Courses of Study 2005-2006

Programmes

Doctor of Philosophy

Master of Science (Research)

Master of Technology

Master of Design

Master of Business Administration

Master of Science

Indian Institute of Technology Delhi
Hauz Khas, New Delhi

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Postgraduate Programmes Offered by Various Departments/Centres

SN	CO de	Department/Centre	Postgraduate Programmes (PG) offered	
			M. Tech. In	Other PG Programmes
1	AM	Applied Mechanics	Engineering Mechanics	D.I.I.T (Naval Construction, for sponsored candidates from Indian Navy), and Ph. D.
			Design Engineering	
2	BE	Biochemical Engineering & Biotechnology		Ph. D. and M.S. (Research)
3	CH	Chemical Engineering	Process Engineering & Design	Ph. D. and M.S. (Research)
4	CY	Chemistry	Modern Methods of Chemical Analysis	Ph. D. and M.Sc.
5	CE	Civil Engineering	Geotechnical & Geoenvironmental Engineering	Ph. D. and M.S. (Research)
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			Structure Engineering	
			Water Resources Engineering	
			Construction Engineering & Management	
			Construction Technology & Management (For L & T Sponsored Candidates)	
			Environmental Engineering & Management	
			Transportation Engineering	
6	CS	Computer Science & Engineering	Computer Science & Engineering	Ph. D. and M.S. (Research)
7	EE	Electrical Engineering	Communications Engineering	Ph. D. and M.S. (Research)
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			Control & Automation	
			Integrated Electronics & Circuits	
			Power Electronics, Electrical Machines & Drives	
			Power Systems	
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11	ME	Mechnical Engineering	Design of Mechanical Equipment	Ph. D. and M.S. (Research)
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			Production Engineering	
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			Textile Engineering	
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18	IT	Industrial Tribology, Machine Dynamics & Maintenance Engineering	*	Ph. D.
19	ID	Instrument Design & Development	*	Ph. D.
20	PT	Polymer Science & Engineering	*	Ph. D.
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23	SI	Amar Nath and Shashi Khosla School of Information Technology		Ph. D. and M.S. (Research)
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		Technology and Management		and M.B.A.

*** postgraduate elective courses are offered for PG programmes.**

interdisciplinary M. Tech Programmes	**Computer Applications**
	Energy Studies
	Energy and Environmental Management (Evening)
	Industrial Tribology and Maintenance Engineering
	Instrument Technology
	Opto-Electronics & Optical Communication
	Polymer Science & Technology
	VLSI Design Tools & Technology
	Power Generation Technology (For NTPC Sponsored Engineers)
	Telecommunication Technology & Management

Interdisciplinary Master of Design (M.Des.) Programme in Industrial Design

The requirements and scheduling of courses for the M. Des. Programme are given in the following pages.

Requirements and Scheduling of the courses for M. Tech.

The requirements and scheduling of courses for various M. Tech. Programmes are given in the tables in the following pages.

Requirements for M.S. (Research)

Core course : 20 Credits

Research work : 40 Credits

For scheduling of courses and research work, the concerned departments may be contacted.

RULES, REGULATIONS, EVALUATION AND GRADING

POSTGRADUATE PROGRAMMES

Credit System

Education at the Institute is organised around the credit system of study. 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 requirement for continuation.

Each course has a certain number of credits which describe its weightage. A student's performance/progress is measured by the number of credits that he/she has completed satisfactorily. A minimum grade point average is required to be maintained for satisfactory progress. Also a minimum number of earned credits should be acquired in order to qualify for the degree.

Every course is coordinated by a member of the teaching staff of the Department/Centre which is offering the course in a given semester. This faculty member is called the Course Coordinator. He/she has the full responsibility for conducting the course, coordinating the work of the other members of the faculty involved in that course, holding the tests and assignments, and awarding the grades. For any difficulty, the student is expected to approach the Course Coordinator for advice and clarification.

Medium of Instructions at the Institute is English

Courses

Each course offered by the Institute is identified by three letters followed by three numerical digits. The details about the numbering are given on page 8.

Credits and their Evaluation

Each course has a certain number of credits which reflect its weightage. Credits of a course are evaluated as under :

(a) For all lecture courses, one credit per lecture/week/semester will generally be adopted.

(b) Every one laboratory hour per week per semester will be assigned half credit. Courses with odd numbers of laboratory hours having fractional credits will be accepted. The courses having 1.5 hour contact/week/ semester or 3 hours contact/alternate week/semester will be rationalized to have integer number of contact hours per week so that fractions smaller than 0.5 are not involved in credit assignment of laboratory courses.

(c) The Minor and Major Project will be treated like any other course and will be registered by the students with full credits. The project grade will be included in the computation of the CGPA. The SGPA or CGPA will be computed in course work only for the semester in which a continuation grade i.e., 'X' is awarded for the Major Project- Part II.

Specialisation

(a) Students will be admitted to the M.Tech./M.S. (Research)/M.Des. programmes in the departments and in interdisciplinary programmes for an M.Tech./M.S. (Research)/M.Des. degree of the Institute with specialization in one of the areas approved by the Senate.

(b) The areas of specialisation for a department will be approved by the Senate by following the normal procedure applicable to the establishment of a new programme.

(c) Which of the allowed specialisations are to be offered by a department/ interdisciplinary programme to its students in any particular year will be determined by the Department Board/ Programme Executive Committee.

Minimum Student Requirement for a Course

On the day of registration, a course will normally have a minimum of four students and in the case of a pre-Ph.D. course, a minimum of three students excluding those auditing the course.

Minimum Student Requirement for a Programme

No programme will be run unless the number of students registered for the 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 & Planning.

Audit Course Requirement

The requirement for an Audit Pass (NP) grade would be laid down by the teacher of a course at the beginning of the course. If the performance of a student is not satisfactory, he would be awarded 'NF' grade.

Candidates registered for Ph.D. programmes shall be required to audit a three-credit course on Communication Skill in addition to the course work of 12/6 credits depending on entry qualification referred to under Ph.D.requirements.

A Ph.D. student registered in the compulsory audit course - HUL 810 "Communication Skills" be given exemption in this course by the DRC/CRC only till the last date for withdrawal of a course. A student who is not allowed exemption by the said date, will have to complete the course as per registration in the semester.

Audit grade can be requested by a student in a particular course in which he/she is already registered not later than four weeks from the date of registration.

The Grading System

The grade awarded to a student in any particular course will be based on his/her performance in minor tests (usually 2), major test, quizzes, home assignments, laboratory work, workshop and drawing assignment etc. The distribution of the weightage will be decided by the Course Coordinator.

The letter grades that can be awarded and their equivalent grade points are listed below :

Grade	*Grade points*	*Description of performance*
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 Project (only for Major Project part II).
S	-	Satisfactory completion of practical training.
Z	-	Non-completion of practical training.

RULE

The Grade Point Average (GPA) is calculated as follows :

$$GPA = \frac{S\ (\text{Number of Credits x Grade Point})}{S\ (\text{Number of Credits Registered})}$$

For the purpose of calculation of GPA for SGPA or CGPA, only those courses (including minors and major project) will be taken into account in which the student has been awarded one of A, B, C, D, E or F grade.

'E' and 'F' Grades

These grades refer to unsatisfactory performance in a course. A student is required to repeat all compulsory courses (including Major Project-Part-I) except for Major Project- Part-II in which he/she obtains either an E or F grade. E and F grades obtained in any course will stay permanently on the Grade Card and they are included in the evaluation of SGPA. However, 'Fail' grades (E&F) will not be counted for calculating the CGPA of all postgraduate students.

'I' Grade

This refers to an "incomplete" grade which is required to be converted into a regular grade later.

Guidelines for the Award of 'I' Grade

(a) 'I' grade may be awarded to a student if she/he has not fulfilled all the requirements for the course on account of extraordinary circumstances subject to having 50% attendance in tutorials and/or lab. classes as applicable.

The concerned Course Coordinator should be convinced about the extraordinary circumstances and should certify the attendance record before this rarely used option to award 'I' grade is recommended.

(b) The 'I' grades so awarded will be notified by the Department to which the student belongs and copy of the notification will be enclosed to Academic Section (Postgraduate Studies) and to the Course Coordinator concerned (e.g., the notification for 'I' grade of a Civil Engineering student will be notified by the Civil Engineering Department on the recommendation of the concerned Course Coordinator, even if the course pertains to another department.

(c) The 'I' grade shall be converted into a proper grade and sent to Academic Section (Postgraduate Studies) within 10 days from the date on which all the major tests are over.

(d) In special situations arising due to extraordinary circumstances the period of conversion of 'I' grade may be extended to the first week of the next semester, with the approval of Dean, Postgraduate Studies & Research on the recommendation of the Course Coordinator, the Head of the Department to which the student belongs and the concerned Warden, for which the request has to be made sufficiently in advance.

'NP'/'NF' Grades

These grades are awarded to an audit course defined as one which a student may register for on pass (NP)/fail (NF) basis. These grades are not counted in the calculation of SGPA or CGPA.

The courses in which a student has got `NP' grade will not count towards his/her valid credits required for completion of degree/ diploma.

'W' grade

This refers to withdrawal from a course other than Major Project which is allowed upto one week after the end of first Minor Test with prior permission of Course Coordinator.

Notwithstanding the above, the Board of Postgraduate Studies & Research may permit a student to withdraw from all courses provided the Board of Postgraduate Studies & Research is convinced that the student could not pursue his studies for reasons beyond his control.

Major Project

An M.Tech. student shall register Major Project part-I of 6 credits. Fail Grades `E' & `F' are not to be counted for computing the CGPA.

A student shall be eligible to register for the Major Project - Part-II only on satisfactory completion of the Major Project Part-I.

'X' Grade

This grade is provided for incomplete Major Project - Part-II work and will be converted to a regular grade on completion of the Project work and its evaluation.

Guidelines for the Award of 'X' Grade

An M.Tech. student is required to submit a dissertation as a part of his/her Major Project - Part-II. A student who is unable to complete his/her major project may be awarded an 'X' grade on recommendation by a Committee consisting of (i) Head of the Department/ Centre or his/her nominee; (ii) Nominee of the D.R.C./C.R.C.; and (iii) Supervisor(s) of the project, and the student concerned may be required to present his/her work to the Evaluation Committee 6-8 weeks before the date of registration for the next semester.

A student who has been awarded an 'X' grade is required to formally register for the next semester and pay the fees. Also he will be normally required to vacate the hostel room.

The following criteria will be used for the award of the 'X' grade :

(1) Number of times 'X' grade to be awarded will be as under :

For Full-time students : one

For part-time students : two

(2) Grounds for award of 'X' Grade:

'X' grade will be awarded in exceptional cases under the circumstances beyond student's/supervisor's control. However, the following are the grounds recognised for the award of 'X' grade :

(a) Medical grounds to the satisfaction of the Institute authorities.

(b) Technical reasons/grounds such as supervisor/equipment not being available.

(c) On long period assignment, on the written request of the employer of the student concerned. 'X' grade on this ground will be awarded only once during the entire period of the study of the student. If the valid period of absence is more than half of the duration of a semester, the student will apply for withdrawal. (For Part-time students only)

Semester Withdrawal

Requests for permission to withdraw from all courses/semester will be considered as per the following guidelines :

(a) Under no circumstances will a request for withdrawal be entertained after the major tests have begun. Students should present the medical certificate in support of their absence on health reasons within 2 days of joining. The students may not ask for withdrawal retrospectively.

(b) Period of authorized absence in the semester should not be less than 8 weeks of contact period of withdrawal to be granted.

(c) In case of request for withdrawal on medical grounds, students residing in the hostel must produce a certificate from the Institute hospital. The medical certificate issued by a registered medical practitioner will be acceptable in those cases where the student has

valid reasons for his absence from the Institute hostel.

(d) Regularity in attending the classes and satisfactory performance in the minor(s), if any held prior to the date of application for withdrawal, are factors which would be taken into account while recommending/granting withdrawal.

