biomechanical analysis and network representation; State of art bioinstrumentation techniques; monitoring physiological parameters electrical, mechanical and chemical parameters of human body, Microminiaturization of electronics including MEMS; BIOMEMS technology; Biomedical signal processing and imaging modalities; Research planning and interpretation of biomedical data; Telemedicine; Robotics in Medicine.

BML810 Tissue Engineering
3 credits (2-0-2)
The course will cover importance and scope of tissue engineering, Introduction to biomaterials and scaffolds, Criteria of modifying biomaterials as tissue engineering scaffolds, Properties and types of scaffolds, Different methods employed in the synthesis of scaffolds, animal cell biology, stem cells, organization of cells into tissues, tissue microenvironment, tissue injury and wound healing. Basic immunology, response of body to foreign materials. Animal cell culture on scaffolds, consequences, optimization strategies and important considerations for Skin, Liver, Bone, Cartilage, Nerve and Vascular tissue engineering.

BML820 Biomaterials
3 credits (3-0-0)
Introduction to the use of implants. Structure and properties of materials used as implants : polymers, ceramics, metal and composites; biological response to implants, wound healing process, cellular response to foreign materials, criteria for selecting implants both for soft tissue and hard tissue, polymers used as vascular prosthesis, contact lens and reconstructive surgery materials.

BML830 Biosensor Technology
4 credits (3-0-2)
Measurements and instrumentation principles. Fundamentals of transducers and sensors, their sensitivity, specificity, linearity and transduction system analysis. Introduction to biosensors; transduction principles used in biosensors viz. electrical, optical, microchip sensors and Surface acoustic wave devices and transducers and related technology. Biotechnological components of the sensor based on enzymes, antigen-antibody reaction, biochemical detection of analytes, organelles, whole cell, receptors, DNA probe, pesticide detection, sensors for pollutant gases. Kinetics, stability and reusability of sensors. Selected examples and future developments.

BMV840 Emerging Biomedical Technology & Health Care
1 credit (1-0-0)
Importance of health related data collection and analysis, Epidemiological survey; brief them about various communicable & non-communicable diseases, path-physiological processes, environmental health and Life style diseases. Define the process of evolution of emerging technologies to solve the current health problems through an integrated approach of synergizing the discipline of medicine, engineering and management systems. Importance/ methodology of conducting clinical trials-human & animals.

BMV870 Vascular Bioengineering
1 credit (1-0-0)
Embryology and formation of vascular networking in fetus and adult human body, autonomic nervous system influences, peculiarities of micro and macro vasculatures, the physiological fluid dynamic principles involved, the molecular level changes occuring in normal and abnormal conditions like atheroclerosis, cancers, utero-placental system and various imaging modalities.

Centre for Energy Studies

ESL300 Self-organizing Dynamical System
3 credits (3-0-0)
Pre-requisites: EC 60
Dynamical systems dissipative and area preserving, Patterns in Hamiltonian dynamics invariants and symmetry, KAM theorem / coherent structures, complexity and pattern formation, Belousov- Zhabutinsky reaction, Landau-Ginzburg / mean-field models, Caling fractals, Cellular automata, Wavelet transforms, Phase transitions and order parameter, Criticality the border of order and chaos, Entropy and direction of time, Negentropic systems, Self-organized criticality, lattice models, Examples: Electrical circuits, Management systems, Astrophysical systems, Plasma and magnetic surface systems, Biological systems, Non-linear systems.

ESL330 Energy, Ecology and Environment
4 credits (3-1-0)
Pre-requisites: EC 60
Concepts of ecosystems and environment, Characteristics and types of ecosystems, Autecology and synecology, Energy flow in ecosystems, Feedback loops, Trophic webs, Eco-technology and Eco-development, Energy-environment interaction, Impact of energy sources (coal, oil, natural gas, solar, wind, biomass, hydro, geothermal, tidal, wave, ocean thermal and nuclear) on environment, local regional and global implications, Approaches to mitigate environmental emissions from energy sector, Global initiatives Kyoto Protocol, Clean development mechanism case studies.

ESL340 Non-Conventional Source of Energy
4 credits (3-0-2)
Pre-requisites: EC 60
Global & National energy scenarios, Forms & characteristics of renewable energy sources, Solar radiation, Flat plate collectors, Solar concentrators, Thermal Applications of solar energy, Photovoltaics technology and applications, Energy storage, Energy from biomass, Thermochemical, Biochemical conversion to fuels, biogas and its applications, Wind characteristics, Resource assessment, Horizontal & vertical axis wind turbines, Electricity generation and water pumping, Micro/Mini hydropower systems, Water pumping and conversion to electricity, Hydraulic ram pump, Ocean Thermal Energy Conversion (OTEC), Geothermal, Tidal and Wave energies, Material aspects of Renewable energy technologies and systems.

ESL350 Energy Conservation and Management
3 credits (3-0-0)
Pre-requisites: EC 60
Thermodynamic basis of energy conservation, Irreversible processes, Reversibility and Availability, Exergy and available energy, Energy conservation in HVAC systems and thermal power plants, Solar systems, Second law efficiency and LAW, Energy conservation in buildings, U-Value of walls / roof, Ventilation systems - Fan and ducts Lighting Systems - Different light sources and luminous efficacy, Insulation use – Materials properties, Optimum thickness, Thermo economic analysis, Energy conservation in electrical devices and systems, Economic evaluation of energy conservation measures, Electric motors and transformers, Inverters and UPS, Voltages stabilizers, Energy audit and Instrumentation.

ESL360 Direct Energy Conversion Methods
4 credits (3-1-0)
Pre-requisites: EC 60
Energy classification, Sources and utilization, Principle of energy conversion, Indirect / direct energy conversion, Basic principles of design and operations of (i) Thermoelectric (ii) Thermionic convertors (iii) Photovoltaic energy systems (iv) Fuel cells (v) Plasma diodes (vi) Magneto hydrodynamic Power generators and (vii) Advanced energy conversion systems.

ESP700 Energy Laboratories
3 credits (0-0-6)

ESN704 Basic Thermal Engineering
0 credit (1-0-0)
First and second law of thermodynamics, Thermal fluid systems, Standard cycles, Mixtures of gases, Heat transfer, Fluid mechanics, Practical examples, Use of steam tables.

ESL710 Energy, Ecology and Environment
3 credits (3-0-0)
Interrelationship between energy, ecology and environment, Sun as a source of energy, nature of its radiation, Biological processes, Photosynthesis, Autecology and synecology, Population, Community, Ecosystems (wetland, terrestrial, marine), Food chains, Ecosystem theories, Sources of energy, Classification of energy sources, Environmental issues related to harnessing of fossil fuels (coal, oil, natural gas, geothermal, tidal, nuclear energy, solar, wind, hydropower, biomass, Energy flow and nutrient cycling in ecosystems, Environmental degradation, Primary and secondary pollutants. Thermal/ radioactive pollution, Air & water pollution, Micro climatic effects of pollution, Pollution from stationary and mobile sources, Biological effects of radiation, Heat and radioactivity disposal, Acid rain, Global warming and green house gases, Ozone layer depletion.

ESL711 Fuel Technology
3 credits (3-0-0)
Solid, liquid and gaseous fuels, Coal as a source of energy and chemicals in India, Coal preparation, Carbonization, Gasification and liquefaction of coal and lignite, Principle of combustion, Petroleum and its derived products, Testing of liquid fuels, Petroleum refining processes, Inter-conversion of fuels, Natural gases and its derivatives, sources, potential, Gas hydrates, Combustion appliances for solid, liquid and gaseous fuels, Introduction to nuclear fuel, RDF, Bio-fuels, etc.

ESN712 Basic Electrical Engineering
0 credit (1-0-0)
Power circuits and electrical machinery, AC circuit analysis, Three phase circuits, Power circuits components and energy conservation devices, Variable speed drives, Demand controls.

ESP713 Energy Laboratories
3 credits (0-0-6)

ESL714 Power Plant Engineering
3 credits (3-0-0)
Types of thermal power stations, Steam power stations based on fossil fuels, Economy and thermal scheme of the steam power stations, Thermal power plant equipment, boilers (coal based, RDF based), super heaters, super critical steam generator, economizers, feed water heater, condensers, combustion chamber and gas loop, turbines, cooling towers, etc. Gas turbine power stations, Combined cycle power plants, Internal combustion engine plant for peak load standby and start up, Elements of hydropower generation and wind turbine, Elements of nuclear power plants, nuclear reactors and fuels, Recent advances in power plants, (IGCC, super critical power plant, etc.), Case studies, Introduction to solar power generation, Sterling engine, Decentralized power technologies.

ESL718 Power Generation, Transmission and Distribution
3 credits (3-0-0)
Generation: Synchronous generator operation, Power angle characteristics and the infinite bus concept, Dynamic analysis and modeling of synchronous machines, Excitation systems, Prime-mover governing systems, Automatic generation control, Auxiliaries, Power system stabilizer, Artificial intelligent controls, Power quality of AC Transmission: Overhead and cables, Transmission line equations, Regulation and transmission line losses, Reactive power compensation, Flexible AC transmission, HVDC Transmission: HVDC converters, Advantages and economic considerations converter control characteristics, Analysis of HVDC link performance, Multi terminal DC system, HVDC and FACTS, Distribution: Distribution systems, Conductors size, Kelvin's law performance calculations and analysis, Distribution inside and commercial buildings entrance terminology, Substation and feeder circuit design considerations, Distributions automation, Futuristic power generation.

ESL720 Energy Conservation
3 credits (3-0-0)
Introduction, Thermodynamics of energy conservation, Energy and exergy concepts, Irreversibility and second law analysis and efficiency of thermal systems such as mixing, throttling, drying and solar thermal

systems, Thermal power plant cycles, Refrigeration and air conditioning cycle, Thermal insulation in energy conservation, Energy conservation through controls, Electric energy conservation in building heating and lighting, Energy Efficient Motors, Tariffs and power factor improvement in Electrical systems, Energy conservation in domestic appliances, transport, Energy auditing, Energy savings in boilers and Furnaces, Energy Conservation Act, Energy conservation in small scale domestic appliances and agriculture.

ESL722 Integrated Energy Systems
3 credits (3-0-0)
Pattern of fuel consumption: agricultural, domestic, industrial and community needs, Projection of energy demands, Substitution of conventional sources by alternative sources and more efficient modern technologies, Potential, availability as well as capacity of solar, wind, biogas, natural gas, forest produce, tidal, geothermal, mini-hydro and other modern applications, Hybrid and integrated energy systems, Total energy concept and waste heat utilization, Energy modeling to optimize different systems.

ESN725 Energy Audit
0 credit (1-0-0)
Energy audit concepts, Basic elements and measurements, Mass and energy balances, Scope of energy auditing industries, Evaluation of energy conserving opportunities and environmental management, Preparation and presentation of energy audit reports, Some case study and potential energy savings.

ESL730 Direct Energy Conversion
3 credits (3-0-0)
Basic science of energy conversion, Indirect verses direct conversion, Physics of semiconductor junctions for photovoltaic and photo-electrochemical conversion of solar energy, Fabrication and evaluation of various solar cells, Applications of solar cells in photovoltaic power generation systems, Technology and physics of thermo-electric generations, Thermal-electric materials and optimization studies, Basic concepts and design considerations of MHD generators, Cycle analysis of MHD systems, Thermionic power conversion and plasma diodes, Thermodynamics and performance of fuel cells and their applications.

ESL732 Bioconversion and Processing of Waste
3 credits (3-0-0)
Biomass and solid wastes, Broad classification, Production of biomass, photosynthesis, Separation of components of solid wastes and processing techniques, Agro and forestry residues utilisation through conversion routes: biological, chemical and thermo chemical, Bioconversion into biogas, mechanism, Composting technique, Bioconversion of substrates into alcohols, Bioconversion into hydrogen, Thermo chemical conversion of biomass, conversion to solid, liquid and gaseous fuels, pyrolysis, gasification, combustion, Chemical conversion processes, hydrolysis and hydrogenation, Solvent extraction of hydrocarbons, Fuel combustion into electricity, case studies.

ESL734 Nuclear Energy
3 credits (3-0-0)
Introduction: Scope of nuclear energy (fission and fusion energy), typical reactions.

Basics Concepts: Binding Energy of a nuclear reaction, mass energy equivalence and conservation laws, nuclear stability and radioactive decay, radioactivity calculations.

Interaction of Neutrons with Matter: Compound nucleus formation, elastic and inelastic scattering, cross sections, energy loss in scattering collisions, polyenergetic neutrons, critical energy of fission, fission cross sections, fission products, fission neutrons, energy released in fission, γ -ray interaction with matter and energy deposition, fission fragments.

The Fission Reactor: The fission chain reaction, reactor fuels, conversion and breeding, the nuclear power resources, nuclear power plant & its components, power reactors and current status.