Continuous Absence

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

Qualifying Criteria

M.Sc. Requirements

The minimum credit requirements for the M.Sc. degree in Mathematics, Physics and Chemistry are 90 valid credits ('D' grade or above) inclusive of the minimum of 12 credits in departmental and 6 credits outside departmental elective courses. The Department may, however, require a student to register for more than 90 credits. Subject to revised structure a student is normally permitted to register for a minimum of 20 credits and a maximum of 28 credits per semester.

Students can take electives in various areas during the last semester.

The minimum Cumulative Grade Point Average (CGPA) required for the award of M.Sc. degree is 5.00.

The minimum SGPA required for the continuation of registration is 4.00 at the end of first semester and CGPA of 4.50 at the end of 2nd and 3rd semester. In addition to CGPA requirment, the minimum valid credits required at the end of each semester is 75% of the credits registered in a semester.

Every student must register and seriously attempt to complete all the requirements for the award of degree in two years. However, on the recommendation of the DRC, the Dean (PGS&R) may consider allowing a student to register in the 5th semester to complete any shortfall in his credit or CGPA requirement. The entire programme must, however, be completed within a maximum period of 3 years including any semester withdrawals. The M.Sc. degree is awarded by the Institute with the name of the subject (Chemistry, Mathematics or Physics) mentioned on it.

Attendance

They must attend 75% of the classes in each course for which they are registered.

Requirement for the Postgraduate Diploma in Naval Construction

The minimum credit requirement for D.I.I.T. in Naval Construction is 49 valid credits ('D' grade or above). A student is normally permitted to register for a minimum of 12 credits and a maximum of 20 credits.

The minimum CGPA required for the award of D.I.I.T. is 6.00. The minimum CGPA required for continuation of registration is 5.00 at the end of each semester.

Every student must register and seriously attempt to complete all the requirements for the award of Diploma in 1½ years. However, on recommendation of the DRC, the Dean (PGS&R) may consider allowing a student to register in the 4th semester to complete any shortfall in his credit or CGPA requirement. The entire programme must, however, be completed within a maximum period of 3 years including any semester withdrawals.

M.Tech./M.S. (Research)

Requirements

The minimum credit requirement for the M.Tech. degree will be 60 valid credits ('D' grade or above) including a minimum of 42 credits of course work and 18 credits of project work. (Major project - part-I- 6 credits + major project- part-II 12 credits). Departments, may however, require a higher credit limit for the award of the degree. All M.Tech. students are expected to earn a minimum of 6 credits from courses outside their specialization. A full-time M.Tech. student will normally be allowed to register for a minimum of 12 credits and a maximum of 22 credits per semester with the condition that the No. of lecture courses to be not more than 6.

A part-time M.Tech. student will be allowed to register for a maximum of 12 credits per semester with the condition that the No. of lecture courses to be not more than 3 and a minimum of one course or a Major and Minor Project in each semester. In the semester in which a part-time student registers for the Major Project - part-II, he may be allowed to register for any one additional course along with the Project even though the total number of credits registered exceeds 12. He/she is expected to complete M.Tech. degree requirements in 6 semesters.

The minimum credit requirements for M.S. (Research) Programmes is 60 credits — 20 of course work normally to be completed during first two semesters of admission and research work of 40 credits spread over three semesters.

The minimum CGPA required for the award of M.Tech./M.S. (Research) degree is 6.00/7.00 respectively.

For continuation of registration, a minimum SGPA of 5.50 at the end of Ist Semester and CGPA of 5.50 and valid credits to the extent of 75% of the registered credits (except Major Project - part-II) at the end of subsequent semester is required.

The full-time/part-time student of M.S. (R) Programme must score a minimum CGPA of 7.0 in course work for continuation of registration.

If a student gets a CGPA between 5.50 and 6.00 at the end of his M.Tech. Programme and has earned at least 45, valid credits, he may be considered, on request, for award of a Diploma (D.I.I.T.) even though the department/centre does not run a regular Diploma programme. Likewise, if a student gets a CGPA of 6.00 or more but has not earned 60 valid credits at the end of his M.Tech. programme, he/she may be considered for the award of D.I.I.T. only provided that he/she has earned at least 45 valid credits. The request for the award of D.I.I.T. must be made within 5 years of the date of joining the programme.

Every full-time student must register and seriously attempt to complete all the requirements for the award of degree in 4 semesters. However, on the recommendation of the DRC, the Dean (PGS&R) may consider allowing a student to register in the subsequent semesters to complete any shortfall in his credit or CGPA requirement. The entire programme must however, be completed within a maximum period of 6 semesters including any semester withdrawals. Likewise for part-time students, the normal duration for completing the programme is 6 semesters, extendable as above, up to a maximum of 10 semesters.

All part-time M.Tech. students must register and complete the required course credits and thesis project in not more than 6 semesters except in cases where semester withdrawal is allowed or 'X' grade is awarded in Major Project-Part-II. However, if a part-time student is able to complete the required course credits and thesis project in 6 semesters, he may be conferred the degree of M.Tech., after completion of 6 semesters only. Further, if a part-time M.Tech. student, due to certain circumstances beyond his/her control is not able to complete degree in 6 semesters, he/she may be allowed to register in the subsequent semester by Dean, PGS&R on the recommendations of the DRC/CRC/PEC. The request for registration beyond the 6th semester will state the circumstances in which the student failed to complete the requirements. DRC/CRC/PEC will record its observations on the request of the student. Each case will be decided by the Dean, PGS&R on merit. The maximum period for which a part-time

M.Tech. student may be permitted to register should be 10 semesters.

M.Des. Requirements

Presently, only one M.Des. programme in Industrial Design is being run at the Institute. This is a 2-year (4 semesters) programme. The CGPA and credit requirements for the programme are given below.

Besides, there will be a departmental elective in the 3rd semester Elective/In-depth study.

The course allows plenty of opportunity for the students' creativity and individuality to flower through studio practice, minor and major projects. The programme emphasises on a learning by creative doing. Great importance is attached to interaction with design educationists and design practitioners. Field visits to product development houses and design firms is an essential part of the programme.

Every student must register and seriously attempt to complete all the requirements for the Degree in 4 semesters. However, on the recommendations of the DRC, the Dean (PGS&R) may consider allowing a student to register in the subsequent semesters to complete any shortfall in his/her credit or CGPA requirement. The entire programme must, however, be completed within a maximum period of 6 semesters.

The M.Sc./M.Tech./M.S. (Research)/ M.Des./D.I.I.T. degree or the diploma as the case may be is awarded by the Institute with the name of the programme mentioned on it.

Grant of Leave and Attendance Requirements for M.Tech./M.S. (Research)/M.Des./D.I.I.T. Students

Leave

A full-time M.Tech./M.S.(Research)/ M.Des./D.I.I.T. student during his/her stay at the Institute will be entitled to leave for 30 days (including leave on medical grounds), per academic year. He/she will not be entitled to mid-semester breaks, summer and winter vacations. 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.

An M.Tech. student may be allowed to avail a maximum of 9 days extra leave without Assistantship during his entire stay at the Institute, while an M.Des. student may avail 12 days in the similar manner.

Attendance Requirement for Assistantship

An M.Tech./M.S.(Research)/M.Des./D.I.I.T. 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.

M.B.A. Programmes

The objective of the M.B.A. programmes is to impart management education in an engineering environment so as to enable the student to be optimally equipped to respond to the changing requirements of the industry in the Indian ethos.

The full-time MBA programme is focused on "Management Systems" and "Telecommunication Systems Management". The programme can be completed in minimum two years and can go up to a maximum of three years.

The minimum credit requirement for the M.B.A. degree will be 72 valid credits + 6 compulsory audit courses. The minimum CGPA required for the award of MBA degree is 6.00.

Operating Procedures

The operating prodecures with reference to credit system, credits and evaluation, audit course requirement, grading system, semester withdrawal, continuing absence, and academic performance criteria for continuation of registration, etc. will be the same as applicable to other M. Tech. programmes of the Institute.

Ph.D.

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. Candidates having a B.Tech./ M.Sc./M.A. or equivalent degree are required to complete a minimum of 12 credits. Relaxation upto 6 credits in the course work can be considered for those with M.Phil. degree. 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 a particular case. 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. No independent study course will be allowed for Ph.D. students.

The minimum CGPA requirement is 7.50. If the SGPA at the end of Ist 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 discontinue the doctoral programme. In some departments, the required performance level may be higher than that stated above. The admitted students must acquire copy of departmental norms. The course work must be completed within the first two semesters of joining the programme.

In addition to the requirement of prescribed minimum CGPA, he/she shall be required to secure valid credits to the extent of 75% of the credits registered in a semester for continuation of registration.

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 comprehensive examination only after they have submitted a research plan and have completed the course work (including compulsory Audit Course - HUL 810 Communication skill). 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 2 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.

Time Limit for Ph.D. Work

(a) Candidates having a B.Tech./M.A./ M.Sc. or equivalent degree are required to be registered for a period of not less than 3 years from the commencement of registration (date of registration). In exceptional cases the minimum period of registration may be reduced to two

years with the approval of the Senate. The minimum period of registration for candidates having an M.Tech. or equivalent degree is two years.

(b) A candidate is normally expected to submit his thesis within five years from the date of registration. This period may be extended by BPGS as a special case to a maximum of seven years after which the registration will stand cancelled.

(c) A full-time candidate may be allowed by Dean, PGS&R, to convert his/her registration into part-time registration only after completion of at least three years from initial registration or after submission of synopsis.

(d) Full-Time Ph.D. scholars with M.Tech. qualification can be permitted to convert their registration from full-time to part-time after one year or after completion of course work and comprehensive examination whichever is later, if they get employed in the Institute's sponsored projects.

e) Full-time Ph.D. scholars in the Science Departments with M.Sc. qualifications can be permitted to convert their registration from full-time to part-time after two years or after completion of course work and comprehensive examination, whichever is later, if they get employed in the Institute's sponsored projects. Such conversion will be permissible only if the work is in the Projects of the Institute and not for employment outside. This provision will also be applicable to the Ph.D. scholars having B.Tech. Degree.

Grant of Leave and Attendance Requirements for Ph.D. Students

Leave

(a) **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. He/she will not be entitled to mid-semester breaks, summer and winter vacations. 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 upto additional 30 days will be granted only once during the programme of the scholar.

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.

(b) **After Completing the Course Work :** A full-time Ph.D. student during his/her stay at the Institute, will be entitled to leave for 30 days per academic year. He/she will not be entitled to mid-semester breaks, summer and winter vacations. 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.

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

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.

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 during that semester if the progress is 'satisfactory'.

(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 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 GPA not below 7.50 and has also cleared the comprehensive examination.

(c) He/she has submitted at least two months previously, the title and a synopsis of the thesis.

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 develop-ment, or a combination of them. It should bear evidence of the candidate's capacity for analysis and judgement and also his ability to carry out independent investigation, design or development. A thesis may be supplemented by published work, if necessary. 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 of 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 6 to 8, 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 have passed before submission of the thesis.

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 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 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 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

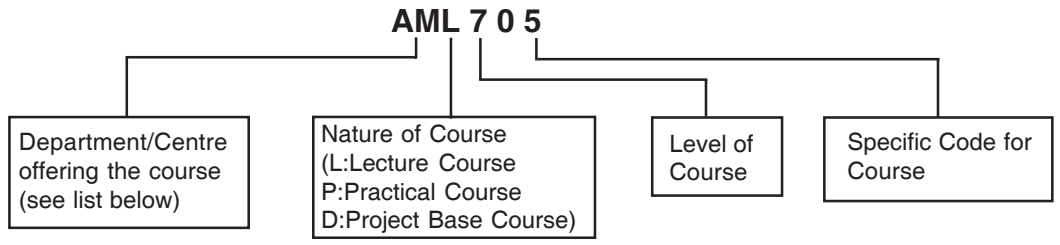
(b) any additional work required can be adequately supervised.

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.

Course Numbering

Course Numbers are denoted by six characters:



Typically, courses whose three numerals are between 500 and 899 are taken by postgraduate students; detailed course descriptions of all these courses are given in this booklet.

Course Category

Letter symbols for course categories are:

PC : Programme Core **PE : Programme Elective** **OE : Open Elective**

Code	**Name of Department or Centre**
AM	Department of Applied Mechanics.
AS	Centre for Atmospheric Sciences.
BE	Department of Biochemical Engineering & Biotechnology.
BM	Centre for Biomedical Engineering.
CH	Department of Chemical Engineering.
CY	Department of Chemistry.
CE	Department of Civil Engineering.
CR	Centre for Applied Research in Electronics.
CS	Department of Computer Science & Engineering.
EE	Department of Electrical Engineering.
ES	Centre for Energy Studies.
HU	Department of Humanities and Social Sciences.
ID	Centre for Instrument Design and Development.
IT	Centre for Industrial Tribology, Machine Dynamics and Maintenance Engineering.
SM	Department of Management Studies.
MA	Department of Mathematics.
ME	Department of Mechanical Engineering.
PH	Department of Physics.
PT	Centre for Polymer Science and Technology.
RD	Centre for Rural Development & Technology.
TT	Department of Textile Technology.
VE	National Resource Centre for Value Education in Engineering.
SI	Amar Nath and Shashi Khosla School of Information Technology.
BS	Bharti School of Telecommunication Technology and Management.

(Note : A course code starting with "J" indicates Interdisciplinary Programme Code.)

Contact Hours and Credits

The number of credits and contact hours per week are given after the course number and title:

AML 705 Finite Element Methods : *4 credits (3-0-2)*

4 credit course **3** h Lectures **0** h Tutorial **2** h Practical

Per week

Requirements and Scheduling of Courses for M.Tech. Programme

Name of the M.Tech. Programme	Engineering Mechanics

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
45	9	6	60

Scheduling of Courses

S.No.	Course No.		Title	Type L-T-P	Credits
		Semester I			
1.	AML711	Advanced Fluid Mechanics	PC	3-1-0	4
2.	AML731	Applied Elasticity	PC	3-1-0	4
3.	AML750	Modern Engineering Materials	PC	3-0-0	3
4.	AML702	Applied Computational Methods	PC	3-0-2	4
5.	AML734	Advanced Dynamics	PC	3-1-0	4
		Total Credits			19
		Semester II			
1.	AML705	Finite Element Methods	PC	3-0-2	4
2.	AML700	Experimental Medhods for Solid and Fluids	PC	3-0-2	4
3.		Programme Elective I	PE	3-0-0	3
4.		Programme Elective II	PE	3-0-0	3
5.		Open Elective I	OE	3-0-0	3
		Total Credits			17
		Semester III			
1.		Programe Elective III	PE	3-0-0	3
2.		Open Elective II	OE	3-0-0	3
3.	AMD811	Major Project Part 1	PC	0-0-12	6
		Total Credits			12
		Semester IV			
1.	AMD812	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

List of program Electives

S.No.	Course No.	Title	L-T-P	Credits
1.	AML712	Numerical Methods in Fluid Flows	3-0-0	3
2.	AML811	Advanced Computational Fluids Dynamics	3-0-0	3
3.	AML812	Turbulent Shear Flows	3-0-0	3
4.	AML814	Fluid Transportation Systems	3-0-0	3
5.	AML831	Theory of Plates and Shells	3-0-0	3
6.	AML833	Applied Plasticity	3-0-0	3
7.	AML835	Mechanics of Composite Materials	3-0-0	3
8.	AML851	Fracture Mechanics	3-0-0	3
9.	AMS801	Independent Study	0-3-0	3

Name of the M.Tech. Programme	Design Engineering

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
45	9	6	60

Scheduling of Courses

S.No.	Course No.		Title	Type L-T-P	Credits
		Semester I			
1.	AML771	Decision Theory & Design Optimization	PC	3-0-0	3
2.	AMP772	Feasibility Study	PC	1-0-4	3
3.	AML773	Modelling & Analysis - 1	PC	3-0-0	3
4.	AML775	Design Methods	PC	3-0-0	3
5.	AMP776	Products Design - 1	PC	1-0-4	3
6.	AML710	Computer Aided Design	PC	3-0-2	4
		Total Credits			19
		Semester II			
1.	AML774	Modelling & Analysis - II	PC	3-0-0	3
2.	AMP777	Products Design Project - II	PC	0-0-4	2
3.	AML 883	Properties & Selection of Engg. Materials	PC	3-0-0	3
4.		Programme Elective I	PE	3-0-0	3
5.		Programme Elective II	PE	3-0-0	3
6.		Open Elective I	OE	3-0-0	3
		Total Credits			17
		Semester III			
1.		Programe Elective III	PE	3-0-0	3
2.		Open Elective II	OE	3-0-0	3
3.	AMD813	Major Project Part 1	PC	0-0-12	6
		Total Credits			12
		Semester IV			
1.	AMD814	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

List of program Electives

S.No.	Course No.	Title	L-T-P	Credits
1.	AML700	Experimental Methods for Solids & Fluids	3-0-2	4
2.	AML734	Advanced Dynamics	3-1-0	4
3.	AML835	Mechanics of Composite Materials	3-0-0	3
4.	AML852	Engineering Failure Analysis & Prevention	3-0-0	3
5.	AML871	Product Reliability & Maintenance	3-0-0	3
6.	AML873	Design for Production	3-0-0	3
7.	CEL717	Advanced Structural Analysis	3-0-0	3
8.	DIL713	Design for Sustainable Development	3-0-0	3
9.	DIP741	Product form & Aesthetics	1-0-4	3
10.	EEL781	Neural Networks	3-0-0	3
11.	EEL801	Micro-Processor based Design	3-0-0	3
12.	MEL731	Design of Mechanism & Manipulators	3-0-2	4
13.	MEL749	Mechatronic product Design	3-0-2	4
14.	AMS802	Independent Study	0-3-0	3

Name of the M.Tech. Programme	Process Engineering and Design

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
40	14	6	60

Scheduling of Courses

S.No.	Course No.		Title	Type L-T-P	Credits
		Semester I			
1.	CHL701	Process Engineering	PC	3-0-2	4
2.	CHL724	Environmental Engineering and Waste Management	PC	3-1-0	4
3.	CHL723	Chemical Reaction & Reactor Engineering	PC	3-0-0	3
4.		Programme Elective I	PE		3
5.		Programme Elective II	PE		3
6.		Open Elective I	OE		0
		Total Credits			17-21
		Semester II			
1.	CHL702	Plant Design	PC	3-0-2	4
2.	CHL735	Design of Separation Process	PC	3-0-2	4
3.	CHD760	Minor Project	PC	0-0-6	3
4.		Programme Elective III	PE		
5.		Programme Elective IV	PE		
6.		Programme Elective V	PE		
7.		Open Elective II	OE		
		Total Credits			17-21
		Semester III			
1.	CHD770	Major Project Part 1	PC	0-0-12	6
2.		Programme Elective VI	PE		4
3.		Programme Elective VII	PE		
4.		Open Elective III	OE		
		Total Credits			12-14
		Semester IV			
1.	CHD780	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

List of Program Electives

	Course No.	Title	L-T-P	Credits
1.	CHL626	Multiphase Contactors	3-0-0	3
2.	CHL653	Application of Programming in Chemical Engineering	3-0-2	4
3.	CHL705	Electrokinetic Transport in Chemical Engineering	3-0-2	4
4.	CHL813	Thermodynamics and process design	2-0-2	3
5.	CHL717	Mechanical design of process equipment	3-0-2	4
6.	CHL794*	Petroleum Refinery Engineering	3-0-2	4
7.	CHL604	Fluid Solid Reaction Engineering	3-0-2	4
8.	CHL710	Process Dynamics and Control	3-1-2	5
9.	CHL751	Multicomponent Mass Transfer	3-0-0	3
10.	CHP711*	Process Development Lab	0-0-6	3
11.	CHL714	Advanced Heat Transfer	3-0-0	3
12.	CHL761*	Chemical Engineering Mathematics	3-0-0	3
13.	CHS780	Independent Study	0-3-0	3

* Course details may be had from the Programme Coordinator.

Name of the M.Tech. Programme	Modern Methods of Chemical Analysis

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
42	12	6	60

Scheduling of Courses

Semester I					
S.No.	Course No.		Title	Type L-T-P	Credits
1.	CYL701	Electro-analytical Chemistry	PC	3-0-4	5
2.	CYL703	Spectrochemical Methods	PC	3-0-4	5
3.		Program Elective - I	PE	3-0-0	3
4.		Program Elective - II	PE	3-0-0	3
				Total	16
Semester II					
1.	CYL702	Chemical Seperations	PC	3-0-4	5
2.	CYL704	Chemical Computations	PC	2-0-2	3
3.	CYD799	Minor Project	PC	0-0-6	3
4.		Programme Elective III	PE	3-0-0	3
5.		Open Elective I	OE	3-0-0	3
6.		Open Elective II	OE	3-0-0	3
				Total	20
Semester III					
1.	CYP803	Glass Blowing	PC	0-0-2	1
2.	CYC805	Seminar	PC	0-2-0	2
3.		Programme Elective IV	PE	3-0-0	3
4.	CYD801	Major Project Part 1	PC	0-0-12	6
				Total	12
Semester IV					
1.	CYD802	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

List of program Electives

S.No.	Course No.	Title	L-T-P	Credits
1.	CYL705	Environmental Analytical Chemistry	3-0-0	3
2.	CYL707	Electronics and Chemical Instrumentation	3-0-0	3
2.	CYL711	X-ray and Electron Microscopic Methods	3-0-0	3
3.	CYL712	Characterization of Surfaces	3-0-0	3
4.	CYL713	Characterization of Polymers	3-0-0	3
5.	CYL714	NMR and Mass Spectrometric Methods	3-0-0	3
6.	CYL715	Bio-analytical chemistry	3-0-0	3
7.	CYL716	Data Analysis, Experimental Design and Chemometrics	3-0-0	3
8.	CYL717	Principles of Chemical and Bio sensors	3-0-0	3
9.	CYL718	On Line Methods of Chemical Analysis	3-0-0	3
11.	CYS800	Independent Study	0-3-0	3

Name of the M.Tech. Programme	Geotechnical and Geoenvironmental Engineering

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
45	9	6	60

Scheduling of Courses

Semester I					
S.No.	Course No.		Title	Type L-T-P	Credits
1.	CEL701	Engineering Behaviour of Soils	PC	3-0-0	3
2.	CEL703	Site Investigations and Ground Improvement	PC	3-0-0	3
3.	CEL705	Geoenvironmental Engineering	PC	3-0-0	3
4.	CEP701	Soil Engineering Laboratory	PC	0-0-6	3
5.		Programme Elective - I	PE	3-0-0	3
6.		Open Elective - I	OE	3-0-0	3
		Total Credits			18
Semester II					
1.	CEL704	Shallow and Deep Foundations	PC	3-0-0	3
2.	CEL702	Slope Stability and Earth Dams	PC	3-0-0	3
3.	CEL708	Earth Pressures and Retaining Structures	PC	3-0-0	3
4.	CEL706	Geosynthetics	PC	3-0-0	3
5.	CEP702	Geoenvironmental & Geotechnical	PC	0-0-6	3
	Or	Engineering Laboratory			
	CED701	Minor Project (Only for PT students)	PC	0-0-6	3
6.		Programme Elective-II	PE	3-0-0	3
		Total Credits			21
Semester III					
1.		Programme Elective - III	PE	3-0-0	3
2.		Open Elective II	OE	3-0-0	3
3.	CED811	Major Project Part 1	PC	0-0-12	6
		Total Credits			12
Semester IV					
1.	CED812	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

List of Program Electives

	Course No.	Title	L-T-P	Credits
1.	CEL760	Finite Element Method in Geotechnical Engineering	3-0-0	3
2.	CEL709	Offshore Geotechnical Engineering	3-0-0	3
3.	CEL707	Soil Dynamics and Geotechnical Earthquake Engineering	3-0-0	3
4.	CEL714	Special Topics in Geotechnical and Geoenvironmental Engineering	3-0-0	3
5.	CEL712	Landfills and Ash Ponds	3-0-0	3
6.	CEL715	Soil Structure Interaction Analysis	3-0-0	3
7.	CEL614	Geoenvironmental and Geohazard Engineering*	3-0-0	3
8.	CEL610	Foundation Engineering*	3-0-0	3
9.	CEL612	Construction Methods in Geotechnical Engineering+	3-0-0	3
10.	CES840	Independent Study	0-3-0	3

* for other specializations only

\+ for Construction Technology and Management Programme only.