Reactor Theory: Neutron flux, Fick's law, continuity equation, diffusion equation, boundary conditions, solutions of the DE, group diffusion method, Neutron moderation (two group calculation), one group reactor equation and the slab reactor.

Health Hazards: radiation protection & shielding.

Nuclear Fusion: Fusion reactions, reaction cross-sections, reaction rates, fusion power density, radiation losses, ideal fusion ignition, Ideal plasma confinement & Lawson criterion.

Plasma Concepts: Saha equation, Coulomb scattering, radiation from plasma, transport phenomena.

Plasma Confinement Schemes: Magnetic and inertial confinement, current status.

ESL735 Hazardous Waste Management
3 credits (3-0-0)
Sources and classification of hazardous wastes, Assessment of exposure potential: Transport processes, Overview of waste management problems, Guidelines for handling hazardous wastes, Energy from organic wastes, Chemical waste treatment processes, Physical waste treatment processes, Biological waste treatment processes, Thermal waste treatment processes, Waste elimination option, Domestic hazardous waste, Hazardous waste management options, Toxic metallic waste, Biomedical waste, Remediation of hazardous waste contaminated soils, Engineering issues in waste remediation, case studies.

ESL736 Power from Renewables & Environmental Impacts
3 credits (3-0-0)
Environmental impacts of fossil fuel based power generation, Renewable electricity and key elements, Hydropower and its constraints, Wind energy: technology and economics, Resources, systems and regional strategies, Solar thermal power, Photovoltaic technology, Biomass power, tidal power, OTEC, Global climate change, CO_2 reduction potential of renewable energy, Social considerations, standalone systems and grid integration.

ESL737 Plasma Based Materials Processing
3 Credits (3-0-0)
Pre-requisites: Nil
Introduction: Plasma based processing of materials

Plasma Concepts: Plasma fluid equations, single particle motions, unmagnetized plasma dynamics, diffusion and resistivity, the DC sheath and probe diagnostics

Basics of Plasma Chemistry: Chemical reactions and equilibrium, chemical kinetics, particle and energy balance in discharges

Low Pressure Plasma Discharges: DC discharges, RF discharges-Capacitively and inductively coupled, microwave, ECR and helicon discharges

Low pressure Materials Processing Applications: Etching for VLSI, film deposition, surface modification and other applications (plasma nitriding, plasma ion implantation, biomedical and tribological applications)

High Pressure Plasmas: High pressure non-equilibrium plasmas, thermal plasmas - the plasma arc, the plasma as a heat source, the plasma as chemical catalyst

Applications of High Pressure Plasmas: Air pollution control, plasma pyrolysis and waste removal, plasma based metallurgy – oro enrichment, applications in ceramics, plasma assisted recycling.

ESL738 Power System Planning & Operation
3 credits (3-0-0)
Generation system capacity adequacy planning: Probabilistic models of generating unit outage performance and system load-evaluation of loss of load and loss of energy indices, Probabilistic production costing, Inclusion of power generation from renewable energy sources in the reliability analysis, Interconnected systems: multi-area reliability analysis, power pool operation and power/energy exchange contracts, Quantification of economic and reliability benefits by pool operation, Demand / energy forecasting: sector-wise peak demand and energy forecasting by trend and econometric projection methods, Optimal power system expansion planning: formulation of least cost optimization

problem incorporating the capital, operating and maintenance costs of candidate plants of different types (thermal, hydro, nuclear, non conventional etc.) and minimum assured reliability constraint-optimization techniques for solution by linear and dynamic programming approaches-case studies.

ESL740 Non-Conventional Sources of Energy
3 credits (3-0-0)

Types of non-conventional sources, Solar energy principles and applications, efficiency of solar thermal and PV systems, Biomass: generation, characterization, use as energy source, Biogas: aerobic and anaerobic bio-conversion processes, microbial reactions, purification, properties of biogas (composition and calorific value), Storage and enrichment, Tidal and wind energy: wind energy potential and conversion efficiency, Mini / micro hydro power: classification of hydropower schemes, classification of water turbine, Turbine theory, Jet velocity and nozzle size in pelton wheel turbine, Essential components of hydroelectric system, system efficiency, grass root innovation energy technology, Fusion: Basic concepts, fusion reaction physics, Thermonuclear fusion reaction criteria, Confinement schemes, Inertial confinement fusion, Magnetic confinement fusion, Target gain requirements, Current status, Geothermal: Introduction, structure of the earth, Geothermal regions, Geothermal systems/fields, dry rock and hot aquifer analysis, Geothermal energy conversion technologies, OTEC.

ESL742 Economics & Financing of Renewable Energy Systems
3 credits (3-0-0)

Overview of renewable energy technologies, Relevance of economic and financial viability evaluation of renewable energy technologies, Basics of engineering economics, Financial feasibility evaluation of renewable energy technologies, Social cost – benefit analysis of renewable energy technologies, Technology dissemination models, Volume and learning effects on costs of renewable energy systems, Dynamics of fuel substitution by renewable energy systems and quantification of benefits, Fiscal, Financial and other incentives for promotion of renewable energy systems and their effect on financial and economic viability, Financing of renewable energy systems, Carbon finance potential of renewable energy technologies and associated provisions, Software for financial evaluation of renewable energy systems, Case studies on financial and economic feasibility evaluation of renewable energy devices and systems.

ESL745 Environmental Audit & Impact Assessment
3 credits (3-0-0)

Pollution sources and classification, air, water, soil and noise sampling and monitoring, Instrumentation, Environmental audit-detailed procedure, National environmental policy, Methodology of environmental impact studies, Methods of impact identification, Environmental setting, Production and assessment of impacts on the air environment, Prediction and assessment of impacts on surface water, soil and ground water environment, Socioeconomic environment, Evaluation alternatives, Public participation in environmental decision making.

ESL746 Hydrogen Energy
3 Credits (3-0-0)
Pre-requisites: Nil
Introduction of Hydrogen Energy Systems

Hydrogen pathways introduction – current uses, General introduction to infrastructure requirement for hydrogen production, storage, dispensing and utilization, and Hydrogen production power plants

Hydrogen Production Processes

Thermal – Steam Reformation – Thermo chemical Water Splitting – Gasification – Pyrolysis, Nuclear thermo catalytic and partial oxidation methods.

Electrochemical – Electrolysis – Photo electro chemical. Biological – Photo

Biological - Anaerobic - Digestion – Fermentative Micro- organisms

Hydrogen Storage - Physical and chemical properties – General storage methods, compressed storage – Composite cylinders – Glass micro sphere storage – Zeolites, Metal hydride storage, chemical hydride storage and cryogenic storage.

Hydrogen Utililzation-Overview of Hydrogen utilization: I.C. Engines, gas turbines, hydrogen burners, power plant, refineries, domestic and marine applications. Hydrogen fuel quality, performance, COV, emission and combustion characteristics of Spark Ignition engines for hydrogen, back firing, knocking, volumetric efficiency, hydrogen manifold and direct injection, fumigation, NOx controlling techniques, dual fuel engine, durability studies, field trials, emissions and climate change

ESL750 Economics & Planning of Energy System
3 credits (3-0-0)

Relevance of financial and economic feasibility, Evaluation of energy technologies and systems, Basics of engineering economics, Financial evaluation of energy technologies, Social cost benefit analysis, Case studies on techno-economics of energy conservation and renewable energy technologies, Energy demand analysis and forecasting, Energy supply assessment and evaluation, Energy demand – supply balancing, Energy models, Software for energy planning, Energy – economy interaction, Energy investment planning and project formulation. Energy pricing, Policy and planning implications of energy – environment interaction, clean development mechanism, technology transfer and its financing, carbon credits and trading opportunities, Financing of energy systems, Energy policy related acts and regulations.

ESL755 Solar Photovoltaic Devices and Systems
3 Credits (3-0-0)
Pre- requisites: Direct Energy Conversion/ Solar Energy Utilization Electronics: Semiconductor device physics
Photovoltic materials, Materials in bulk and thin film forms, The role of microstructure (single crystal, multicrystalline, polycrystalline, amorphous and nanocrystalline) in electrical and optical properties of the materials, Need for different cell design, The technology route for making solar cells, Different methods of characterization of materials and devices, Applications of Photovoltaic for power generation from few watts to megawatts. Concentrating Solar Power generation using photoelectron chemical systems

ESL756 Energy Policy & Planning
3 credits (3-0-0)

Energy (and power) policies in the country, Tariffs and subsidies, Energy utility interface, Private sector participation in power generation, State role and fiscal policy, Energy and development, National energy plan, Role of modeling in energy policy analysis, Energy data base, Energy balances, Flow diagrams, Reference energy system, Energy demand analysis, Trend analysis, Econometric models, Elasticities approach, Input-output models, Simulation/process models, Energy supply analysis, Costs of exploration and economics of utilization of depletable and renewable resources, Scarcity rent, International energy supply, Energy demand supply balancing, Energy -economy interaction, Energy investment planning, Energy environment interaction, Energy Pricing.

ESL760 Heat Transfer
3 credits (3-0-0)

General heat conduction equation with heat generation, Analysis of extended surfaces, transient (and periodic) heat conduction, Two dimensional heat conduction problems and solutions, Theory of convective heat transfer, Boundary layer theory, Heat transfer in duct flows laminar and turbulent, Boiling, condensation and heat exchangers, Laws of thermal radiation, Radiation heat transfer between black and grey bodies, Numerical solutions of radiation network analysis, Thermal circuit analysis and correlations for various heat transfer coefficients, Overall heat transfer.

ESL764 Environmental Economics
3 credits (3-0-0)

Economic development and the environment, Relevance of environmental economics, Economic efficiency and markets, The economics of environmental quality, Frameworks for environmental cost and benefit analysis: criteria for evaluating environmental, Command

and control strategies, Incentive based strategies - emission taxes and subsidies, Transferable discharge permits, Environmental policies, International environmental agreements.

ESL766 Environmental Regulation
3 credits (3-0-0)
Environmental legislation and strategies to control pollution, Standards and setting criterion, Role of national and international agencies in dealing with environmental aspects, Standards developed by ministry of environment and forest, Sampling and analysis techniques, Data interpretations and relationships for the design of treatment facilities, Regulations for pollution controls of water, air industrial, automobile, Noise and hazardous waste environmental audit, Public liability insurance, Environmental management systems, Catalytic converts in vehicles in metropolitans, EURO standards, Bharat standards.

ESL768 Wind and Small Hydro Energy Systems
3 credits (3-0-0)
Introduction, General theories of wind machines, Basic laws and concepts of aerodynamics, Micro-siting, Description and performance of the horizontal–axis wind machines, Blade design, Description and performance of the vertical–axis wind machines, The generation of electricity by wind machines, case studies, Overview of micro mini and small hydro, Site selection and civil works, Penstocks and turbines, Speed and voltage regulation, Investment issues, load management and tariff collection, Distribution and marketing issues, case studies, Wind and hydro based stand-alone / hybrid power systems, Control of hybrid power systems, Wind diesel hybrid systems.

ESL770 Solar Energy Utilization
3 credits (3-0-0)
Solar radiation and modeling, solar collectors and types: flat plate, concentrating solar collectors, advanced collectors and solar concentrators, Selective coatings, Solar water heating, Solar cooking, Solar drying, Solar distillation and solar refrigeration, Active and passive heating and cooling of buildings, Solar thermal power generation, Solar cells, Home lighting systems, Solar lanterns, Solar PV pumps, Solar energy storage options, Industrial process heat systems, Solar thermal power generation and sterling engine, Solar economics.

ESL771 Instrumentation & Control in Energy Systems
3 credits (3-0-0)
Basic measurement concepts, Measurement errors, Transducer classification, Static and dynamic characteristics of transducers, Instruments for measuring temperature, pressure, velocity and flow, heat flux, liquid level and concentration in energy systems, characterization of combustors, Flue gas analysers, Exhaust gas analysers, Solar energy measurement requirements and instruments, Meteorological data measurements, Energy auditing instruments, Energy audit kit, humidity measurement, characterization of electrical power systems, Instruments for monitoring electrical parameters, Analysis of power system measurements. Analog signal conditioning, A/D and D/A converters, Digital data processing and display, Computer data processing and control, Feed back control system, Stability and transient analysis of control systems, Application of PID controllers, General purpose control devices and controller design, Air pollution sampling and measurement of particulates, SOx, NOx, CO, O3, hydrocarbons.

ESL774 Quantitative Methods for Energy Management and Planning
3 credits (3-0-0)
A review of probability concepts, Forecasting and decision making in view of multi-variant techniques, Linear programming, Graphical solution, Simplex method, Duality and post-optimality analysis, Integer programming, Optimal technology mix in micro and macro level energy planning exercises, Sequencing, Quening theory, Networks, PERT and CPM, Decision theory, Markov analysis, Non linear programming, Decision making with uncertainty decision making with multiple objectives, Deterministic and probabilistic dynamic programming, Regression analysis.