Name of the M.Tech. Programme	Rock Engineering and Underground Structures

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
45	9	6	60

Scheduling of Courses

S.No.	Course No.	Title	Type	L-T-P	Credits
		Semester I			
1.	CEL751	Engineering Properties of Rocks and Rock Masses	PC	3-0-0	3
2.	CEL753	Structural Geology	PC	2-0-2	3
3.	CEL757	Field Exploration and Insitu Measurements	PC	3-0-0	3
4.	CEP751	Rock Mech. Lab - 1	PC	0-0-6	3
5.	CEL754	Geotech Processes in Rock Engineering	PC	3-0-0	3
6.		Programme Elective - 1	PC	3-0-0	3
		Total Credits			16
		Semester II			
1.	CEL752	Slopes and Foundations	PC	3-0-0	3
2.	CEL758	Analysis and Design of Underground Structures	PC	3-0-0	3
3.	CEL756	Excavation Methods and Machinery	PC	3-0-0	3
4.	CEP752/ CED760	Rock Lab - II (OR) Minor Project (Only for PT students	PC	0-0-6	3
5.		Open Elective- I	OE	3-0-0	3
6.		Programme Elective-II	PE	3-0-0	3
		Total Credits			18
		Semester III			
1.	CED851	Major Project, Part 1	PC	0-0-12	6
2.		Open Elective - II	OE	3-0-0	3
3.		Programme Elective - III	PE	3-0-0	3
		Total Credits			12
		Semester IV			
1.	CED852	Major Project, Part 2	PC	0-0-24	12
		Total Credits			12

List of Program Electives

S.No.	Course No.	Title	L-T-P	Credits
1.	CEL760	Finite Element Method in Geotechnical Engineering	3-0-0	3
2.	CEL761	Underground Space Technology	3-0-0	3
3.	CEL762	Special Topics in Rock Engineering	3-0-0	3
4.	CEL763	Environmental Rock Engineering	3-0-0	3
5.	CEL801	Advanced Rock Mechanics	3-0-0	3
6.	CEL651	Rock Engineering*	3-0-0	3
7.	CES850	Indepenent Study	0-3-0	3

* To be offered to other specializations in Civil Engineering.

Name of the M.Tech. Programme	Structural Engineering

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
42	12	06	60

Scheduling of Courses

Semester I					
S.No.	Course No.	Course Title	Type	L-T-P	Credits
1.	CEL717	Advanced Structural Analysis	PC	3-0-0	3
2.	CEL719	Structural Dynamics	PC	3-0-0	3
3.	CEL721	Design of Concrete Structures	PC	2-1-0	3
4.	CEL733	Finite Element Methods in Structural Engg.	PC	3-0-0	3
5.		Programme Elective I	PE	2-1-0	3
6.		Open Elective I	OE	3-0-0	3
		Total Credits			18
Semester II					
1.	CEL718	Design of Steel Structures	PC	2-1-0	3
2.	CEL722	Solid Mechanics in Structural Engineering	PC	3-0-0	3
3.	CEL724	Earthquake Analysis and Design	PC	3-0-0	3
4.	CEP726	Structural Engineering Lab.	PC	0-0-6	3
5.		Programme Elective II	PE	3-0-0	3
6.		Open Elective II	OE	3-0-0	3
		Total Credits			18
Semester III					
1.		Programme Elective III	PE	3-0-0	3
2.		Programme Elective IV	PE	3-0-0	3
3.	CED821	Major Project Part 1	PC	0-0-12	6
		Total Credits			12
Semester IV					
1.	CED822	Major Project, Part 2	PC	0-0-24	12
		Total Credits			12

List of Program Electives

S.No.	Course No.	Title	L-T-P	Credits
1.	CEL727	Design of Industrial Structures	2-1-0	3
2.	CEL729	Advanced Design of Bridges	2-1-0	3
3.	CEL731	Prestressed/Composit Structures	3-0-0	3
4.	CEL734	Mathematical and Numerical Methods	2-1-0	3
5.	CEL817	Structural Safety and Reliability	3-0-0	3
6.	CEL819	Concrete Machanics	3-0-0	3
7.	CEL771	Civil Engineering Materials	3-0-0	3
8.	CEL818	Design of Plates and Shells	2-1-0	3
9.	CEL832	Design of Tall Buildings	2-1-0	3
10.	CEL824	Design of Offshore Structures	2-1-0	3
11.	CEL826	Advanced FEM and Programming	2-0-2	3
12.	CEL828	Wind Resistant Design of Structures	3-0-0	3
13.	CES822	Stability Theory in Structural Engineering	3-0-0	3
14.	CES820	Independent Study	0-3-0	3

Name of the M.Tech. Programme	Water Resources Engineering

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
40	15	6	61

Scheduling of Courses

Semester I					
S.No.	Course No.	Title	Type	L-T-P	Credits
1.	CEL735	Hydrologic Processes & Modeling	PC	3-0-0	3
2.	CEL737	Optimization Techniques in Water Resources	PC	3-0-0	3
3.	CEL739	Groundwater Hydrology	PC	3-0-0	3
4.	CEP740	Simulation Laboratory I	PC	1-0-6	4
5.	CEL741	Surface Water Quality Modeling & Control	PC	3-0-0	3
6.		Programme Elective - I	PE	3-0-0	3
7.		Programme Elective - II	PE	3-0-0	3
				Total	19
Semester II					
1.	CEL738	Advanced Hydraulics	PC	3-0-0	3
2.	CEL742	Finite Element in Water Resources	PC	3-0-0	3
3.		Program Elective-III	PE	3-0-0	3
4.		Program Elective-IV	PE	3-0-0	3
5.		Program Elective-V	PE	3-0-0	3
6.		Open Elective-I	OE	3-0-0	3
		Total Credits		Total	18
Semester III					
1.	CED841	Major Project Part 1	PC	0-0-12	6
2.		Programme Elective - VI	PE	3-0-0	3
3.		Open Elective - II	OE	3-0-0	3
		Total Credits		Total	12
Semester IV					
1.	CED842	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

List of Program Electives

S.No.	Course No.	Title	L-T-P	Credits
1.	CEL736	Environmental Dynamics & Management	3-0-0	3
2.	CEL743	Economic Aspects of Water Resources Development	3-0-0	3
3.	CEL744	Groundwater Flow and Pollution Modelling	3-0-0	3
4.	CEL745	Water Management	3-0-0	3
5.	CEL746	Hydroelectric Engineering	3-0-0	3
6.	CEL747	Geographical Information System (GIS)	2-0-2	3
7.	CEL748	Hydrologic Applications of Remote Sensing Technology	2-0-2	3
8.	CEL749	Water Resources Systems	3-0-0	3
9.	CEL840	Stochastic Hydrology	3-0-0	3
10.	CEP724	Water Resources Management Lab.	1-0-4	3
11.	CES840	Independent Study	0-3-0	3

Name of the M.Tech. Programme	Construction Engineering and Management

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
42	12	06	60

Scheduling of Courses

S.No.	Course No.	Title	Type	L-T-P	Credits
		Semester I			
1.	CEL769	Project Planning and Control	PC	2-1-0	3
2.	CEL772	Quantitative Methods in Construction Management	PC	2-1-0	3
3.	CEL771	Civil Engineering Materials	PC	3-0-0	3
4.	CEL774	Construction Engineering Practices	PC	3-0-0	3
5.		Programme Elective - (I)	PE	3-0-0	3
6.		Open Elective - (I)	OE	3-0-0	3
		Total Credits			18
		Semester II			
1.	CEL778	Construction Methods and Equipments	PC	3-0-0	3
2.	CEL767	Construction & Contract Management	PC	3-0-0	3
3.	CEL779	Construction Economics & Finance	PC	3-0-0	3
4.	CEP775	Construction Engineering and Information Technology Lab	PC	0-0-6	3
5.		Programme Elective (II)	PE	3-0-0	3
6.		Programme Elective (III)	PE	3-0-0	3
		Total Credits			18
		Semester III			
1.		Programme Elective (IV)	PE	3-0-0	3
2.		Open Elective - (II)	OE	3-0-0	3
3.	CED871	Major Project - I	PC	0-0-12	6
		Total Credits			12
		Semester IV			
1.	CED872	Major Project - II	PC	0-0-24	12
		Total Credits			12

List of Program Electives

S.No.	Course No.	Title	L-T-P	Credits
1.	CEL766	Systems Design and Value Analysis	3-0-0	3
2.	CEL768	Recent Advances in Construction Materials	3-0-0	3
3.	CEL773	Management of Quality and Safety in Construction	2-1-0	3
4.	CEL776	Functional Planning, Building Services and Maintenance Management	3-0-0	3
5.	CEL777	Building Science	3-0-0	3
6.	CES870	Independent Study	0-3-0	3

Name of the M.Tech. Programme	Construction Technology and Management

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
42	09	09	60

Scheduling of Courses

Semester I					
S.No.	Course No.	Title	Type	L-T-P	Credits
1.	CEL773	Management of Quality and Safety in Construction	PC	2-1-0	3
2.	CEL769	Project Planning and Control	PC	2-1-0	3
	CEL774*	Construction Engineering Practices		3-0-0	3
3.	ITL709**	Maintenance Planning & Control	PC	3-0-0	3
	EEL***	Power System Protection		3-0-0	3
4.		Programme Elective (I) from respective discipline	PE	3-0-0	3
5.	CEL772	Quantitative Methods in Construction Management	PC	2-1-0	3
6.		Open Elective (I)	OE	3-0-0	3
		Total Credits			18
Semester II					
1.	CEL778	Construction Methods and Equipments	PC	3-0-0	3
2.	CEL767	Construction & Contract Management	PC	3-0-0	3
3.	CEP 770	Computational Laboratory for Construction Management	PC	0-0-6	3
4.	CEL779	Construction Economics & Finance	PC	3-0-0	3
5.		Programme Elective (II) from respective discipline	PE	3-0-0	3
6.		Open Elective (II)	OE	3-0-0	3
		Total Credits			18
Semester III					
1.		Programme Elective (III) from respective discipline	PE	3-0-0	3
2.		Open Elective (III)	OE	3-0-0	3
3.	CED875	Major Project Part 1	PE	0-0-12	6
		Total Credits			12
Semester IV					
1.	CED876	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

* For Civil Engg. background students. **For Mechanical Engg. background students.
*** For Electrical Engg. background students

List of Programme Electives for Construction Technology & Management

Civil Engineering Courses

S.No.	Course No.	Course Title	L-T-P	Credits
1.	CEL766	Systems Design and Value Analysis	3-0-0	3
2.	CEL768	Recent Advances in Construction Materials	3-0-0	3
3.	CEL771	Civil Engineering Materials	3-0-0	3
4.	CEL776	Functional Planning, Building Services and Maintence Management	3-0-0	3
5.	CEL777	Building Science	3-0-0	3
6.	CEL612	Construction Methods in Geotechnical Engineering	3-0-0	3
7.	CES874	Independent Study	0-3-0	3

Mechanical Engineering Courses

S.No.	Course No.	Course Title	L-T-P	Credits
1.	ITL752	Bulk Solids Handling	2-1-0	3
2.	MEL661	Materials Management	2-0-2	3
3.	MEL674	Principles of Management	3-0-0	3
4.	MEL710	Air Conditioning	3-0-2	4
5.	MEL711	Refrigeration & Air-conditioning Technology	3-0-2	4
6.	MEL752	Quality Assurance	3-0-2	4
7.	MEL754	Operations Planning and Control	3-0-2	4
8.	MEL778	Design & Metallurgy of Welded Joints	3-0-2	4
9.	MEL787	Welding and Allied Processes	3-0-2	4
10.	MEL808	Refrigeration Systems & Component Design	2-0-4	4
11.	MEL866	Maintenance Management	3-0-0	3

Electrical Engineering Courses

S.No.	Course No.	Course Title	L-T-P	Credits
1.	EEL743	Power Electronics Devices and DC Converters	3-0-0	3
2.	EEL744	AC Controllers	3-0-0	3
3.	EEL745	Electrical Drives System	3-0-0	3
4.	EEL746	Non-conventional Energy Systems & Energy Conservation	3-0-0	3
5.	EEL747	Electrical Systems for Construction Industries	3-0-2	4
6.	EEL790	Power System Control and Instrumentation	3-0-0	3
7.	EEL791	Power System Analysis	3-0-0	3
8.	EEL794	High Voltage DC Transmission	3-0-0	3
9.	EEL841	Solid State Control of Drives	3-0-0	3
10.	EEL845	Special Electromechanical Devices	3-0-0	3
11.	EEL891	Selected Topics in Power Systems	3-0-0	3
12.	EEL899	Distribution Automation	3-0-0	3
13.	EEP841	Electrical Machines Laboratory	0-0-3	1.5
14.	EEP842	Power Electronics Laboratory	0-0-3	1.5
15.	EEP843	Electric Drives Laboratory	0-0-3	1.5

Name of the M.Tech. Programme	Environmental Engineering & Management

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
42	12	6	60

Semester-wise Schedule

Semester I					
S.No.	Course No.	Title	Type	L-T-P	Credits
1.	CEP789	Environmental Chemistry and Microbiology	PC	1-0-4	3
2.	CEL795	Water and Wastewater Treatment Processes	PC	3-0-0	3
3.	CEL793	Air Pollution and Control	PC	3-0-2	4
4.	CEL886	Environmental Systems Analysis	PC	3-0-2	4
5.		Programme Elective - I	PE	3-0-0	3
6.		Open Elective - I*	OE		3
		Total Credits			17-20
Semester II					
1.	CEL796	Advance Wastewater Treatment	PC	3-0-0	3
2.	CEP790	Advance Environmental Engineering Laboratory	PC	1-0-6	4
3.	CEL794	Solid and Hazardous Waste Management	PC	3-0-0	3
		Programme Elective (One/Two)			
4.		Programme Elective II	PE	3-0-0	3
5.		Programme Elective III	PE	3-0-0	3
6.		Open Elective - II*	OE	3-0-0	3
		Total Credits			16-19
Semester III					
		Programme Elective (One/Two)			
1.		Programme Elective IV	PE	3-0-0	3
2.		Programme Elective V	PE	3-0-0	3
3.		Open Elective -III*	OE		3
4.	CED891	Major Project Part 1	PC	0-0-12	6
		Total Credits			12-15
Semester IV					
1.	CED892	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

List of Program Electives

S.No.	Course No.	Title	L-T-P	Credits
1.	CEL797	Environmental Impact Assessment	3-0-0	3
2.	CEL879	Industrial Waste Management and Audit	3-0-0	3
3.	CEL889	Emerging Technologies for Environmental Management	3-0-0	3
4.	CEL891	Thermal Techniques for Waste Treatment	3-0-0	3
5.	CEL892	Air Quality Modelling	3-0-0	3
6.	CEL894	Management of Water, Waste and Sanitation Utilities	3-0-0	3
7.	CEL895	Ecology and Eco System Dynamics	3-0-0	3
8.	CEL896	Design of Water and Wastewater Facilities	3-0-0	3
9.	CEL897	Membrance Processes for Water and Waste Treatment	3-0-0	3
10.	CEL898	Life Cycle Analysis and Design for Environment	3-0-0	3
11.	CEL899	Environmental Risk Assessment	3-0-0	3
12.	CES890	Independent Study	0-3-0	3

* any two out of 3 OEs.

Name of the Programme	Transportation Engineering

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
41	12	9	62

Semester-wise Distribution of Credits:

Semester I	Semester II	Semester III	Semester IV	Total Credits
19	19	12	12	62

Table 1: Scheduling of Courses

Semester I						
S.No.	Course No.	Course Title	Type	L-T-P	Total	Prerequisite
I-1.	CEL772	Quantitaive Methods in Construction Management	PC	2-1-0	3	None
I-2.	CEL781	Urban and Regional Transportation Planning	PC	2-0-2	3	None
I-3.	CEL782	Pavement Materials and Construction Techniques	PC	2-0-2	3	None
I-4.	CEL783	Traffic Engineering	PC	3-0-2	4	None
I-5.		Programme Elective-I (PE-I)	PE		3	
I-6.		Open Elective - I*	OE		3	
		Total Credits	-	-	19	
Semester II						
II-1.	CEL784	Design and Maintenance of Pavements	PC	3-0-2	4	CEL 782 or#
II-2.	CEL785	Advanced Transportation Modelling	PC	2-0-2	3	CEL 781 or#
II-3.	CEL786	Geometric Design of Streets and Highways	PC	2-0-2	3	CEL 783 or#
II-4.		Programme Elective-II (PE-II)	PE		3	
II-5.		Programme Elective-III (PE-III)	PE		3	
II-6.		Open Elective - II*	OE		3	
		Total Credits			19	
Semester III						
III-1.		Programme Elective-IV (PE-IV)	PE		3	
III-2.		Open Elective-III	OE		3	
III-3.	CED881	Major Project Part 1	PC	0-0-12	6	
		Total Credits			12	
Semester IV						
IV-1.	CED 882	Major Project Part 2	PC	0-0-24	12	
		Total Credits			12	

Table 2: Elective Courses

A List of Programme Electives for M.Tech. Transportation Engineering

S.No.	Course No.	Title	L-T-P	Credits	Group	Prerequisite
1.	CEL787	Transportation Safety and Environment	3-0-0	3	PE-I & PE-IV	None
2.	CEL788	Public Transportation Systems	3-0-0	3	PE-I & PE-IV	CEL 781 or#
3.	CEL789	Transportation Systems Management	3-0-0	3	PE-I & PE-IV	None
4.	CEL843	Traffic Engineering & Simulation	2-0-2	3	PE-II & PE-III	CEL 783 or CEL 786
5.	CEL844	Transportation Economics and Finance	3-0-0	3	PE-II & PE-III	None
6.	CEL845	Transportation and Traffic Infrastructure Design	3-0-0	3	PE-II & PE-III	CEL 786 or#
7.	CEL729	Advanced Design of Bridges	2-1-0	3	PE-I & PE-IV	CEL 786 or#
8.	CES880	Independent Study	0-3-0	3		

Consent of Instructor

Name of the M.Tech. Programme	Computer Science & Engineering

Distribution of Total Credits
Minimum limits given for elective categories

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
40	14	6	60

Scheduling of Courses

		Semester I			
S.No.	Course No.	Course Title	Type	L-T-P	Credits
1.	CSL665	Introduction to Logic and Functional Programming	PC	3-0-2	4
2.	CSL630	Date Structures and Algorithms	PC	3-0-2	4
3.	CSP601	Sofware Systems Laboratory	PC	0-0-6	3
4.		Programme Elective - 1	PE	3-0-2	4
5.		Open Elective - 1	OE	3-0-0	3
		Total Credits			18
		Semester II			
1.	CSL758	Advanced Algorithms	PC	3-0-0	3
2.	CSL718	Architecture of High Performance Computer Systems	PC	3-0-2	4
3.	CSD745	Minor Project	PC	0-1-6	4
4.		Programme Elective-2	PE	3-0-2	4
5.		Open Elective-2	OE	3-0-0	3
		Total Credits			18
		Semester III			
1.		Programme Elective-3	PE	3-0-0	3
2.		Programme Elective-4	PE	3-0-0	3
3.	CSD893	Major Project Part 1	PC	3-0-12	6
		Total Credits			12
		Semester IV			
1.	CSD894	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

Notes :

The schedule as presented is only indicative of how a typical student may register for courses, but allows considerable flexibility to the student of choice of when to register for programme and open electives.

Select students who wish to conduct their project work outside Delhi, e.g. those in special academic exchange programmes, may, on approval, swap the Minor project with an OE/PE course usually taken in Semester III, and may also register for an additional OE/PE course in the Semester II. The Minor Project and Independent Study courses may be taken in the summer in these special cases.

600 level courses are not available to undergraduate and dual degree students.

600 level programme elective courses may be taken by students only an approval of M.Tech coordinator, since these are courses typically in undergraduate curricula, which are made available to PG students who have taken equivalent courses earlier.

List of Program Electives Courses for M.Tech. Progromme in Computer Science and Engineering

S.No.	Course No.	Title	L-T-P	Credits
1.	CSL632	Introduction To Database System	3-0-2	4
2.	CSL633	Resource Management in Computer Systems	3-0-2	4
3.	CSL671	Artifical Intelligence	3-0-2	4
4.	CSL672	Computer Networks	3-0-2	4
5.	CSL719	Synthesis of Digital Systems	3-0-2	4
6.		CSL728Compiler Design	3-0-3	4.5
7.	CSL740	Software Engineering	3-0-2	4
8.	CSL750	Foundations of Automatic Verification	3-0-2	4
9.	CSL755	Mathematics Foundations of Computer Science	3-0-0	3
10.	CSL771	Database Implementation	3-0-2	4
11.	CSL781	Computer Graphics	3-0-3	4.5
12.	CSL783	Digital Image Analysis	3-0-3	4.5
13.	CSS799	Independent Study	0-3-0	3
14.	CSL812	System Level Design and Modelling	3-0-0	3
15.	CSL821	Reconfigurable Computing	3-0-0	3
16.	CSL830	Distributed Computing	3-0-0	3
17.	CSL831	Semantics of Programming Languages	3-0-0	3
18.	CSL832	Proof and Types	3-0-0	3
19.	CSL840	Computer Vision	3-0-2	4
20.	CSL847	Distributed Algorithms	3-0-0	3
21.	CSL851	Algorithmic Graph Theory	3-0-0	3
22.	CSL852	Computational Geometry	3-0-2	4
23.	CSL853	Complexity Theory	3-0-0	3
24.	CSL854	Approximation Algorithms	3-0-0	3
25.	CSL855	Mathematical Foundations of Computing	3-0-0	3
26.	CSL856	Mathematical Programming	3-0-2	4
27.	CSL858	Advanced Computer Networks	3-0-2	4
28.	CSL859	Advanced Computer Graphics	3-0-2	4
29.	CSL860	Special Topics in Parallel Computation	3-0-0	3
30.	CSL861	Special Topics in Hardware Systems	3-0-0	3
31.	CSL862	Special Topics in Software Systems	3-0-0	3
32.	CSL863	Special Topics in Theoretical Computer Science	3-0-0	3
33.	CSL864	Special Topics in Artificial Intelligence	3-0-0	3
34.	CSL865	Special Topics in Computer Applications	3-0-0	3
35.	CSL866	Special Topics in Algorithms	3-0-0	3
36.	CSL867	Special Topics in High Speed Networks	3-0-0	3
37.	CSL868	Special Topics in Database Systems	3-0-0	3
38.	CSL869	Special Topics in Concurrency	3-0-0	3
39.	CSV880	Special Module in Parallel Computation	1-0-0	1
40.	CSV881	Special Module in Hardware Systems	1-0-0	1
41.	CSV882	Special Module in Software Systems	1-0-0	1
42.	CSV883	Special Module in Theoretical Computer Science	1-0-0	1
43.	CSV884	Special Module in Artificial Intelligence	1-0-0	1
44.	CSV885	Special Module in Computer Applications	1-0-0	1
45.	CSV886	Special Module in Algorithms	1-0-0	1
46.	CSV887	Special Module in High Speed Networks	1-0-0	1
47.	CSV888	Special Module in Database Systems	1-0-0	1
48.	CSV889	Special Module in Concurrency	1-0-0	1