ESL776 Industrial Energy and Environment Analysis
3 credits (3-0-0)
Energy and the environment, The greenhouse effect, Global energy and environmental management, Energy management and conservation, Energy in manufacture, Energy technologies, Instrumentation measurement and control, Energy management

information systems, Hazardous waste management, Contamination of ground water, Treatment & disposal, Pollution from combustion and atmospheric pollution control methods.

ESL777 Environmental Science and Engineering
3 credits (3-0-0)
Environmental Pollution Sources and their impact on environment, Air, Pollution, The green house effect, Radiative forcing, due to green house gases, aerosols and land use changes, Global warming potential, the Carbon Cycle, Changes in Atmospheric Ozone, International Treaties, Kyoto protocol, Montrelo protocol, Particulate Control Equipment (ESP), Performance Analysis, Risk assessment Analysis, Ozone depletion in the strato sphere and troposphere.

ESL778 Industrial Waste Management and Recycling
3 credits (3-0-0)
Solid waste management – Treatment and disposal sanitary landfills, Leachate collection and gases emissions estimation, Resource recovery and recycle of materials, Waste management in different industries-steel, Aluminium, Chemical, Paper, Distilleries, Energy from the waste, waste water treatment techniques, Agricultural Pollution, Application of air pollution control in Industries

ESL784 Cogeneration and Energy Efficiency
3 credits (3-0-0)
The concept of cogeneration, main design parameters for cogeneration, cogeneration alternatives, Bottoming and topping cycles, Steam turbine plants, Gas turbine plant, Diesel and gas engine plants, Thermodynamic evaluation, Combined cycle applications, Sterling engine, Industry / utility cogeneration, Trigeneration, Techno economic and Environmental aspects, Cogeneration in sugar, textile, paper and steel industry, Case studies.

ESL785 Energy Analysis
3 credits (3-0-0)
Energy theory of value: Principles and systems of energy flows, Methods of energy analysis, Energy intensity method, Process analysis input-output method based energy accounting, Energy cost of goods and services energy to produce fuels: Coal, Oil, Natural Gas, Energy to produce electricity, Energy cost of various modes of passenger & freight transportation, Industrial energy analysis: Aluminium, Steel, Cement, Fertilizers, Energetics of materials recycling, Energetics of renewable energy utilization (case studies), General energy equation, Energy loss, Reversibility & irreversibility, Pictorial representation of energy, Energy analysis of simple processes, Expansion, Compression, Mixing and separation, Heat transfer, Combustion, Energy analysis of thermal and chemical plants, Thermo economic applications of energy analysis and national energy balance.

ESL788 Industrial and Commercial Applications of Renewable Energy Sources
3 credits (3-0-0)
Commercial and industrial energy demand; Qualitative and quantitative features and characteristics, Renewables & electricity for a growing economy, Water heating, process heating and drying applications, Solar, Biomass and geothermal energy based systems, Combined space and building service hot water systems, Electricity generation from renewable to meet commercial and industrial power requirement, Stand alone and grid connected systems, Ethanol and methanol from cellulosic biomass, Use of renewable in commercial and industrial buildings for load leveling, lighting and space heating and cooling, Economics of renewable energy based commercial and industrial installations case studies, Thermal low and medium energy requirements of different industries.

ESN791 Applied Mathematics and Computational Methods
0 credit (1-0-0)
Fourier and laplace transform, Complex and vector analysis, Matrices, Numerical and computational methods, Finite difference, Numerical methods of integration, Least square curve fitting, Introduction to C++ and METLAB.

ESL792 Advanced Energy Systems
3 credits (3-0-0)
Latest topics on energy, Integrated Gasification combined cycle (IGCC), Fuels for power generation, Advanced energy storage systems, Hydrogen power, Clean coal technologies, Pressurized fluidised bed

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combustion, Natural gas cycles, Integrated generation, Fuel cells, Energy conservation in power plant, Battery vehicles, Electric vehicles, Algal bio fuels, Metal hydrates, Geological CO_2 sequestering.

ESN794 Principles of Chemical Processes and Combustion
0 credit (1-0-0)
Process development and chemical manufacture in industries, Major unit operations and unit processes in chemical industries, Petrochemical industries, Food, Paint, Fertilizer, Drugs, Paper and pulp industries, Coal based chemicals and combustion.

ESL795 Project Evaluation and Management
3 credits (3-0-0)
Life cycle approach and analysis, conception, definition, planning, feasibility and analysis, Environmental impact analysis, Project planning matrix, Aim oriented Project planning, Network analysis for project management-PERT, CPM and CERT, Fuzzy logic analysis, Stochastic based formulations, Project design, Evaluation and management techniques, Funds planning, Project material management, Evaluation & analysis, Implementation & monitoring, Performance indices, Case studies, Supply chain management, Customer relation management.

ESL796 Operation and Control of Electrical Energy Systems
3 credits (3-0-0)
Introduction, Power plant operation and control, Heretical operation of the grid system, Power system, operation aspects: classification, Time decomposition, Network level decomposition, Mode decomposition, User oriented decomposition, Analysis decomposition, Control flow decomposition, Energy management: energy control centre functions, Power system control centre: hardware and software structure, Dispatcher's activities, Power system and dispatch raining simulator, Energy management systems, Expert systems, Optimal operation of electrical power systems: modelling of fuel costs, equal incremental cost loading, transmission line losses, optimal operation of hydro thermal and all thermal systems. Energy conservation, Demand reduction options: industrial, illumination and electric traction, Cogeneration, Computer based flexible load balancing systems, Economic analysis tariffs, Power quality-voltage fluctuations and harmonics: Voltage fluctuations, Equipment design to withstand voltage fluctuations harmonics, Effect of harmonic currents and voltage, Harmonic standards, UPS selection, Installation operation and maintenance, Voltage and reactive power calculations and control: Voltage classes and nomenclature, voltage drop calculations, Voltage control, VAR requirements and power factor Capacitors unit and bank rating, Protection of capacitors and switching Controls for switched capacitors and fields testing.

ESL804 Pollution Control in Power Plants
3 credits (3-0-0)
Coal and Nuclear based Power Plants – Fly Ash generation and environment impact, Fly ash utilization and disposal, Nuclear fuel cycle, Radioactive wastes – treatment and disposal, Pollution control methods (i) Pre-combustion controls, (ii) Combustion controls Low NOx burners, fluidized bed boilers, (iii) Post Combustion Controls, Particulate controls, Cyclone, Wet scrubbers, ESP and fabric filters, Gaseous pollutants controls flue gas desulfurization (FGD) systems, CSR reduction applications of electron beam and non thermal plasmas for SOx and NOx treatments, Thermal pollution and its impact on aquatic life.

ESL810 MHD Power Generation
3 credits (3-0-0)
Principle of MHD power generation, Properties of working fluids, MHD equation and types of MHD duct, Losses in MHD generators, Diagnostics of parameters, MHD cycles, MHD components (air heater, combustion chamber, heat exchanger, diffuser, insulating materials and electrode walls, magnetic field etc.) Economics and applications of MHD, Liquid metal MHD generators.

ESL840 Solar Architecture
3 credits (3-0-0)
Thermal comfort, sun motion, Building orientation and design, passive heating and cooling concepts, thumb rules, heat transfer in buildings: thermal modeling of passive concepts, evaporative cooling, Energy efficient windows and day lighting, Earth air tunnel and heat exchanger, zero energy building concept and rating systems, Energy conservation building codes, Softwares for building simulation, Automation and energy management of buildings.

ESL850 Solar Refrigeration and Airconditioning
3 credits (3-0-0)
Potential and scope of solar cooling, Types of solar cooling systems, Solar collectors and storage systems for solar refrigeration and air-conditioning, Solar operation of vapour absorption and vapour compression refrigeration cycles and their thermodynamic assessment, Rankine cycle, sterling cycle based solar cooling systems, Jet ejector solar cooling systems, Fuel assisted solar cooling systems, Solar desiccant cooling systems, Open cycle absorption / desorption solar cooling alternatives, Advanced solar cooling systems, Thermal modeling and computer simulation for continuous and intermittent solar refrigeration and air-conditioning systems, Refrigerant storage for solar absorption cooling systems, Solar thermoelectric refrigeration and air-conditioning, Solar thermo acoustic cooling and hybrid air-conditioning, Solar economics of cooling systems.

ESL860 Electrical Power System Analysis
3 credits (3-0-0)
Network modeling and short circuit analysis: Primitive network, Y bus an Z bus matrices formulation, Power invariant transformations, Mutually coupled branches Z bus, Fault calculations using Z bus, Power flow solutions: AC load flow formulations, Gauss-siedel method, Newton Raphson method, Decoupled power flow method, Security analysis: Z bus methods in contingency analysis, Adding and removing multiple lines, Interconnected systems, Single contingency and multiple contingencies, Analysis by DC model, System reduction for contingency studies, State Estimation: Lone power flow state estimator, Method of least squares, Statistics error and estimates, Test for bad data, Monitoring the power system, Determination of variance, Improving state estimates by adding measurements, Hierarchical state estimation, Dynamic state estimation, Power system stability: transient and dynamic stability, Swing equation, Electric power relations, Concepts in transient stability, Method for stability assessment, Improving system stability.

ESL870 Fusion Energy
3 credits (3-0-0)
Fission and fusion, Need for plasma, Lawson criterion, Confinement problem, Laser driven fusion, Magnetic confinement, Plasma concept, Single particle motions in complex magnetic field geometries, Equilibrium and stability, Cross field transport, Important heating schemes, Tokamak and magnetic mirror, Reactor concepts, Current status.

ESL871 Advanced Fusion Energy
3 credits (3-0-0)
Tokamak confinement Physics, Particle Motions in a Tokamak, Torroidal equilibrium toroidal Stability, High-beta Tokamak, Experimental observations, Fusion Technology, Commercial Tokamak Fusion - power plant, Tandem - mirror fusion power plant, other Fusion reactors concepts, Inertial confinement fusion reactors, Reactor cavity, Hybrid fusion / fission systems, Process heat and synthetic fuel production.

ESL875 Alternative Fuels for Transportation
3 credits (3-0-0)
An introduction to hydrocarbon fuels–their availability and effect on environment, Gasoline and diesel self ignition characteristics of the fuel, Octane number, Cetane number, Alternative fuels - liquid and gaseous fuels, Physico-chemical characteristics, Alternative liquid fuels, Alcohol fuels - ethanol & methanol, Fuel composition, Fuel induction techniques, Fumigation, Emission of oxygenates, Applications to engines and automotive conversions, Biodiesel formulation techniques, Trans esterification, Application in diesel engines, DME (Dimethyl ether), properties fuel injection consideration general introduction to LPG and LNG, Compressed natural gas components, mixtures and kits, fuel supply system and emission studies and control, Hydrogen combustion characteristics, Flashback control techniques, Safety aspects and system development, NOx emission control, Biogas, Producer gas and their characteristics system development for engine application.

Centre for Rural Development and Technology

RDL340 Technology and Community Development
4 credits (3-1-0)
Pre-requisites: EL 60
Concepts of appropriateness of technology to community, based on region specific factors. Technology assessment: Techno economic evaluation, energy audit, short and long term impacts of technology on environment and society. Basic needs and technology alternatives for sustainable development. Technology choices in agriculture (modern system, organic farming, permaculture, natural farming, equipments, implements and devices, water management); energy (renewable resources, biomass production, conversion and utilization, social forestry); housing (low cost materials, designs and habitats); health care (traditional practices, water and sanitation); rural industries (based on traditional and emerging technologies). Issues of Technology transfer.

RDL700 Biomass Production
3 credits (3-0-0)
Introduction to biomass and biomass classification.

Phytobiomass : Primary production-photosynthesis, measurement of productivity and statistical analysis of data. Plant's nutrient cycles. Plant improvements-Tissue culture and other vegetative methods, seed technology and nursery raising. Biofertilizers., bioinoculants and biopesticides-Organic manures., nitrogen fixers, phosphorus solubilizers and organic matter decomposers, allelopathy, interactions among micro and macroflora and biological equilibrium. Plantations and cropping pattern agroforestry models, plantations crops, tuber crops, petro crops, forage crops and grasses. Soil and water conservation in farm, grassland and forest management.Aquatic Phytobiomass-Floating plants, submerged plants and potential aquatic algal biomass.Animal biomass : Cow, buffalo, goats, sheep and pigs. Fisheries and bee keeping.

RDL710 Rural India and Planning for Development
3 credits (3-0-0)
Historical and Geographical Aspects : Ancient and present structure of villages characteristics of rural life, zonal and regional peculiarities, social and religious stratifications.

Social Aspects : Influence of religion/tradition/superstitions, psycho-social and cultural background and practices, barriers, life patterns including community living, status of women, migration. General Aspects: Health education, nutrition, sanitation, housing, indebtedness, and bonded labour. Economic Aspects : General economic conditions, disparity, unemploy-ment and wage pattern. Changes in techniques of production and requirements of storage, transportation and marketing facilities, private and public finance, rural banks. Postal and other services. Political Aspects : Village Panchayats and links of rural society with state's organisations; functions and role of various organisations. Planning for Rural Development : Historical perspective. Gandhian ideas and their impact; planning in independent India and emphasis on integrated rural development and attempts at rural reconstruction. Shift in development policies. Role of S&T voluntary, government and other agencies in rural development.

RDL720 Rural Industrial Planning and Management
3 credits (3-0-0)
Basic Concepts in Rural Financing : Techniques of collecting, processing and reporting information for financial decision-making, aiding rural growth, subsidised versus self-growth incentives, subsidies, investment patterns, risk and uncertainty versus welfare, structure of capital and financing of projects, funds/cash flow, role of cooperatives, banks, insurance companies and macro planning techniques, methodology of project preparation and evaluation including market studies and shadow pricing, costing and pricing policies supporting organisational structures.

RDL730 Technology Alternatives for Rural Development
3 credits (3-0-0)
Concept of technologies appropriate for Rural India. Social, economic and environmental considerations. Appropriate technology for energy, agriculture, housing, textiles, water-supply and sanitation, health care, transport and small-scale industries. An integrated approach to the use of alternate technologies. Issues of technology transfer.

RDL740 Technology for Utilization of Wastelands and Weeds
3 credits (3-0-0)
Land as a parameter in rural development. Wastelands and importance of using them. Biomass growth on various types of lands. Introduction to plant taxonomy, under-utilized terrestrial plants and aquatic weeds, flora of tropics, arid lands and hilly areas. Constituents of biomass, biochemical and chemical conversion processes.

Applications of biomass as unconventional plant-based source for food, cattlefeed, chemicals, fibres, construction materials and energy. An integrated technological approach to biomass and wasteland utilization. Possible ecological effects.

RDD750 Minor Project: Intensive Study on Topics of Specific Interest
3 credits (0-0-6)
Project work related to any topics of inteest within the specified time frame.

RDP750 Biomass Laboratory
3 credits (0-0-6)
Soil and Water analysis for Biomass Production : Soil Sampling from a plot/field and soil analysis for its texture, pH. EC. C.N.P and K. Water analysis : TDS, Alkalinity, Total Hardness, EC and pH.

Soil Microflora and Root Association : Isolation and culturing of nitrogen fixers (Rhizobium. Azotobacter, Azospirillum and blue green algae). ecto and endomycorrhizal fungi. Measurement of total microbial biomass in soil and respiration rate of microbes. Bacterial and fungal root infection.

Biomass Production and Recycling : Micropropagation and other vegetative techniques for biomass production. Seed treatment. seed germination and nursery raising. Vermiculturing and Vermicomposting, mushroom culturing and spawn production, silkworm rearing. Bioinoculants for rapid composting.

Compost Analysis : C.N.P.K. cellulose, hemicellulose, lignin, humus and its fractions. Physico-chemicial properties of biomass.

Industrial Tribology, Machine Dynamics and Maintenance Engineering Centre

ITL702 Diagnostic Maintenance and Monitoring
4 credits (3-0-2)

Introduction to Condition Based Maintenance (CBM), Application and economic benefits, Signature analysis - online and off-line techniques, Various Condition Monitoring (CM) techniques - Vibration monitoring and analysis, Shock Pulse Method, Noise monitoring, Envelope detection technique, Oil analysis including wear debris and contaminant monitoring, Performance monitoring, Acoustic emission and other techniques, Non-destructive techniques, Application and choice of the method, Computer aided monitoring including expert systems. Practical applications of diagnostic maintenance, Condition monitoring of mechanical and electrical machines, Case studies.

ITL703 Fundamentals of Tribology
4 credits (3-0-2)

Introduction to tribology and its historical background. Factors influencing Tribological phenomena. Engineering surfaces - Surface characterization, Computation of surface parameters. Surface measurement techniques. Apparent and real area of contact. Contact of engineering surfaces- Hertzian and non-hertzian contact. Contact pressure and deformation in non-conformal contacts. Genesis of friction, friction in contacting rough surfaces, sliding and rolling friction, Various laws and theory of friction. Stick-slip friction behaviour, frictional heating and temperature rise. Friction measurement techniques. Wear and wear types. Mechanisms of wear - Adhesive, abrasive, corrosive, erosion, fatigue, fretting, etc., Wear of metals and non-metals. Wear models - asperity contact, constant and variable wear rate, geometrical influence in wear models, wear damage. Wear in various mechanical components, wear controlling techniques. Introduction to lubrication. Lubrication regimes. Introduction to micro and nano tribology.

ITL705 Materials for Tribological Applications
3 credits (3-0-0)

Introduction to tribological processes and tribological relevant properties of materials. An overview of engineering materials having potential for tribological application.

Characterization and evaluation of Ferrous materials for tribological requirements/applications, Selection of ferrous materials for rolling element bearings, gears, crank shafts, piston rings, cylinder liners, etc. Non-ferrous materials and their applications such as sliding bearings, piston rings, cylinder liners, etc., materials for dry friction materials.

Composite materials (PM, CMC and MMC) for tribological applications.

Surface treatment techniques with applications such as carburising, nitriding, induction hardening, hard facing, laser surface treatments, etc.

Surface coating techniques such as electrochemical depositions, anodizing, thermal spraying, Chemical Vapour Deposition (CVD), Physical Vapour Deposition (PVD), etc. and their applications.

Lubricants- Introduction, requirements, types, Evaluation and testing of lubricants.

ITL709 Maintenance Planning and Control
3 credits (3-0-0)

Objectives of planned maintenance, Maintenance philosophies, Preventive and Predictive maintenance, Emerging trends in maintenance-Proactive Maintenance, Reliability Centred Maintenance (RCM), Total Productive Maintenance (TPM), etc, Implementation of Maintenance strategy, Maintenance organization, Basis of planned maintenance system, Maintenance planning and scheduling, Maintenance control system and documentation. Spares and inventory planning, Manpower planning, maintenance auditing. Human factors in maintenance and training, maintenance costing, Maintenance performance. Repair decisions- Repair, replacement and overhaul, Computer applications in maintenance, Expert systems applications, maintenance effectiveness, Case studies.

ITL710 Design of Tribological Elements
4 credits (3-0-2)

Introduction-Tribological consideration in design, Conceptual design, Classification of tribological components, Mechanisms of tribological failures in machines, Zero wear concept, Computational techniques in design.

Design of Dry Frictional Elements-Dry friction concepts, Brakes and Clutches, Friction belts and Dry rubbing bearing.

Design of Fluid Frictional Elements- Fluid friction concepts, Design of hydrodynamically loaded journal bearings, externally pressurized bearings, Oscillating journal bearings, Externally pressurized bearings, Design of oil groove, Design of elliptical, multilobe and titled pad bearings, Rolling elements bearings, Performance analysis of bearings, gears, seals, piston rings, machine tool slide ways, cams and follower and wire rope.

Design exercises using TK-Solver, Finite Elements analysis software.

ITL711 Reliability, Availability and Maintainability Engineering
3 credits (3-0-0)

System concepts in RAM Engineering, Fundamentals of reliability, Failure distributions, Statistical analysis of failure data, Weibull analysis, Monte Carlo simulation, System reliability assessment. Reliability of repairable and non-repairable systems. Point, mission and steady state availability. Availability assessment. Maintainability and its assessment. Design for reliability and maintainability', Practical applications of RAM Engineering to systems, products and processes.

ITL714 Failure Analysis and Repair
4 credits (3-0-2)

Introduction, need for failure analysis, Classification of failures, Fundamental causes of failures, influence of type of loading (e.g. static, fatigue, shock, etc.) on nature of failures, Role of stress; processing and fabrication defects, Effect of residual stresses induced during fabrication processes, Influence of temperature and environment on failure, Crack and subsurface crack like defects and their significance in failure.

Micro mechanisms of failures; Ductile and brittle fracture, Fracture initiation and propagation, Fatigue failures, Wear related failures, High temperature failures, low temperature failures, etc., Studies and analysis of failed surfaces.

Identification of failures, Techniques of failure analysis, Microscopic methods, Fracture mechanics techniques, Prediction of failures, Residual life assessment and life extension, Typical case studies in failure analysis, Logical fault finding and its application, Inspection and safety measures, Repair techniques and economic considerations, Failure analysis for design improvement and proactive maintenance, Design for repairbility, Case Studies.

ITL716 Computer Application in Maintenance Management
3 credits (2-0-2)

Role of computer in maintenance management. Maintenance overview. Basics of software engineering. System analysis and design. Fundamentals of programming with specific emphasis of object oriented paradigms. Study of various available software and their implementation for maintenance. System analysis of various maintenance strategies, activities / modules and their implementation. Evaluation and optimum selection of computerised maintenance management system(CMMS), Knowledge based approach to maintenance management. Neural network for CMMS, Software consideration for design of CMMS, Maintenance through internet based technology. Case studies.

ITL717 Corrosion and its Control
3 credits (3-0-0)

Importance of corrosion control in industrial practices. Thermodynamics of corrosion.

Broad forms of corrosion - uniform, uneven, pitting, cracking, etc. Influencing factors on corrosion. Surface film. Polarisation and effects. Theory of passivity. Kinetics of corrosion.

Various types of corrosion along with case studies - Galvanic, Thermo-galavanic, High temperature corrosion. Intergranular, Pitting, Selective attack (leaching). Fretting corrosion-erosion, Cavitation, Stress corrosion cracking. Hydrogen embrittlement.

Corrosion fatigue and Corrosive wear.

Application of Non Destructive Techniques (NDT) for corrosion evaluation and monitoring.

Corrosion Control- Design improvement. Selection of material, fabrication processes for corrosion control. Role of residual stresses. Changes in operating conditions. Use of inhibitors. Anodic and cathodic protection. Corrosion resistant coatings. Case studies.

ITL730 Lubricants
3 credits (2-0-2)
Overview of friction, wear and lubrication, Primary role of lubricants in mitigation of friction and wear & heat transfer medium, Composition and properties of lubricant, Fundamentals - Mineral oil based liquid lubricants, Synthetic liquid lubricants, Solid lubricants, greases and smart lubricants, Characteristics of lubricants and greases, Rheology of lubricants, Lubricants for industrial machinery - I.C. Engines, turbines, Hydraulic control systems, Lubricants for tribological components - sliding and rolling bearings, gearing, wire ropes and chains, etc., Metal working lubricants, Maintenance and conservation of lubricating oils, Storage and Handling of lubricants, Used lubricating oil -Environment and health hazards, and Disposability and Recycling, Technical regulation for lubricants - Test specifications, and standards for maintenance management of industrial lubricants including greases and used oils, Selection of optimum lubricant for given application.

ITL740 Risk Analysis and Safety
3 credits (2-1-0)
Introduction, Typical Hazards, Tools for hazard identification and analysis in plants and machinery, Accident indices, Check lists, Preliminary Hazard Analysis (PHA), Failure mode and effects analysis (FMEA) and Failure mode, effects and criticality analysis (FMECA), Hazard and operability studies (HAZOP), Fire and explosion hazards, Dow's fire and explosion index, Hazard analysis-Fault tree analysis (FTA), Event tree analysis (ETA), Cause consequence analysis (CCA), Mathematical models for cause consequence analysis, Risk evaluation and acceptance criteria, Human factors in safety, safety management, Disaster management plan, Safety aspects of lubricants, Safety codes, Case studies.

ITL752 Bulk Materials Handling
3 credits (2-0-2)
Nature of bulk materials, Flow of gas-solids in pipelines, Mechanical Handling equipments like screw conveyors and belt conveyors, Pneumatic conveying systems- Components, Design and Selection, Troubleshooting and Maintenance of pneumatic conveying systems, Performance evaluation of alternative systems, Bend erosion-influencing factors, materials selection and potential solutions, Case studies, and Design exercises.

ITL760 Noise Monitoring and Control
3 credits (2-0-2)
Introduction to noise, Properties of noise, Loudness and weighting networks, Octave and FFT analysis, Impulsive noise, Instrumentation for noise measurement and analysis, Sound power, Sound intensity technique, Noise source location, Noise diagnostics, Noise monitoring of machines with examples, Cepstrum analysis, Noise control methods, Maintenance and noise reduction, Vehicle and Machinery noise, Noise standards, Case studies.

ITL770 Design for Maintenance
3 credits (2-0-2)
Introduction; Overview of maintenance, Systems approach for maintenance, Modular design, Assembly and disassembly consideration for maintainability design, Accessibility of critical components, Optimisation of maintenance efforts, Evaluation, comparison and optimum selection of maintenance systems, Design for condition monitoring, Design of plant and machinery for a given maintenance strategy, Design for environment friendly maintenance Standardisation and interchangeability, Life cycle costing for optimum design and selection, Maintenance Logistics (facilities and resources), Human and safety factors, Design for maintenance through internet based technology (on-site and off-site), Developing reliable maintenance system, Design for simplicity and ease of maintenance, Design complexity versus mainenance complexity for enhanced availability, Built in diagnostics for fault detection, Fail safe design, Case studies.