Name of the M.Tech. Programme	Communications Engineering

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
40	12	09	61

Scheduling of Courses

S.No.	Course No.	Title	Type	L-T-P	Credits
		Semester I			
1.	EEL711	Signal Theory	PC	3-0-0	3
2.	EEL713	Microwave theory and circuits	PC	3-0-0	3
3.	EEP717	Communication lab. - I	PC	0-0-4	2
4.	EEP719	Communication lab. - II	PC	0-0-4	2
5.	EEL762	Digital communications	PC	3-0-0	3
6.	EEL731	Digital signal processing	PC	3-0-0	3
7.		Programme Elective - I	PE	3-0-0	3
		Total Credits			19
		Semester II			
1.	EED860	Minor project	PC	0-0-6	3
2.	EEL768	Detection and estimation	PC	3-0-0	3
3.		Programme Elective-II	PE	3-0-0	3
4.		Programme Elective-III	PE	3-0-0	3
5.		Open Elective-I	OE	3-0-0	3
6.		Open Elective-II	OE	3-0-0	3
		Total Credits			18
		Semester III			
1.	EED861	Major Project Part 1	PC	0-0-12	6
2.		Programme Elective-IV	PE	3-0-0	3
3.		Open Elective	OE	3-0-0	3
		Total Credits			12
		Semester IV			
1.	EED862	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

List of Program Electives

S.No.	Course No.	Title	L-T-P	Credits
1.	EEL703	Computer networks	3-0-0	3
2.	EEL710	Coding theory	3-0-0	3
3.	EEL718	Statistical signal processing	3-0-0	3
4.	EEL760	Antenna theory & techniques	3-0-0	3
5.	EEL766	Numerical techniques in electromagnetics	3-0-0	3
6.	EEL812	Millimetre wave integrated circuits	3-0-0	3
7.	EEL716	Telecommunication Switching & Transmission	3-0-0	3
8.	EEL763	Monolithic microwave integrated circuits & technology	3-0-0	3
9.	EEL861	Selected topics in communication engg.-I	3-0-0	3
10.	EEL862	Selected topics in communication engg.-II	3-0-0	3
11.	EEL863	Selected topics in communication engg.-III	3-0-0	3
12.	EEL864	Modern antennas and arrays	3-0-0	3
13.	EEL865	Microwave propagation & systems	3-0-0	3
14.	EEL866	Microwave solid state devices & circuits	3-0-0	3
15.	EEL867	Fading channels	3-0-0	3
16.	EEL715	Image processing	3-0-2	4
17.	EEL869	Optical data processing	3-0-0	3
18.	EES810	Independent study	0-3-0	3
19.	CRL705	Advanced sensor array signal processing	3-0-0	3
20.	CRL707	Human and machine speech communication	3-0-0	3
21.	CRL712	RF and microwave active circuits	3-0-0	3
22.	CRL715	Radiating systems for RF communications	3-0-0	3
23.	CRL722	RF and microwave solid state devices	3-0-0	3
24.	CRL723	Fabrication lab for RF and microwave devices	1-0-4	3
25.	CRL725	Technology for RF and microwave solid state devices	3-0-0	3

Name of the M.Tech. Programme	Computer Technology

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
40	14	6	60

Scheduling of Courses

Semester I					
S.No.	Course No.	Title	Type	L-T-P	Credits
1.	EEP701	Digital system lab	PC	0-0-4	2
2.	EEL601	Computer architecture	PC	3-0-0	3
3.	EEL702	System software	PC	3-0-2	4
4.		Open elective-I	OC	3-0-0	3
5.		Programme elective-II	PE	3-0-0/3-0-2	3 Or 4
		Total			15 to16
Semester II					
1.	EEP702	Software lab	PC	0-0-4	2
2.	EEL602	Operating systems	PC	3-0-2	4
3.	EEL703	Computer networks	PC	3-0-0	3
4.	EEP703	Computer networks lab	PC	0-0-4	2
5.	EED701	Minor project	PC	0-0-4	2
6.		Programme, Elective-II	PE	3-0-0/3-0-2	3 Or 4
7.		Programme, Elective-III	PE	3-0-0/3-0-2	3 Or 4
		Total			19 to 21
Semester III					
1.	EED801	Major Project Part 1	PC	0-0-12	6
2.		Programme Elective-4	PE	3-0-0	3
3.		Programme Elective-5*	PE	3-0-0/3-0-2	3 Or 4
4.		Open Elective 2	OE	3-0-0	3
		Total			12 to 16
Semester IV					
1.	EED802	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

* PE-5 will be required if a student does not take three PE's of 4 credits;

List of Program Electives

S.No.	No.	Title	L-T-P	Credits
1.	EEL832	Computer aided VLSI design	3-0-0	3
2.	EEL851	Special Topics in Computers I	3-0-0	3
3.	EEL852	Special Topics in Computers II	3-0-0	3
4.	EEL802	Testing & fault tolerance	3-0-0	3
5.	EEL758	Intelligent and Knowledge Based System	3-0-0	3
6.	EEL707	Multimedia systems	3-0-2	4
7.	EEL706	Computer vision	3-0-2	4
8.	EEL715	Image processing	3-0-2	4
9.	EEL754	Computer graphics	3-0-2	4
10.	EEL704	Robotics and Automation	3-0-0	3
11.	EEL708	Information retrieval	3-0-0	3
12.	EEL857	Network security	3-0-2	4
13.	EEL705	Embedded systems & applications	3-0-0	3
14.	EEL859	Network management	3-0-2	4
15.	EEL804	Scientific visualization	3-0-0	3
16.	EEL709	Pattern recognition	3-0-0	3
17.	EEL854	Protocol engineering	3-0-2	4
18.	EEL853	Agent technologies	3-0-0	3
19.	EEL855	Internet technologies	3-0-2	4
20.	EEL858	Mobile computing	3-0-0	3
21.	EEL731	Digital signal processing	3-0-0	3
22.	CSL719	Synthesis of Digital system	3-0-2	4
23.	CSL812	System Level Design and Modelling	3-0-0	3
24.	EES800	Independent study	0-3-0	3

Name of the M.Tech. Programme	Control and Automation

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
40	12	09	61

Scheduling of Courses

Semester I					
S.No.	Course No.	Title	Type	L-T-P	Credits
1.	EEL721	Linear system theory	PC	3-0-0	3
2.	EEL771	Random process in control and estimation	PC	3-0-0	3
3.	EEP725	Control laboratory	PC	0-0-6	3
4.		Programme elective-I	PE	3-0-0	3
5.		Programme elective-II	PE	3-0-0	3
6.		Open elective-I	OE	3-0-0	3
		Total Credits			18
Semester II					
1.	EEL772	Optimal control theory	PC	3-0-0	3
2.	EEL774	Parameter estimation and system identification	PC	3-0-0	3
3.	EEP874	Project laboratory	PC	0-1-6	4
4.	EEL704	Robotics and automation	PC	3-0-0	3
5.		Programme elective-III	PE	3-0-0	3
6.		Open elective-II	OE	3-0-0	3
		Total Credits			19
Semester III					
1.		Programme Elective IV	PE	3-0-0	3
2.	EED875	Major Project Part I	PC	0-0-12	6
3.		Open Elective III	OE	3-0-0	3
		Total Credits			12
Semester IV					
1.	EED876	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

List of Program Electives

S.No.	Course No.	Title	L-T-P	Credits
1.	EED820	Minor project	0-0-6	3
2.	EEL723	Microprocessor based industrial control	3-0-0	3
3.	EEL796	Power system control and instrumentation	3-0-0	3
4.	EEL823	Discrete time systems	3-0-0	3
5.	EEL824	Nonlinear systems	3-0-0	3
6.	EEL829	Selected topics in advanced control & system theory-I	3-0-0	3
7.	EEL879	Selected topics in advanced control & system-II	3-0-0	3
8.	EEL758	Intelligent & Knowledge based systems	3-0-0	3
9.	EEL745	Electrical drives system	3-0-0	3
10.	IDL711	Instrumentation transducers	3-0-0	3
11.	EEL731	Digital signal processing	3-0-0	3
12.	EEL602	Operating systems	3-0-2	4
13.	EEL878	Artificial intelligence for control applications	3-0-0	3
14.	MEL783	Automation in manufacturing	3-0-2	4
15.	CHL710	Chemical dynamics and control	3-0-0	3
16.	EEP701	Digital system laboratory	0-0-4	2
17.	EEL705	Embedded systems & applications	3-0-0	3
18.	EES720	Independent study	0-3-0	3

Name of the M.Tech. Programme	Integrated Electronics & Circuits

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
42	12	06	60

Scheduling of Courses

Semester I					
S.No.	Course No.	Title	Type	L-T-P	Credits
1.	EEL732	Micro electronics	PC	3-0-0	3
2.	EEL734	MOS VLSI	PC	3-0-0	3
3.	EEP735	IEC laboratory-I	PC	0-0-6	3
4.	***	Elective-I	OE	3-0-0	3
5.	***	Elective-II	OE	3-0-0	3
		Total Credits			15**
Semester II					
1.	EEL731	Digital signal processing	PC	3-0-0	3
2.	EEL782	Analog Integrated	PC	3-0-0	3
3.	EEL784	IC technology	PC	3-0-0	3
4.	EEP785	IEC laboratory-II	PC	0-0-6	3
5.	EEL832	Computer aided VLSI design	PC	3-0-0	3
6.		Elective-III	PE	3-0-0	3
		Total Credits			18
Sumar	EEP788	IC Precessing lab	PE	0-0-6	3
		Total Credits			3
Semester III					
1.	EED888	Major Project Part 1	PC	0-0-12	6
2.		Elective-IV	PE	3-0-0	3
3.		Elective-V	OE	3-0-0	3
4.		Independent study/minor project	PE	0-0-6	3
		Total Credits			15
Semester IV					
1.	EED889	Major Project, Part 2	PC	0-0-24	12
		Elective VII	PE	3-0-0	3
		Total Credits			15**

* The course will be registered for in the 3rd semester and will be run in the summer between the second and the third semester. This is a PC for M.Tech. VDTT and is available as PE for M.Tech in IEC.

** Normally the load in the first semester will be 15 credits. However in specific cases the course advisor may recommend 18 credits with elective V shifted from semester III to semester I

*** If EED 788 is registered for, then elective VII need not be registered for in semester IV and the total credits will be only 12.