JIS800 Independent Study
3 credits (0-3-0)
This is meant only for such students who are selected for DAAD fellowship.

JID801 Major Project-Part I
6 credits (0-0-12)
The students will select a research topic for the major project. It is expected that such topics would involve understanding of basic processes and expensive experimentation.

JID802 Major Project-Part II
12 credits (0-0-24)
The research topic selected in Part I shall continue in part II also.

ITL810 Bearing Lubrication
3 credits (2-0-2)
Pre-requisite : ITL703
Introduction-Historical background, Bearing concepts and typical applications. Viscous flow concepts-Conservation of laws and its derivations: continuity, momentum (N-S equations) and energy, Solutions of Navier-Strokes equations. Order of magnitude analysis, General Reynolds equation-2D and 3D (Cartesian and Cylindrical), Various mechanisms of pressure development in an oil film, Performance parameters.

Boundary Layer Concepts-Laminar and turbulent flow in bearings, mathematical modeling of flow in high-speed bearings. Elastic Deformation of bearing surfaces-Contact of smooth and rough solid surfaces, elasticity equation, Stress distribution and local deformation in mating surfaces due to loadings, methods to avoid singularity effects, Estimation of elastic deformation by numerical methods-Finite Difference Method (FDM), Governing equation for evaluation of film thickness in Elasto Hydrodynamic Lubrication (EHL) and its solution, Boundary conditions. Development of computer programs for mathematical modeling of flow in bearings, Numerical simulation of elastic deformation in bearing surfaces by FDM.

Instrument Design and Development Centre

DIC701 Seminars
1 credit (0-0-2)
Objective : To develop self study of social cultural aspects/ implications in design.

The students will be required to present a well researched seminar on a design subject chosen in consultation with the faculty.

DIC702 Product in Usage and Beyond (Seminar)
1 credit (0-0-2)
Objective : To become aware of man-made environment and to observe, analyse and formulate trends and possibilities.

The student will be required to survey a product and present a seminar on the same highlighting its development, usage and future trends.

IDP703 Instrument Technology Laboratory I
3 credits (0-0-6)
The laboratory essentially supports the courses taught in the first semester courses. It consists of experiments on:-

Study of packaging and characterisation of transducers used for measurement of different physical variables like displacement, temperature, pressure, strain, flow etc; Study of practical signal conditioning techniques and electronic measurement methods; Study of Electronic subsystems used in instruments.

Study of optical and fibre-optics components, optical coatings, simple optical systems; Measurement of refractive index of solids (glass) and liquids, measurement of focal length of lenses and optical systems, Measurement of flatness, estimation of peak errors by optical methods, measurement of angles, prisms, parallel plates, radius of curvature, Vacuum deposition of thin films, experiments with optical fibres.

The structure of experiments is designed to impart design level familiarity with various subsystems of instrumentation set up.

IDP704 Instrument Technology Laboratory II
3 credits (0-0-6)
The laboratory supports the subjects taught in the second semester courses. The laboratory consists experiments on:

Study of various techniques used for analog and digital conditioning of signals from various transducers/detectors; Study on modulation/demodulation techniques, noise generation and measurement, Study of testing and calibration methods of instruments. Microprocessor/Microcontroller based system design with emphasis on real world interfacing. Study of optical instruments, interferometers and laser based instruments. Interferometers and laser based instruments; Experiments on optical techniques; Experiments with Fizeau Interferometer, Fitness/curvature/surface quality, Experiments with optical fibres, Measurement of vibrations using optical methods, Digital speckle pattern interferometry/Talbot interferometry/Moire interferometry, grating based linear transducers, Laser speckel method for displacement measurement. Experiments on precision measurement methods and metrology. The structure of experiments has been designed to impart design level familiarity with various subsystems of instrumentation set up. The subsystems may consist of a detector-transducer, signal conditioner, a level power amplifier, display, actuator/final control element. The study will generally focus attention on one of the above subsystems.

IDP705 Advanced Instrument Technology Lab
4 credits (0-0-8)

DIL711 Framework of Design
4 credits (2-0-4)
Objective : To develop insight into design in space, time, and evolution of products. Products as mimics of biological and physical functions/situations.

Epistemology and techno-cultural evolution. Materials, structures, machines, controls and systems paradigm for Cascadian growth. A global survey of products identifying design trends with cultural ethos, new discoveries, new materials, processes, instrumentation. History of art and design movements. Social symbols and traditional art forms. Cultural determinants of design forms. A survey of successful products and product innovating companies. Product lifecycle. Product constraints engineering, economic, production, marketing, consumer, maintenance, usage, disposal, environmental. Designers' role in delineating/conceptualizing a specific product scenario of quality and potentiality. Integrated product development. The shape of the future.

Creativity : Criterion of connectivity, originality, institution, openness and self actualization. Visual thinking : Analogies, metaphors, lateral thinking, brain storming, synectics imagery, role playing etc.

IDL711 Instrumentation Transducers
3 credits (3-0-0)
Transducer Fundamentals : Transducer terminology, principals, design and performance characteristics, criteria for transducer selection, smart sensor, Resistive transducer; Inductive transducers; capacitive transducers; piezoelectric transducer; semiconductor and other sensing structures. Displacement transducers; tachometers and velocity transducers; accelerometers and gyros; strain guages; force and torque transducers; flowmeters and level sensors; pressure transducers; sound and ultrasonic transducer. Phototubes and photodiodes; photovoltaic and photoconductive cells, photoemission, photoelectromagnetic, detectors pressure actuated photoelectric detectors, design and operation of optical detectors, detector characteristics. Transducer Performance : Electrical tests, measurement unit, measurement of voltage, current, frequency, impedance, noise, loading errors, resolution and threshold tests. Calibration, dynamic tests, environmental test, life test. Application of transducers: displacement, velocity, acceleration, force, stress, strain, pressure and temperature measurement. angular and linear encoders, Radar, laser and sonar distance measurement, Tachometers, Viscometer and densitometers.

IDL712 Electronic Techniques for Signal Conditioning and Interfacing
3 credits (3-0-0)
Analog and digital representation of data; comparisons and relative merits; multiplexing and demultiplexing of analog and digital data, ADC/DAC. Microcontroller and DSP applications. Analog signal conditioning, Ultra-precision conditioning, Gain; attenuation; input and output impedances; single ended and differential signals; CMRR; system-module interfacing consideration; measurement and characterisation of electronic system modules. Analog and digital data transmission; modulation & demodulation; Data transmission; channel noise and noise immunity factors. Data busses; GPIB and other standards in parallel data transmission. Opto-electronic interfacing techniques. Application of CPU's in signal and data handling; response linearisation and drift compensation; data logger, computer aided measurement and control.

Analog and digital System Co-housing: EMI effects and EMC measures; circuit card placement; shielding and grounding techniques; ground loop management; isolation and interference filtering. EMI hardening and EMC interfacing.

IDL713 Advanced Electronic Components and Circuits
3 credits (3-0-0)
Review of Electronic Components: Passive Components, Active Components including components used in Industrial Environment. Electronic Circuits: Choppers, Clampers, analog circuits, precision and instrumentation amplifiers, signal conditioning circuits, industrial electronic circuits. Nonlinear devices and circuits, computing circuits and waveform generators. Analog-Digital circuits: A/D and D/A converters, classification and characteristic parameters of DAC's and ADC's, Testing criteria, Multiplying DAC's. Digital Electronics: Logic gates, Combinational logic design, Sequential logic design, Counters, Memory Devices, SRAM, DRAM, ROM, EPROM, Flash Memories and Programmable Gate Arrays. Microprocessors: 8 bit and 16 bit microprocessor, basic structure and programming. Application of microprocessors in instruments, Introduction to micro-controllers and embedded systems. Introduction to DSP Chips and their application in Instruments.

IDL714 Instrument Design and Simulations

3 credits (3-0-0)

Review of circuit analysis and design. Review of signals and systems in time and frequency domain: Fourier and Laplace Transforms, response plots. Dynamic properties of instrument systems: Review of instrument control systems, on-off, proportional and PID controllers. Stability considerations, gain and phase margin. Use of pulse and harmonic test signals for performance evaluation. Linear modeling of instrument systems. Models for basic instrument building blocks. Simulation studies of circuits, instrument modules, transducers and control schemes using expert software: Numerical techniques for linearisation. The theory will be supplemented with design and simulation laboratory sessions covering the above topics.

IDL716 Quality Control & Standardisation

3 credits (3-0-0)

Measurement standards, errors of measurement, classification of errors, statistical analysis of errors. Regression and correlation. Analysis of various methods of measurement/testing. Minimisation of errors. Design considerations and instrument reliability. Calibration and testing standards. Environmental testing of instruments.

DIP721 Exploratory Product Design Methods

3 credits (1-0-4)

Objective : To develop courage to think and design creatively. Understanding of factors that directly or indirectly influence the product definition and its context. Groups assignment on assessing relevance of available products in the futuristic context. Methods of exploring design situations : Developing questionnaires for interviewing users and investigating user behaviour. Data logging and data reduction techniques. Searching for visual inconsistencies. Selecting scales of measurement, ranking and weighting, checklist, specification writing. Methods of exploring problem structure : Relationship of product in the environmental context. Classification of design information. Alexander's method of determining components. Interaction matrix and net. Analysis of interconnected decision areas. System transformation. Functional innovation by boundary shifting. Evaluation of critical decision areas through boundary searching and experimentation.

IDL721 Materials and Mechanical Design

4 credits (3-0-2)

Basics of Design: Stresses, strain, hardness, toughness, visco-elasticity, torision, bending, deflection of beams, combined stresses, energy methods. Material: metals and their alloys, heat treatment, polymers, composites, ceramics etc. Design of machine elements: Failure theories for static and alternating loadings. Design of shafts, fasteners, springs, curved beams, thick and thin vessels, gears etc; Lubrication, journal bearings and rolling contact bearings, limits, fits and tolerances. Deflection of thin plates. Design of mechanical elements for strain gage and other instrumentation applications. Intro-duction to vibrations and its isolation. Mechanical Fabrication techniques used in instruments. Practical sessions on basic mechanical fabrication processes. Design and drawing sessions.

IDL722 Precision Measurement Systems

3 credits (3-0-0)

Measurements and errors; internal and external estimates of errors; least square method and its applications, to deviation from true line, plane and circle. Surface roughness and length measurements, study of some precision measuring systems, such as, profile projector, tool makers microscope, talysurf, talyond, floating micrometer, optical and mechanical comparator, interferometers, etc. Fundamentals of precision engineering; basic design principles for precision systems; basic fabrication principles for precision systems.

IDL724 Advanced Fabrication and Finishing

3 credits (3-0-0)

Manufacturing techniques for instrument components : Injection and compression moulding of plastics, mould design considerations, common defects in moulded parts and remedies. Vacuum forming practices,

former design and manufacture, applications. Fibre moulding techniques, selection and use of raw material. Pressure die casting of non-ferrous instrument parts, die design considerations. Press working of sheet metal components, behaviour of common engineering material under press working, die design considerations. Newer methods of manufacturing like EDM, ECM, laser machining and photo fabrication techniques for fine and intricate components. NC machining for precision fabrication. Finishing Processes : Heat treatment like annealing, hardening, tempering and stress relieving. Vaccum deposition, electro-deposition, hard facing and electroplating and anodizing of surfaces, surface preparation and control of parameters. Metallizing and decorative finishing, applications. Painting techniques, like electrostatic painting, powder coating.

IDL730 Photochemical Machining

3 credits (2-0-2)

Introduction: What is PCM, Design and manufacture of Photo-tools, Microphoto-graphy, Photo-resist technology, Selection and preparation of metallic materials, Isotropic etching-various etch parameters and their measurements, Etching to dimensional specifications, Quantitative Examination of Photo-fabricated profiles, 2D-and 3D machining with case studies. Inspection & Quality control, Engineering, benefits, Limitations and difficulties with PCM, Electro-photo-etching and Photo-forming. Technical considerations and economic implication.

DIL731 Applied Ergonomics

13.5 credits (2-0-3)

Objective : To develop awareness, acquire information, and experience human factors in design. Datalogging, data collection, data reduction and data analysis techniques. Gross human anatomy, anthropometry, biomechanics, muscle strength and exertion potential of different limbs, work capacity, environmental effects. Exercises for evaluation of postural forms and work spaces. Environmental conditions including temperature, illumination, noise and vibration. Perception and information processing, design of displays, hand controls, typography and readability, layout and composition. Exercises in evaluation of human response to product interface. Product safety and products liability. Student seminar on critical ergonomical study of an existing product/ service. Exercise in form design for ergonomic optimality.

IDL731 Optical Components and Basic Instruments

3 credits (3-0-0)

Generation of light: Thermal, non-thermal and semiconductor light sources. Measurement of light; photometry, colorimetry and instrumentation, Properties and propagation of light; The Ray Optics, Wave Optics, and Electromagnetic Optics; Basics of interference, diffraction and polarization of light. Optical Components: Reflecting components, plane, spherical, paraboloidal, phase conjugated, dielectric multilayer and digital micro mirrors, AR-coatings, total internal reflection. Refracting components; Converging, diverging and combination of lenses, Design analysis and image formation by lenses, and micro-lenses, Eyepices: Huygens, Ramsden, and special eyepieces; Prisms; Diffracting components; diffraction by single/multiple/openings, types of gratings and fabrication techniques, gratings produced by acousto-optics, and electro-optics, and diffractive optical elements. Polarizing components; Polarization by reflection, and double refraction, birefringence crystals, and polarization based liquid-crystal optical devices. Wavefront aberrations; Monochromatic (Seidel), and chromatic aberrations, optical and modulation transfer function. Optical instruments: Microscopes; simple, compound phase contrast and confocal microscopes. Telescopes; Refracting, reflecting, interferometric telescopes. Interferometers; two- beam, multiple-beam, and shearing interferometers, Spectrum measuring instruments; Spectrometers/ monochromators, Spectrophometers, and Spectro-radiometers, and Fourier transform spectrometers (FTIR-spectrometers), Detectors: Photodetectors, photo-multiplier tubes, multi-channel plates, image intensifiers, CCD and CMOS detectors, IR-detectors.

IDL732 Optical Materials and Techniques

3 credits (3-0-0)

Optical measurements: Photometry, Primary Standard, sub-standards and working standards, measurement of radiant intensity and flux.

Application of these measurements to optical systems, Eye and Vision, Optical materials for UV, visible and IR regions. Photosensitive materials for photography, photolithography and photo fabrication. Optical fibres as optical components. Multimode and single mode fibres. Fibre coupling techniques. Introduction to fibre based sensors, imaging systems and communication links. Illuminating systems. Detection of optical radiation, noise in optical detection systems. Design considerations of opto-mechanical and opto-electronic systems, including encoders and choppers, with case studies.

IDL734 Laser Based Instrumentation
3 credits (3-0-0)
Basics of lasers; The photon and it's properties, radiation and matter interaction; Generation and properties of laser light; laser systems and instrumentation (gas, liquid, solid state, semiconductor, and Ion laser systems); laser beam optics; The Gaussian, Hermite-Gaussian, Laguerre-Gaussian and Bessel beams and their propertiesHolographic techniques; Basic holographic principle, Types of Holograms, Recording media, and applications of holography. Laser Applications, Holographic Interferometry; Double exposure, Time averaged, Real time H.I., Laser speckle techniques; speckle photography/interferometry, and digital speckle pattern interferometry and applications of laser speckles, Lengths, displacement and shape measurement; laser-heterodyne, two-wavelength or multiplewavelength and phase-shifting interferometry, Velocity measurement; Laser Doppler and particle image velocimetry, Laser remote sensing: Different types of LIDARs (Light Detection And Ranging), and Applications; Laser alignment, gaging inspection and Laser machine vision, Industrial laser systems and instrumentation, beam delivery systems; and applications laser material processing, Laser Applications to Chemical and Environmental Analysis; Laser-induced fluorescence, Temperature measurement techniques; Laser based point-by-point, full field, holographic interferometry, and laser speckle techniques. Laser Tweezers: Single-dual-and multiple-beam tweezers, and applications.

IDL735 Scientific and Engineering Applications of Moire Patterns
3 credits (2-0-2)
Pre-requisites: EPL115/ EPL443/ PHL558/ EC90
General introduction, theory of Moire fringes, pure rotation, pure elongation, vernier mechanism of fringes. Linear and angular displacement transducers. Use of Moire technique in strain analysis, vibrations, deflections, refractometry, surface roughness. Experimental techniques and fringe photography. Technology to generate moire grids for various applications. High resolution moire. photography and its application for deformation studies in small, medium and large size structures and in thermal strains.

IDL736 Optical 3d-Surface Profilometry and Tomography
3 credits (3-0-0)
Pre-requisites: EPL105 or PHL558 and EC90
Introduction to optical micro/nano-metrology for industrial and biological applications. Basics of optical interferometry, grating and fringe projection profilometry. Digital interferogram analysis techniques: Phase-shifting and Fourier-transform fringe analysis techniques, their principles and algorithms.

Measuring optical microscopes: principles and instrumentation of confocal, interferometric, differential interference contrast, two and multi-photon, and total internal reflection microscopy. Principles of ellipsometry and it's applications.

Optical coherence based 3D-surface profilometry: Coherence scanning, low coherence and white-light profilometry. Optical time, frequency and coherence-domain reflectometry. Optical frequency-comb metrology.

Optical coherence tomography: technology imaging concepts, instruments and applications. Time, polarization, Doppler, frequency, and spectral-domian OCT and applications.

Principles, imaging concepts, and instruments of near-field scanning optical microscopy, atomic-force microscopy, photonic-force microscopy, scanning election microscopy, & optical tweezers microscope. Surface Plasmon resonance microscopy. Basics of nanoscopy.

IDL737 Inforamtion Display Devices and Technologies
3 credits (3-0-0)
Pre-requisites: EC 90 and EPL105
Human vision, Basics of luminescence, fluorescence, and phosphorescence. Display materials and their characterizations. Emissive displays: Review of cathode ray tube (CRT) displays. Plasma display devices and technologies, field-emissive, electro and photo-chromic displays. Inorganic, organic and polymeric LED based display devices: Device physics, materials, fabrication processes, structures, and drive circuits. Electro-optical characterization of LEDs. LED based passive and active displays and TFTs. Display electronics, and LED display manufacturing technologies. Applications of LED in display technologies. Non-emissive displays: basics of liquid-crystal materials, their properties and characterization. Liquid-crystal display devices and technologies.

Transmissive, reflective, active and passive matrix, thin-film transistor (TFT), transreflective, and back lighting technologies for LCDs.

Electronic-ink, electronic paper, and flexible display technologies and applications.

Display electronics and digital light processing technologies. Three-dimensional (3-D) imaging and display technologies: Microdisplays, STEREOSCOPIC 3D displays. HOLOGRAPHIC 3-D displays. Laser based 3D-TV.

DIP741 Product Form and Aesthetics
3 credits (1-0-4)
Objective : To develop awareness of form, its experiencing and creation. Spatial analysis, spatial organization, depth illusion. Spatial composition in 2D & 3D space. 2D form transitions and radii manipulation. Exercises in graphic composition and layout. Grids in page layouts and compositions. 3D form analysis, linear form, planar form, solid form, linear planar form, linear solid form, planar solid form, linear planar solid form. Boolean algebra of forms. Form in nature, form expressing function/material/production process. hands as tool, hands as form maker with or without constraints, three dimensional concept formation. Non-orientable forms, form and colour to accentuate and ameliorate perception and understanding of that form. Product styling and relationship to cultural personalities. Attitudes and attributes of the visual designer.

IDL741 Instrument Organisation and Ergonomics
3 credits (2-0-2)
Management of Technology. Need analysis and product specification. Solution search, product planning and system break up. Subsystem interaction. Environmental factors for successful operation. Classification of tasks of instruments; activity analysis in terms of man-machine tasks; identification of constraints on instrument design arising out of scientific, technical, production, environmental and maintenance considerations. Design of configuration/options; design of controls, displays and graphics. Aesthetics of colour and form. Value Engineering. Design of manuals, job-aids and training aids.

DIP742 Studies in Product Configuration and Detailing
3.5 credits (1-0-5)
Objective : To develop creative conceptualization capabilities in form and structural integration and its implications to user society and the producer. Configuration design for export. Behavioural aspects in product configuration. Product in its context, family of products, inter-changeability of parts, Indian and foreign standards, market availability. Detailing plastic products while using processes like injection moulding, compression moulding, blow moulding and FRP moulding using hand laying and compression processes. Detailing for fabricated products in sheet metal, steel tubes and channel sections, aluminium sheets and extruded sections of different materials. Detailing for die casting and die design. Detailing for fabrication involving combination of materials like fabric, foam leather, cloth, rubber, plastic, metal, wood, adhesives, rivets, welding, brazing and mechanical fasteners. Selection of control panel elements, graphics and typography, colour schemes, safety and

maintainability, operating manuals. Study of well detailed products, product design task Visual creativity and communication. Product design task, selecting a product with wide configuration options and alternative options. Preparation and presentation of models, stretches and renderings. Evaluation and presentation of options.

IDP742 Industrial Design Practice
3 credits (1-0-4)
Cultural parameters of design, Creative thinking. Free hand sketching, presentation drawings, engineering drawings. The design cycle, need analysis. Formulation of design problem product planning, product conceptualisation, design methods for divergent, transformation and convergent thinking. Instrument aesthetics, instrument ergonomics. Model making.

DIP751 Communication and Presentation Skills
4 credits (1-0-6)
Objective : To develop communication/expression skills in visual presentation and provide opportunity for bridge studies. Developing sketching skills through studio exercises for coordinating eye, hand, body movements and developing necessary line control. Exercises to sharpen visual perception of line, form, colour, proportion, size, shape, mass and texture. Figure/ground factors, evaluating composition, positive negative character, proximity, similarity, closure, visual deception. Colour theory, substractive mixture, additive mixture, value and intensity. Exercises to produce rendering of products in different media. Photography as a means of visual recording and presenting of information. Isometric, Axonometric, perspective and exploded views and general assembly drawing as per BIS standards. Exercises to represent products. Learning photoshop: Exercises to produce product drawings. Preparing text and image files, preparing style-sheets, tags, fonts, windows and orphans, hyphenation, spacing and breaks, margins and columns, headers, footers, graphics, frames. Understanding these with reference to popular desk-top publishing packages. Exercises to produce a brochure as part of the studio exercises.

DIP752 Computer Aided Product Design
3 credits (1-0-4)
Objective : To learn the use of computers as a tool in product design. Introduction to computer aided industrial design. The technique of concurrent engineering. Using databases for material selection. Structure of CAD programmes and hardware. Relation of object space and screen space, 2D & 3D databases. Introduction to solid modelling. Detailed study of solid modelling software, studio exercises in solid modelling applications. Animation techniques and product animation. Product design task, communication of designs using CAD.

DIP762 Prototype and Die Development
2.5 credits (1-0-3)
Objective : To experience detailing and manufacture. Preparing detailed drawings, selecting materials, specifying fasteners, bushes, bearings, belts, springs, finishes, heat-treatments. Designing and using jigs and fixtures, supervising fabrication, assemb- ling & using test procedure, quality control. Controlling allowances, tolerances, alignments. Prototype fabrication of one of the projects. Designing for various types of manufacturing processes. Basic prin- ciples. Die and tool design for different manufacturing processes. Advanced manufacturing and its implications in Design. Visits to factories and tool rooms. Product design task.

DIP781 Engineering Function Material and Processes
3 credits (1-0-4)
Objective : To acquire engineering perception, information and model making skills and provide opportunity for bridge studies. Basic engineering principles of forces, strength, failure, stability, wear, and basic components in electronic and mechanical products. Tinker thinker. Study of well designed products, their function. Relationship of components. Sketching and representing how products work. Types of model making, model making as a thinking tools. Visual survey of model making by designers, architects, sculptures and engineers. Paper and

cardboard, material its properties and fabrication techniques. Plaster, clay and wax, mould making casting techniques. Ceramics and glass, forming and fabrication techniques. Wood stone, plastics and metals, forming and fabrication techniques. Mixed media, preparation and presentation of models. Visit to model making shops.

DIL782 Advanced Materials, Processes and Finishes
3.5 credits (2-0-3)
Objective : To acquire information and material usage skills. Structure, properties and usage of thermoplastics, thermosetting plastics. Selection and use of plastics for engineering and consumer products. Design limitation and potentials of various moulding proces- ses. Designing for plastics. Properties and use of rubber, ceramics and glass textiles. Ferrous and non-ferrous metals—their properties, processes and assembly techniques. Composites, adhesives. Significance of form in structural strength of materials and products. Influence of materials and processes on product aesthetics. Stiffness, strength and modes of failure. Ecological and environmental effects of materials: toxic and hazardous materials. International standards and code of practice. Properties and application of space age alloys. Properties and processing of natural materials like wood, bamboo, cane, leather, cloth, jute and paper and their usage at craft and industrial levels. Finishes, plating, paintings and heat treatment. Value analysis. Evaluation of comparative costs, energy requirements, wastages. Advances in new materials/processes. Sources of supply, quality evaluation. Explorations with new materials; electronic, mechanical, optical, magnetic, organic. Change of product concepts with new materials. Future trends. Product design task.