List of Program Electives

S.No.	Course No.	Title	L-T-P	Credits
1.	EEL781	Neural networks	3-0-0	3
2.	EEL783	Filter Design	3-0-0	3
3.	EEL786	Mixed signal circuit design	3-0-0	3
4.	EEL787	Memory design and testing	3-0-0	3
5.	EEP788	IC processing laboratory*	0-0-6	3
6.	EEL802	Testing and fault tolerance	3-0-0	3
7.	EED830	Minor project	0-0-6	3
8.	EEL831	Digital signal processing-II	3-0-0	3
9.	EEL833	Selected topics in IEC	3-0-0	3
10.	EEL834	VLSI design	3-0-0	3
11.	EEP835	Project laboratory	0-0-6	3
12.	EEL836	Biomedical electronics	3-0-0	3
13.	EEL881	Issues in deep submicron CMOS IC design	3-0-0	3
14.	EES837	Independent study	0-3-0	3

Name of the M.Tech. Programme	Power Electronics, Electrical Machines & Drives

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
42	12	6	60

Scheduling of Courses

Semester I					
S.No.	Course No.	Title	Type	L-T-P	Credits
1.	EEL741	Modelling & Analysis of Electrical Machines	PC	3-0-0	3
2.	EEL742	Physical Phenomenon And Design Concepts in Machines	PC	3-0-0	3
3.	EEL743	Power Electronic Devices & D.C. Converters	PC	3-0-0	3
4.	EEL744	A.C. Controllers	PC	3-0-0	3
5.	EEP841	Electrical Machines Laboratory	PC	0-0-3	1.5
6.	EEP842	Power Electronics Laboratory	PC	0-0-3	1.5
7.		Programme Elective - I	PE	3-0-0	3
		Total Credits			18
Semester II					
1.	EEL745	Electrical Drive System	PC	3-0-0	3
2.	EEP843	Electric Drives Labratory	PC	0-0-3	1.5
3.	EEP844	Microprocessors and DSP Laboratory	PC	0-0-3	1.5
4.	EEL841	Solid-State Controllers of Drives	PC	3-0-0	3
5.		Programme Elective-II	PE	3-0-0	3
6.		Programme Elective-III	PE	3-0-0	3
7.		Open Elective-I	OE	3-0-0	3
		Total Credits			18
Semester III					
1.	EED842	Major Project Part 1	PC	0-0-12	6
2.		Programme Elective-IV	PE	3-0-0	3
3.		Open Elective-II	OE	3-0-0	3
		Total Credits			12
Semester IV					
1.	EED843	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

List of Program Electives

S.No.	Course No.	Course Title	L-T-P	Credits
1.	EEL723	Microprocessor Based Industrial control	3-0-0	3
2.	EED841	Minor Project	0-0-6	3
3.	EEL846	Computer Aided Design of Electrical Machines	3-0-0	3
4.	EEL845	Special Electromechanical Devices	3-0-0	3
5.	EEL705	Embedded System and Applications	3-0-0	3
6.	EEL842	Power Conditioning	3-0-0	3
7.	EEL844	Advanced or Selected Topics in power Electronics	3-0-0	3
8.	EEL847	Selected Topics in Machines & Drives	3-0-0	3
9.	EEL843	Computer Aided Simulation and Design of power Electronic Systems	3-0-0	3
10.	EET841	Industrial Training and Seminar	0-0-6	3
11.	EEL746	Nonconventional Energy Systems and Energy Conservation	3-0-0	3
12.	EES841	Independent Study	0-3-0	3

Name of the M.Tech. Programme	Power Systems

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
40	12	9	61

Scheduling of Courses

Semester I					
S.No.	Course No.	Title	Type	L-T-P	Credits
1.	EEL791	Power system analysis	PC	3-0-0	3
2.	EEL792	Power system protection	PC	3-0-0	3
3.	EEP791	Power system lab-I	PC	0-0-4	2
4.		Programme elective-II	PE	3-0-0	3
5.		Programme elective-II	PE	3-0-0	3
6.		Open elective-I	OE	3-0-0	3
		Total Credits			17
Semester II					
1.	EEL796	Power system control and instrumentation	PC	3-0-0	3
2.	EEL797	Power system dynamics	PC	3-0-0	3
3.	EEP798	Power system lab-II	PC	0-0-4	2
4.	EED790	Minor project	PC	0-0-6	3
5.		Programme elective-III	PE	3-0-0	3
6.	EEL894	Flexible AC transmission system	PC	3-0-0	3
7.		Open elective-II	OE	3-0-0	3
		Total Credits			20
Semester III					
1.	EED890	Major Project Part 1	PC	3-0-12	6
2.		Programme elective-IV	PE	3-0-0	3
3.		Open elective III	OE	3-0-0	3
		Total Credits			12
Semester IV					
1.	EED898	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

List of Program Electives

S.No.	Course No.	Title	L-T-P	Credits
1.	EEL799	Power system reliability	3-0-0	3
2.	EEL793	Power system transients	3-0-0	3
3.	EEL794	High voltage DC transmission	3-0-0	3
4.	EEL897	Load forecasting and load management	3-0-0	3
5.	EEL892	Power system communication	3-0-0	3
6.	EEL896	Power system optimization	3-0-0	3
7.	EEL891	Selected topics in power system	3-0-0	3
8.	EEL885	EHV AC transmission	3-0-0	3
9.	EEL899	Distribution automation	3-0-0	3
10.	EES893	Independent study	0-3-0	3

Name of the M.Tech. Programme	Design of Mechanical Equipment

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
42	12	6	60

Scheduling of Courses

		Semester I			
S.No.	Course No.	Title	Type	L-T-P	Credits
1.	MEL731	Design of Mechanisms and manipulators	PC	3-0-2	4
2.	MEL733	Vibration Engineering	PC	3-0-2	4
3.	MEL737	Advanced Mechanical Engineering Design	PC	3-0-2	4
4.	MEL735	Computer Methods in Mechanical Design	PC	3-0-2	4
			Total	16	
		Semester II			
1.	MEL740	Instrumentation and Automatic Control Systems	PC	3-0-2	4
2.	MEL742	Optimum Design of Mechanical Systems	PC	3-0-2	4
3.	ME...(List A1)	Design Technology Elective	PE	3-0-2	4
4.	ME...(List A2)	Equipment Design Elective	PE	3-0-2	4
5.		Open Elective*	OE	3/4-0-0	3 or 4
			Total	19/20	
		Semester III			
1.	MED831	Major Project Part 1	PC	0-0-12	6
2.	ME... (List A3)	Specialised Elective	PE	3-0-2	4
3.		Open Elective	OE		3
4.	(If not	Open Elective	OE		3 or 0
	taken in				
	3rd sem.)				
			Total	16 or 13	
		Semester IV			
1.	MED832	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

List A1 : Design Technology Elective

S.No.	Course No.	Title	L-T-P	Credits
1.	MEL832	Multibody Systems & Vibration Design	3-0-2	4
2.	MEL744	Design for Manufacture and Assembly	3-0-2	4
3.	MEL746	Design for Noise Vibration and Harshness	3-0-2	4
4.	MEL748	Tribological Systems Design	3-0-2	4
5.	MEL749	Mechatronic Prouduts Design	3-0-2	4
6.	MEL844	Designing with new Materials	3-0-2	4

List A2 : Equipment Design Elective

1.	MEL732	Machine tool Design	3-0-2	4
2.	MEL736	Automotive Design	3-0-2	4
3.	MEL743	Plant Equipment Design	3-0-2	4

List A3 : Specialized Electives

1.	MEL734	Noise Engineering	3-0-2	4
2.	MEL738	Dynamics of Multibody Systems	3-0-2	4
3.	MEL739	Robotics.	3-0-2	4
4.	MEL741	Blade & Disc Dynamics	3-0-2	4
5.	MEL842	Advanced Concurrent Engineering	3-0-2	4
6.	MEL831	Advanced Theory of Vibrations	3-0-2	4
7.	MEL835	Special Topics	3-0-2	4
8.	MEL836	Advanced Lubrication	3-0-2	4
9.	MEL837	Advanced Mechanisms	3-0-2	4
10.	MEL838	Rotor Dynamics	3-0-2	4
11.	MEL839	Precision Engineering	3-0-2	4
12.	MEL840	Experimental Modal Analysis & Dynamic Design	3-0-2	4
13.	MEL841	Advanced Structural Dynamics	3-0-2	4
14.	MES830	Independent Study	0-4-0	4

Name of the M.Tech. Programme	Industrial Engineering

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
42	12	6	60

Scheduling of Courses

		Semester I			
S.No.	Course No.	Title	Type	L-T-P	Credits
1.					
2.	MEL751	Industrial Engineering and Systems	PC	3-0-2	4
3.	MEL761	Statistics for Decision Making	PC	3-0-2	4
4.	MEL765	Operations Research I	PC	3-0-2	4
5.		Programme Elective - 1	PE		3
6.		Programme Elective - 2	PE		3
		Total Credits			18
		Semester II			
1.	MEL752	Quality Assurance	PC	3-0-2	4
2.	MEL754	Operations Planning and Control	PC	3-0-2	4
3.	MEL756	Supply Chain Management	PC	3-0-2	4
4.		Programme Elective - 3	PE		3
5.		Open Elective - 1	OE		3
		Total Credits			18
		Semester III			
1.		Programme Elective - 4	PE		3
2.		Open Elective - 2	OE		3
3.	MED861	Major Project Part 1	PC	0-0-12	6
		Total Credits			12
		Semester IV			
1.	MED862	Major Project Part 2	PC	0-0-24	12
	Total Credits			12	

List of Program Electives

S.No.	Course No.	Course Title	L-T-P	Credits
1.	MEL661	Materials Management	2-0-2	3
2.	MEL667	Long Range Planning	3-0-0	3
3.	MEL671	Value Engineering	2-0-2	3
4.	MEL674	Principles of Management	3-0-0	3
5.	MEL760	Project Management	2-0-2	3
6.	MEL762	Facilities Planning and Plant Engineering	2-0-2	3
7.	MEL763	Methods Engineering & Ergonomics	2-0-2	3
8.	MEL764	Human Factors Engineering	2-0-2	3
9.	MEL768	Quality Management: A Systems Perspective	2-0-2	3
10.	MEL775	IT in Manufacturing Enterprises	3-0-0	3
11.	MEL783	Automation in Manufacturing	3-0-2	4
12.	MEL786	Metrology	2-0-2	3
13.	MEL794	CAD/CAM	3-0-2	4
14.	MEL850	Network Models and Applications	2-0-2	3
15.	MEL851	Industrial Engineering Challenges in E-Business	3-0-0	3
16.	MEL852	Computer Integrated Manufacturing Systems	2-0-2	3
17.	MEL861	Industrial Applications of Simulation	2-0-2	3
18.	MEL865	Systems Dynamics : Modeling and Industrial Applications	2-0-2	3
19.	MEL866	Maintenance Management	3-0-0	3
20.	MEL868	Operations Research II	3-0-0	3
21.	MEL870	Knowledge Management	3-0-0	3
22.	MEL871	Financial Engineering	2-1-0	3
23.	MEL875	Operations Research III	3-0-0	3
24.	MEV760	Special Topics in Industrial Engineering	2-0-0	2
25.	VEL700	Human Values and Technology	2-1-0	3
26.	MES860	Independent Study	0-3-0	3

Name of the M.Tech. Programme	Production Engineering

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
45	11	6	62

Scheduling of Courses

Semester I					
S.No.	Course No.	Title	Type	L-T-P	Credits
1.	MEL769	Metal Forming Analysis	PC	3-0-2	4
2.	MEL781	Machining Processes & Analysis	PC	3-0-2	4
3.	MEL787	Welding & Allied Processes	PC	3-0-2	4
4.	MEL791	Composite Meterials & Processing	PC	3-0-2	4
5.		Open Elective -1	OE	3-0-0	3
		Total Credits			19
Semester II					
1.	MEL780	Casting Technology	PC	3-0-2	4
2.	MEL784	CNC Technology & Programming	PC	3-0-2	4
3.	MEL786	Metrology	PC	2-0-2	3
4.		Program Elective - 1	PE	3-0-2*	4
5.		Program Elective - 2	PE	3-0-0*	3
		Total Credits			17/19
Semester III					
1.		Program Elective - 3	PE	2-0-2*	3
2.		Program Elective - 4	PE	3-0-0*	3
3.		Open Elective-2	OE	3-0-0	3
4.	MED881	Major Project Part 1	PC	0-0-12	6
		Total Credits			13/15
Semester IV					
1.	MED882	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

*LTP 3-0-0 or 3-0-4 or 2-0-2

List of Program Electives

S.No.	Course No.	Course Title	L-T-P	Credits
1.	MEL674	Principles of Management	3-0-0	3
2.	MEL732	Machine Tool Design	3-0-2	4
3.	MEL749	Mechatronic Product Design	3-0-2	4
4.	MEL752	Quality Assurance	3-0-2	4
5.	MEL754	Operations Planning and Control	3-0-2	4
6.	MEL763	Methods Engineering & Ergonomics	2-0-2	3
7.	MEL772	Metal Forming Technology	3-0-0	3
8.	MEL775	IT in Manufacturing Enterprises	3-0-0	3
9.	MEL778	Design and Metallurgy of Welded Joints	3-0-2	4
10.	MEL783	Automation in Manufacturing	3-0-2	4
11.	MEL792	Injection Molding and Mold Design	2-0-2	3
12.	MEL794	CAD/CAM	3-0-2	4
13.	MEP790	Process Engineering	2-0-4	4
14.	MES880	Independent Study	0-3-0	3