DIP791 Product Interface Design (Project 1)
4 credits (1-0-6)
Objective : To acquire analysis, synthesis and presentation experience in design of product. Interface for modulating user involvement. Product semantics, communication of feelings, communication of structure and purpose. Communication through form, colour, graphics and text. Typography choice and readability. Printing and transfer techniques. Product graphics. Functioning of controls and display elements, knobs, push buttons, handles, and electronic displays. Investigation and study of visual, functional and ergonomical requirements of controls and displays, legibility of display elements. Study of different textures and patterns. Area, volume and proportion. Order and system. Human factors and safety in interface design. Individually planned design projects involving research analysis and design of product interface.

DID792 Project II
5.5 credits (0-0-11)
Objective : To experience product design through self expression and the experience with others. The industry will be invited to present a product for design consideration to the class. The product will be an appliance, instrument, equipment, where user interaction is of significant importance. The student will be required to prepare his own design reflecting his analysis of the problem and creativity in synthesizing. The solution will be presented in the form of sketch book and presentation of the model and renderings.

DIS802 Invited Faculty Seminars
1 credit (1-0-0)
Objective : To expose high level design research carried out by professionals and to reinforce inputs of earlier semesters.

DIP811 Product Systems Services and Environment
3 credits (1-0-4)
Objective: To relate/realize designing in a corporate indentity framework and understand design at the level of systems services. Development of integrated ethos in an organization : Corporate policy, management outlook, work ethics, in a social institution/public service. Development of a visual identity as a means of communication. Corporate mark : Logo, symbol, colour. Corporate alphabets or type style : Display style, text style or styles. Company paper : stationery design, all business forms, transmittal envelopes, mailing labels and containers. Environment

design and structures : Office architecture, plant architecture, reception, interiors and entrance design. Product design : Consumer items, service image, idea, visual, presen- tation. Package design advertising and sales promotion : all visual media. Signage and vehicle identification and uniforms. Exhibition and displays; design control manual.

IDL811 Selected Topics in Instrumentation
3 credits (3-0-0)
(No prescribed course contents)

IDC812 Term and Seminar
3 credits (3-0-0)

DIR 812 Placement/Degree Show
2 credits (0-0-4)
The student is required to plan & design various product elements needed for their own placement in the industry and preparation of exhibition/literative needed for exhibitions of their work.

DIS812 Placement/Degree Show
2 credits (0-0-4)
Objective : To work towards interaction with the industry/clients. The students will be required to visit industry, take up assignments from the industry and execute them to their highest professional capabilities. They would also be required to participate in a degree show and present their work to the public.

DIR813 Designing for Sustainable Development
2.5 credits (1-0-3)
The student will be required to understand what goes into designing products, systems and services for long term sustainable development.

DIR821 Design Management and Professional Practice
2.5 credits (1-0-3)
Objective : To relate/realize designing in a corporate framework. Management of individual, group practice and corporate design office : Setting up a design office, finance, finding clients, running the office, business correspondence, brief and briefing, feasibility reports, letters of contract. Estimates of design fee : lump sum, hourly basis, retainership, consulting fee, royalties. Safety regulation, consumer protection, ISI standard, design registration, patents, copyrights. Planning a design office. Designer and the law, professional ethics in the design profession. Designer and the future of mankind. Integrated product development. How to get results, creating a project, assessing risks and chances of success, exploiting opportunities, con- trolling costs and enhancing quality. Pre-degree show presentation.

DIR833 Designing for Export
2.5 credits (1-0-3)
To study merchandise and product standards for specific foreign countries and to design appropriate product literature, packaging and product style.

DIP841 Advanced Form Studies
3.5 credits (1-0-5)
Objective : To develop insight into form, design and develop sophisti- cation in its application to cultural products. Detailed

study of the structural, perceptual and spatial properties of well ordered three-dimensional orientable and non-orientable forms, their composition and the process of designing them. Exercise in transport design and other consumer/industrial products.

DIR843 Exhibitions and Environmental Design
2.5 credits (1-0-3)
The student is required to study requirements and trends in Exhibition and environmental Design and propose design for public usage that is efficient for communication/pleasure.

DIR853 Computer Aided Industrial Design
2.5 credits (1-0-3)
Objective : To develop proficiency of use of computers for industrial design.

DIR855 Creative Marketing Communication
2.5 credits (1-0-3)
The student is required to study and practice a CAD modeling package and using advanced surface modeling and rendering features, model product to industrial design standards.

DIR857 Animation
2.5 credits (1-0-3)
The student is required to study the process of animation as is applied in visual communication. He/she is expected to conceptualize a story board and develop an animation experience.

DIR859 Media Studies
2.5 credits (1-0-3)
The student is required to study the potential and limits of a given material or process and develop design that exploits/extents the potential/limits of the material or process.

DID891 Project III
8.5 credits (0-0-17)
Objective : To create a carefully detailed product. This project will involve design and development of product chosen from a specific category common to the whole class. Emphasis will be on integration of user/environment aspects, safety and ergonomics, creativity, computer aided design and product detailing/presentation.

DID892 Major Project
19 credits (0-1-36)
Objective : To function as best as one can as an Industrial designer. This is the final 'project and should reflect student's competence in in- depth analysis/synthesis product detailing and prototype development, use of the resources of men, money, information, material, processes. He is expected to produce designs that are elegant in conceptualization and implementation. The project will have a plurality of guides and will also have the involvement of the user/manufacturing sector. The student is expected to submit a dissertation together with models/ drawings that brings out his grasp of the theoretical understanding of the design process and innovativeness in design.

Centre for Polymer Science and Engineering

PTL701 Polymer Chemistry
3 credits (3-0-0)
General characteristics of chain growth polymerisation, alkene polymerisation by free radical, ATRP anionic and cationic initiators, ring opening polymerization of ethers, acetals, lactones, lactams, copolymerisation, cyclopolymerisation, metathesis polymerisation. General characteristics of step growth polymerisation, synthesis by step polymerisation - polyesters, polycarbonates, polyamides, heteromatic polymers, polysiloxanes, liquid crystalline polymers.

PTL702 Polymer Processing
3 credits (3-0-0)
Classification of polymer processing operations. Simple model flows for analysing processing operations with examples. Extrusion and extruders. Calendering; Roller & blade coating; Film blowing. Fibre spinning. Injection moulding, blow moulding, thermoforming, rotational moulding. Compression and transfer moulding. Reaction Injection moulding. Compounding and mixing. Twin screw extruders, Banbury and other mixing equipments in polymer processing.Reactive processing.

PTL703 Polymer Physics
3 credits (3-0-0)
Polymer molecules, their classification, structure and conformations. Elasticity of isolated polymer chain and of the network. Rubber elasticity. Glass Transition: its measurement, effect of various parameters on it, theoretical interpretations. Structure of amorphous phase in bulk polymers. Two-phase structure of semi-crystalline polymers and its characterisation & correlation with properties. Crystal morphologies: extended chain crystals, chain folding, lamellae, spherulites. Concept of unit cell, crystallite size and long period. Crystallization and its kinetics: Avrami equation: Melting: determination of melting point and the effects of various parameters on melting.

PTL705 Polymer Characterisation
3 credits (2-0-2)
Polymer solution thermodynamics. Molecular weight and molecular dimensions by end group analysis, osmometry, light scattering, viscometry, gel permeation chromatography. Infra- red, NMR, UV-visible, Raman Spectroscopy techniques. Thermal properties by differential scanning calorimetry, differential thermal analysis, thermogravimetry. Microscopy: optical and electron microscopy, X-ray scattering from polymers, small angle light scattering. Crystallinity by density measurements.

PTL706 Polymer Testing and Properties
3 credits (3-0-0)
Properties of polymer and their measurement by standard test methods: tensile, flexural and impact properties.Hardness, abrasion resistance, long-term fracture tests, etc.Softening point, heat distortion temperature, melt flow index, mouldability and flow temperature.Various standard specifications: BIS, BS, ASTM, ISO, and DIN etc.· Correlation of tests with actual performance. Statistical quality control in various tests.

PTL707 Polymer Engineering and Rheology
3 credits (3-0-0)
Introduction and definitions related to fluid flow. Relationships describing continuity, dynamic and constitutive equations, deformation tensor. Simple shear flow and its application for measurement of viscosity as well as normal stresses. Simple elongational flow and its significance. Dynamic flow behaviour, time dependent fluid responses. Newtonian, non-Newtonion and viscoelastic fluids. Continuum theories and related models. Molecular, theoretical and related models. Relationships of various approaches taken in describing the viscous and elastic properties.

PTL709 Polymer Technology
3 credits (3-0-0)
Polymers of commercial importance. Additives for plastics: stabilizers, fillers, plasticizers, lubricants, flame retarders, foaming agents, cross-linking agents, etc. Manufacture, properties and applications of major thermoplastic and thermosetting polymers: polyethylene, polypropylene, polyvinyl choloride, polystyrene and other styrenics, polyamides, polyesters, phenolformaldehyde, urea and melamine - formaldehyde, unsaturated polyester, epoxy resins.

PTP710 Polymer Science Laboratory
2 credits (0-0-4)
Experiments: a) Polymer chemistry: identification of polymers, preparation of modified cellulose, thermosetting resins, suspension polymerization of styrene, emulsion polymerization of vinyl acetate and butyl acrylate, bulk and solution polymerization of methyl methacrylate, preparation and testing of epoxy reins, unsaturated polyester resin technology, preparation of nylon 6 and nylon 10 by interfacial polymerization, copolymerization and determination of reactivity ratios, preparation of polyvinyl alcohol, preparation of polyvinyl butyral. b) Polymer physics experiments on polymer characterization

PTL711 Engineering Plastics and Speciality Polymers
3 credits (3-0-0)
Definition. Characteristics of engineering plastics. Important engineering thermoplastics such as acrylics, ABS, polyesters, polycarbonate, polyamides, polyurethanes, polyphenylene oxide, polyphenylene sulfide, PEEK and Engg. Thermosets such as USP, Epoxy, phenolics and aminoplasts.

Materials selection for engineering plastics for various application based on mechanical properties. High temperature stability, electrical properties, oxidative, UV, hydrolytic and chemical stability.

Processing and application of engineering plastics. Definition and characteristics of speciality polymers. Important speciality polymers such as fluropolymer, silicone, liquid crystalline polymers, conducting polymers, polymeric hydrogels. Processing and application of speciality polymers.

PTL712 Polymer Composites
3 credits (3-0-0)
Definition and Classification of Composites Reinforcing fibres-Natural fibres (cellulose, jute, coir etc), boron, carbon, ceramic glass, aramids, polyethylene (UHMWPE), polybenz-thiazoles etc.

Particulate fillers-importance of particle shape an size. Matrix resins-thermoplastics and thermosetting matrix resins. Coupling agents-surface treatment of fillers and fibres, significance of interface in composites. Nanocomposites, short and continuous fibre reinforced composites, critical fibre length, anisotropic behaviour, SMC, BMC, DMC etc. Fabrication techniques-pultrusion, filament winding, prepreg technology, injection and compression moulding, bag moulding, resin transfer moulding, reaction injection moulding. Properties and perfor mance of composites. Applications.

PTL714 Polymer Blends and Alloys
3 credits (3-0-0)
Definition of polymer blends and alloys. General behaviour or polymer mixture. Thermodyamics of polymer blends. Miscibility of polymers. Immiscible blends and compatibilization. Morphology and dispersion of immiscible blends, phase separation. Melt rheology of multiphase blends. IPN, thermoplastics elastomers, reaction blending and processing. Specific polymer blends, their properties and application. Case studies

PTL716 Rubber Technology
3 credits (3-0-0)
Rubber and elastomers, compounding and vulcanization, mastication, fillers–reinforcing and non-black (loading type). Other compounding ingredients: peptizers, vulcanizing agents, accelerators, accelerator activator, softeners, anti aging additives, miscellaneous additives: colorant, flame retarders, blowing agents, deodorants, abrasive, retarders etc.

Processing and vulcanization test. Vulcanization theory and technology. Natural rubber and synthetic rubbers: styrene butadiene rubber,

polybutadiene and polyisoprene rubbers, ethylene-propylene rubber, butyl and halobutyl rubber, nitrile and silicone rubber, thermoplastics elastomers, latex and foam rubber. Acrylate and fluoro elastomers.

PTL718 Polymer Reaction Engineering
3 credits (2-1-0)
Polymerisation kinetics for both step growth as well as chain growth mechanism under ideal and real conditions. Chain growth includes free radical, anionic and cationic polymerisation. Prediction of molecular weight distribution for polymerisation conducted in batch reactors, continuous stirred tank reactors, plug flow reactors, comparison between batch and continuous system, the effect of mixing on kinetics and mwd, considerations for reactor design for commercial use.

PTP720 Polymer Engineering Lab
1 credit (0-0-2)
(a) Processing experiments: compounding of additives on two roll-mill/twin screw extruder, compression moulding, injection moulding, single screw and twin screw extrusion, thermoforming, melt flow index measurement, mixing in HAAKE rheomix, melt rheology on rheometers, mechanical proportion of polymers, mould flow demonstration. **b)** Industry visit for demonstration of specific processing and testing operations.

PTL720 Polymer Product and Mould Design
3 credits (2-0-2)
Fundamentals of plastic moulding. Plastics product design. Type of moulds, tool making processes, equipment and methods. Materials for mould making designing and drafting practice. Design details for compression moulds, transfer moulds, blow and extrusion dies, typical excersises in mould design and production.

PTL722 Polymer Degradation and Stabilization
3 credits (3-0-0)
Principles of thermal, photo, oxidative and biodegradation in polymers. Methods/equipments used for monitoring the degradation in polymers. Mechanism of degradation of some commercial polymers. Biodegradation of polymers. Waste Management.

PTL724 Polymeric Coatings
3 credits (3-0-0)
Introduction and mechanism of adhesion of polymeric coatings on various substrates. Solvent based polymeric coatings. Water based polymeric coatings. UV and EB curable coatings. 100% convertible coatings. Selection criteria of coatings for various substrates. Health, safety hazard and environmental aspects of coatings during manufacturing and applications.

PTL726 Polymeric Nanomaterials and Nanocomposites
3 credits (3-0-0)
Introduction to general aspects of nanostructured materials, e.g. nanocomposites, block copolymers, Interaction parameter, phase behaviour morphology and phase diagrams, microphase separation transition. Polymer nanocomposites: technical challenges and understanding of interfacial dynamics using LJ Potential and many body problems approach. Nanoreinforcements eg. Nanoclay, POSS, carbon nanostuctures and nanoparticles. Dispersion and percolation: influence of size, shape and diameter of nanotubes, functionalisation of nanoparticles and nanoplatelets.

Interdisciplinary M.Tech. Programmes

COURSE DETAILS
M. Tech. Programme in Computer Applications

JCD799 Minor Project
3 credits (0-0-6)

JCS800 Independent Study
3 credits (0-3-0)

JCD801 Major Project (Part-I)
6 credits (0-0-12)

JOD802 Major Project (Part-II)
12 credits (0-0-24)

M. Tech. Programme in Energy Studies

JED799 Minor Project
3 credits (0-0-6)

JES800 Independent Study
3 credits (0-3-0)

JED801 Major Project Part-1
6 credits (0-0-12)

JED802 Major Project Part-2
2 credits (0-0-24)

M. Tech. Programme in Energy & Environmental Management

JSS800 Independent Study
3 credits (0-3-0)

JSD801 Major Project (Part-I)
6 credits (0-0-12)

JSD802 Major Project (Part-II)
12 credits (0-0-24)

M. Tech. Programme in Industrial Tribology & Maintenence Engineering

JIS800 Independent Study
3 credits (0-3-0)

JID801 Major Project (Part-I)
6 credits (0-0-12)

JID802 Major Project (Part-II)
12 credits (0-0-24)

M. Tech. Programme in Opto-electronics and Optical Communications

JOS800 Independent Study
3 credits (0-3-0)
Detailed study on a contemporary topics in the area of Optoelectronics/ Optical Communication as suggested by the course coordinator.

JOD801 Major Project (Part-I)
6 credits (0-0-12)
Studies on topics offered by the faculty in the area of Optoelectronics/ Optical Communication

JOD802 Major Project (Part-II)
12 credits (0-0-24)
Detailed investigations on study of the topics offered by the faculties / supervisors.   The project would generate simulations / experimentation / technology development.

JOP791 Fibre Optics and Optical Communication Lab-I
3 credits (0-0-6)
Experiments on characterisation of optical fibers, sources, detectors and modulators, in the Physics Department and experiments on electronics and communication in the Electrical Engineering Department.

JOP792 Fibre Optics and Optical Communication Lab-II
3 credits (0-0-6)
Experiments on characterisation of optical fibers, sources, detectors and modulators, in the Physics Department and experiments on electronics and communication in the Electrical Engineering Department.

M. Tech. Programme in Power Generation Technology

JGL710 Power Plant Performance and Economics
3 credits (3-0-0)
Electricity demand and growth, siting of power plants. Variable load operation in a grid, load curves for different consumers. Cost of electric power from different types of power plants. Performance characteristics of major equipment, viz., boiler, turbine, condenser, etc, and changes with operation. Data acquisition and analysis, and use of software packages for monitoring and optimization. Introduction to regulatory mechanisms. Case studies, Optimal Generation mix, Economic load dispatch, Unit commitment, Hydro thermal scheduling.

JGL712 Power Plant Control and Instrumentation
3 credits (3-0-0)
Introduction : Static & dynamic characteristics of instruments, sensors, signal processing & data transmission elements, indicating & recording elements. Use of computers for data acquisition & analyzer, Signal and system Analyzers, Instrumentation for measuring temperature, pressure, flow, speed, vibration & noise, electrical parameters, on-line process instruments, choice & calibration of instruments. Automatic Process Control systems Representation. Feedback control concepts, Transient & Frequency response. Types of controllers, stability, Digital Control System, Modern Control theory, Boiler Control, Governing & Control of turbomachines.

JGL716 Selected Topics in Power Plants
3 credit (3-0-0)
Power Plant layout, foundations, erection and commissioning, Fuel for modern power plants - their storage, handling and combustion systems, Diesel and Gas Turbine Power plants stand by and - Captive power plants, Combined cycle power plants, Environmental impacts and pollution control from, Thermal power plants, Miscellaneous topics.

JGS800 Independent Study
3 credits (0-3-0)

JGD801 Major Project (Part-I)
6 credits (0-0-12)

JGD802 Major Project (Part-II)
12 credits (0-0-24)

M. Tech. Programme in Polymer Science & Technology

JPD799 Minor Project
3 credits (0-0-6)
The student will work on a small project on any area of polymers.   The topic of research may not be linked with JPD 801 or JPD 802.

JPS800 Independent Study
3 credits (0-3-0)
Objective: The student is expected to take a course from the PE category and will study the full course under the guidance of course teacher.

JPD801 Major Project (Part-I)
6 credits (0-0-12)
A student will select a topic on any area related with polymers and perform the research work for one semester (IIIrd semester).

JPD802 Major Project (Part-2)
6 credits (0-0-12)
The student will continue to work on the topic selected in the semester III, the work content will be further extended which will include additional studies, modifications/diversification of the broad research. The work will be done for the full 4th semester.

Abbreviations

B.Tech.	Bachelor of Technology
BPGS&R	Board of Postgraduate Studies and Research
CGPA	Cumulative Grade Point Average
CRC	Centre Research Committee
DGPA	Degree Grade Point Average
D.I.I.T.	Diploma of I.I.T. Delhi
DRC	Department Research Committee
EC	Earned Credits
IRD	Industrial Research and Development
M.B.A.	Master of Business Administration
M.Sc.	Master of Science
M.S.(R)	Master of Science (Research)
M.Tech.	Master of Technology
PGS&R	Postgraduate Studies and Research
Ph.D.	Doctor of Philosophy
SGPA	Semester Grade Point Average
SRC	Standing Review Committee (for undergraduate programmes); *also* Student Research Committee (for M.S.(R) and Ph.D. student)
UGS	Undergraduate Studies

DAY	8 - 8:50	9 - 9:50	10 - 10:50	11 - 11:50	12 - 12:50	13 - 13:50	14 - 14:50	15 - 15:50	16 - 16:50	17 - 17:50	18 - 18:50
M	A (8.00 - 9.20)		B (9.30 - 10.50)	H	J	A TUT	C TUT/LAB D TUT/LAB E TUT/LAB F TUT/LAB	B TUT/LAB		M (17.00 - 18.20)	
Tu	C	D	E	F	J	A TUT	C TUT/LAB D TUT/LAB E TUT/LAB F TUT/LAB	B TUT/LAB		K	L
W	C	D	E	H	J	A TUT	C TUT/LAB D TUT/LAB E TUT/LAB F TUT/LAB	B TUT/LAB		K	L
Th	A (8.00 - 9.20)		B (9.30 - 10.50)	F	H	A TUT	C TUT/LAB D TUT/LAB E TUT/LAB F TUT/LAB	B TUT/LAB		M (17.00 - 18.20)	
F	C	D	E	F		A TUT	C TUT/LAB D TUT/LAB E TUT/LAB F TUT/LAB	B TUT/LAB		K	L

SLOT HOURS (I YEAR M COURSES) — effective from I semester 2011-12

DAY	8 - 8:50	9 - 9:50	10 - 10:50	11 - 11:50	12 - 12:50	13 - 13:50	14 - 14:50	15 - 15:50	16 - 16:50	17 - 17:50	18 - 18:50
M	A (8.00 - 9.20)	A	B (9.30 - 10.50)	B		E TUT/LAB	E TUT/LAB	E TUT/LAB			
							Q (PH/CY LAB)	Q (PH/CY LAB)			
								HUN100			
						N (INTRO TO PROG.)	N (INTRO TO PROG.)				
						C TUT	B/D TUT	A TUT/LAB	A TUT/LAB		
						C TUT	B/D TUT	A TUT/LAB	A TUT/LAB		
Tu	C	D	E			E TUT/LAB	E TUT/LAB	E TUT/LAB			
							Q (PH/CY LAB)	Q (PH/CY LAB)			
							HUN100	HUN100			
						N (IINTRO TO PROG.)	N (IINTRO TO PROG.)				
W	C	D	E			N (IINTRO TO PROG.)	N (IINTRO TO PROG.)				
						C TUT	B/D TUT	A TUT/LAB	A TUT/LAB		
						E TUT/LAB	E TUT/LAB	E TUT/LAB			
							Q (PH/CY LAB)	Q (PH/CY LAB)			
							HUN100	HUN100			
							HUN100	HUN100			
Th	A (8.00 - 9.20)	A	B (9.30 - 10.50)	B		N (INTRO TO PROG.)	N (INTRO TO PROG.)				
						C TUT	B/D TUT	A TUT/LAB	A TUT/LAB		
						E TUT/LAB	E TUT/LAB	E TUT/LAB			
							Q (PH/CY LAB)	Q (PH/CY LAB)			
F	C	D	E	E			Q (PH/CY LAB)	Q (PH/CY LAB)			
							HUN100	HUN100			
						N (INTRO TO PROG.)	N (INTRO TO PROG.)				
						C TUT	B/D TUT	A TUT/LAB	A TUT/LAB		
						E TUT/LAB	E TUT/LAB	E TUT/LAB			

SLOT HOURS (I YEAR P COURSES)

DAY	8 - 8:50	9 - 9:50	10 - 10:50	11 - 11:50	12 - 12:50	13 - 13:50	14 - 14:50	15 - 15:50	16 - 16:50	17 - 17:50	18 - 18:50
M		Q (PH/CY LAB)	HUN100 / E TUT/LAB / C TUT | B/D TUT | A TUT/LAB / N (INTRO TO PROG.)				A (14.00 - 15.20)		B (15.30 - 16.50)		
Tu	C	N (INTRO TO PROG.) / Q (PH/CY LAB) / HUN100 / E TUT/LAB / C TUT | B/D TUT | A TUT/LAB					D	E			
W	C	C TUT | B/D TUT | A TUT/LAB / N (INTRO TO PROG.) / Q (PH/CY LAB) / HUN100 / E TUT/LAB / E TUT/LAB					D	E			
Th		C TUT | B/D TUT | A TUT/LAB / N (INTRO TO PROG.) / Q (PH/CY LAB) / HUN100					A (14.00 - 15.20)		B (15.30 - 16.50)		
F	C	HUN100 / E TUT/LAB / C TUT | B/D TUT | A TUT/LAB / N (INTRO TO PROG.) / Q (PH/CY LAB)					D	E			

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INDIAN INSTITUTE OF TECHNOLOGY DELHI

THE HONOUR CODE

I_____, entry no._____

do hereby undertake that as a student at IIT Delhi:

(1) I will not give or receive aid in examinations; that I will not give or receive unpermitted aid in class work, in preparation of reports, or in any other work that is to be used by the instructor as the basis of grading; and

(2) I will do my share and take an active part in seeing to it that others as well as myself uphold the sprit and letter of the Honour Code.

I realize that some examples of misconduct which are regarded as being in violation of the Honour Code include:

☞ copying from another's examination paper or allowing another to copy from one's paper;

☞ unpermitted collaboration;

☞ plagiarism;

☞ revising and resubmitting a marked quiz or examination paper for re-grading without the instructor's knowledge and consent;

☞ giving or receiving unpermitted aid on take home examinations;

☞ representing as one's own work the work of another, including information available on the internet;

☞ giving or receiving aid on an academic assignment under circumstances in which a reasonable person should have known that such aid was not permitted; and

☞ committing a cyber offence, such as, breaking passwords and accounts, sharing passwords, electronic copying, planting viruses, etc.

I accept that any act of mine that can be considered to be an Honour Code violation will invite disciplinary action.

Date:_____   Student's Signature_____

Name_____

Entry no._____

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