Name of the M.Tech. Programme	Thermal Engineering

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
40	14	6	60

Scheduling of Courses

Semester I					
Seme-. ster	Course No.	Course Title	Type	L-T-P	Credits
1.	MEL703	Advanced Thermodynamics	PC	3-0-0	3
2.	AML715	Viscous Fluid Flows	PC	3-0-0	3
3.	MEL705	Experimental Methods in Thermal Engineering	PC	2-0-4	4
4.	MEL707	Applied Mathematics for Mechanical Engineers	PC	2-0-2	3
5.		Open Elective/Program Elective - 1	OE/PE		3
		Total			16
Semester II					
1.	MEL802	Convection Heat and Mass Transfer	PC	3-0-0	3
2.	MEL804	Radiation and Conduction Heat Transfer	PC	3-0-0	3
3.	MEL806	Thermal Systems Simulation & Design	PC	2-0-2	3
4.		Program Elective - 1	PE		3/4
5.		Program Elective - 2	PE		3/4
6.		Program Elective-/Open Elective	PE/OE	2-0-4	4/3
		Total Credits			20/21
Semester III					
1.		Programme Elective-3	PE		3/4
2.		Open Elective/Programme Elective- 4	OE		3/4
3.	MED811	Major Project Part 1	PC	0-0-12	6
		Total			13/14
Semester IV					
1.	MED812	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

List of Program Electives

S.No.	Course No.	Course Title	L-T-P	Credits
1	MEL708	Combustion Generated Pollution and Control	3-0-2	4
2.	MEL709	Heat Exchangers	3-0-2	4
3.	MEL710	Air-conditioning	3-0-2	4
4.	MEL711	Refrigeration and Air-conditioning Technologies	3-0-2	4
5.	MEL712	Advanced Power Plant Cycles	2-0-4	4
6.	MEL713	Design of IC Engine Components & Subsystems	3-0-2	4
7.	MEL714	Thermal and Nuclear Steam Power Plants	3-0-2	4
8.	MEL715	Gas Dynamics	3-0-2	4
9.	MED700	Design Project	0-1-6	4
10.	MEL807	Computational Heat Transfer	2-0-4	4
11.	MEL808	Refrigeration Systems and Components Design	2-0-4	4
12.	MEL809	Heat Transfer Applications	1-0-4	3
13.	MEL811	Steam and Gas Turbines	3-0-2	4
14.	MEL812	Combustion	3-0-2	4
15.	MEL814	Turbocompressors	3-0-2	4
16.	MEL815	Applied Combustion	2-0-4	4
17.	MEL816	Analysis of I.C. Engine Processes	3-0-2	4
18.	MEL818	Multiphase Flows	2-0-4	4
19.	MEL801	Fire Dynamics and Engineering	2-0-4	4
20.	MED710	Mini-Project	0-3-0	3
21.	MEP601	Introduction to Computers and Programming	0-0-4	Audit
22.	MEC601	Mechanical Engineering Seminars	0-1-0	Audit
23.	MES810	Independent Study	0-3-0	3

Name of the M.Tech. Programme	Applied Optics

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
45	9	6	60

Scheduling of Courses

		Semester I			
S.No.	Course No.	Course Title	Type	L-T-P	Credits
1.	PHL751	Optical Sources, Detectors and Photometry	PC	3-0-0	3
2.	PHL753	Optical System Design	PC	3-0-0	3
3.	PHP761	Optics Laboratory-1	PC	0-0-6	3
4.	PHP763	Optical Workshop	PC	0-0-6	3
5.		Programme Elective - 1	PE	3-0-0	3
6.		Open Elective - 1	OE	3-0-0	3
	Total			18	
		Semester II			
1.	PHL752	Lasers Systems and Applications	PC	3-0-0	3
2.	PHL754	Optical Instruments and Metrology	PC	3-0-0	3
3.	PHL756	Fourier Optics and Optical Information Processing	PC	3-0-0	3
4.	PHL758	Theory and Applications and Holography	PC	3-0-0	3
5.	PHP762	Optics Laboratory-II	PC	0-0-6	3
6.		Programme Elective-2/Open Elective-2	PE/OE	3-0-0	3
		Total Credits			18
		Semester III			
1.		Open Elective-2/Programme Elective-2	OE/PE	3-0-0	3
2.		Programme Elective-3	PE (0-3-0/0-0-6)	3-0-0	3
3.	PHD851	Major Project Part I	PC	0-0-12	6
		Total Credits			12
		Semester IV			
1.	PHD852	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

List of Program Electives

S.No.	Course No.	Title	L-T-P	Credits
1.	PHL755	Statistical & Quantum Optics	3-0-0	3
2.	PHL757	Optical Materials and Thin Films	3-0-0	3
3.	PHL759	Selected Topics in Applied Optics	3-0-0	3
4.	PHL791	Fiber Optics	3-0-0	3
5.	PHL792	Optical Electronics	3-0-0	3
6.	PHL795	Optics and Lasers	3-0-0	3
7.	PHL891	Guided Wave Optical Components and Devices	3-0-0	3
8.	PHP764	Mechanical Workshop and Engineering Drawing	0-0-6	3
9.	PHP853	Advanced Optical Workshop	0-0-6	3
10.	PHS855	Independent Study	0-3-0	3

Name of the M.Tech. Programme	Solid State Materials

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
45	9	6	60

Scheduling of Courses

S.No.	Course No.	Title	Type	L-T-P	Credits
		Semester I			
1.	PHL701	Electronic Properties of Materials	PC	3-0-0	3
2.	PHL703	Materials Technology	PC	3-0-0	3
3.	PHL705	Physics of Semiconductor Devices	PC	3-0-0	3
4.	PHL707	Characterization of Materials	PC	3-0-0	3
5.	PHP711	Solid State Materials Laboratory-I	PC	0-0-9	4.5
6.		Programme Elective-I	PE	3-0-0	3
		Total Credits			19.5
		Semester II			
1.	PHL702	Science and Technology of Thin Films	PC	3-0-0	3
2.	PHL704	Semiconductor Device Technology	PC	3-0-0	3
3.	PHP712	Solid State Materials Laboratory-II	PC	0-0-9	4.5
4.		Programme Elective-II	PE	3-0-0	3
4.		Open Elective-I	OE	3-0-0	3
		Total Credits			16.5
		Semester III			
1.	PHD801	Major Project Part 1	PC	0-0-12	6
2.		Open Elective-II	PE	3-0-0	3
3.		Programme Elective - III #	PE	3-0-0	3
		Total Credits			12
		Semester IV			
1.	PHD802	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

List of program Electives

S.No.	Course No.	Title	L-T-P	Credits
1.	PHL721	Electronic Ceramics	3-0-0	3
2.	PHL722	Analytical Techniques	3-0-0	3
3.	PHL723	Vacuum Science & Cryogenics	3-0-0	3
4.	PHL724	Magnetism & Superconductivity	3-0-0	3
5.	PHL725	Physics of Amorphous Materials	3-0-0	3
6.	PHL726	Nanostructured Materials	3-0-0	3
7.	PHL727	Quantum Hetetostructures	3-0-0	3
8.	PHS731	Independent Study	0-3-0	3

Name of the M.Tech. Programme	Fiber Science and Technology

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
42	12	6	60

Scheduling of Courses

Semester I					
S.No.	Course No.	Title	Type	L-T-P	Credits
1.	TTL711	Polymer and Fibre Chemistry	PC	3-0-0	3
2.	TTP711	Polymer and Fibre Chemistry Laboratory	PC	0-0-3	1.5
3.	TTL712	Polymer and Fibre Physics	PC	3-0-0	3
4.	TTP712	Polymer and Fibre Physics Laboratory	PC	0-0-3	1.5
5.	TTL713	Technology of Melt spun Fibres	PC	3-1-0	4
6.	TTL741	Coloration of Textiles	PC	3-0-0	3
7.		Programme Elective-1	PE	2-0-2	3
		Total Credits			19
Semester II					
1.	TTL714	Physical Properties of Fibres	PC	3-0-0	3
2.	TTL715	Technology of Solution Spun Fibres	PC	3-0-0	3
3.	TTP716	Fibre Production and Post Spinning	PC	0-0-4	2
		Operation Laboratory			
4.		Programme Elective-II	PE	3-0-0	3
5.		Programme Elective-III	PE	3-0-0	3
6.		Open Elective-I	OE	3-0-0	3
		Total Credits			17
Semester III					
1.		Programe Elective-IV	PE	3-0-0	3
2.		Open Elective II	OE	3-0-0	3
3.	TTD891	Major Project Part I	PC	0-0-12	6
		Total Credits			12
Semester IV					
1.	TTD892	Major Project Part II	PC	0-0-24	12
		Total Credits			12

List of program Electives

S.No.	Course No.	Title	L-T-P	Credits
1.	TTL717	Advances in Manufactured Fibres	3-0-0	3
2.	TTL718	High Performance FIbres and Composites	3-0-0	3
3.	TTL724	Textured Yarn Technology	3-0-0	3
4.	TTL742	Theory and practice of Textile Finishing	2-0-2	3
5.	TTL743	Principles of Colour Measurement and Communication	2-0-2	3
6.	TTL744	Environmental Management in Textile and Allied Industries	3-0-0	3
7.	TTL763	Technical Textiles	2-1-0	3
8.	TTL765	Product Development	2-1-0	3
9.	TTL772	Computer Programming and it's application	2-0-2	3
10.	TTL773	Design of experiment and Statistical Techniques	3-0-0	3
11.	TTL866	Functional & High Performance Textiles	2-1-0	3
12.	TTS890	Independent Study	0-3-0	3

Name of the M.Tech. Programme	Textile Engineering

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
42	12	6	60

Scheduling of Courses

Semester I					
S.No.	Course No.	Title	Type	L-T-P	Credits
1.	TTL721	Theory of Yarn Structure	PC	2-1-0	3
2.	TTL722	Mechanics of spinning processes	PC	3-0-0	3
3.	TTL731	Theory of Fabric Structure	PC	2-1-0	3
4.	TTL771	Electronics and Controls for Textile Industry	PC	3-0-2	4
5.	TTP761	Evaluation of Textile Materials - I	PC	0-0-2	1
6.		Programme Elective - I	PE	3-0-0	3
		Total Credits			17
Semester II					
1.	TTL733	Selected Topics in Fabric Manufacture	PC	2-1-0	3
2.	TTL763	Technical Textiles	PC	2-1-0	3
3.	TTL773	Design of Experiments and Statistical Techniques	PC	3-0-0	3
4.	TTP762	Evaluation of Textile Materials - II	PC	0-0-2	1
5.		Programme Elective - II	PE	3-0-0	3
6.		Programme Elective - III	PE	3-0-0	3
7.		Open Elective - I	OE	3-0-0	3
		Total Credits			19
Semester III					
1.	TTD893	Major Project Part 1	PC	0-0-12	6
2.		Programme Elective - V	PE	3-0-0	3
3.		Open Elective - II	PE	3-0-0	3
		Total Credits			12
Semester IV					
1.	TTD894	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

List of Program Electives

S.No.	Course No.	Title	L-T-P	Credits
1.	TTL714	Physical Properties of Fibres	3-0-0	3
2.	TTL723	Selected Topics in Yarn Manufacture	2-1-0	3
3.	TTL724	Textured Yarn Technology	3-0-0	3
4.	TTL732	Computer Aided Fabric Manufacturing	2-0-2	3
5.	TTL751	Apparel Engineering and Quality Control	2-0-2	3
6.	TTL761	Costing, Project Formulation and Appraisal	2-1-0	3
7.	TTL762	Management of Textile Production	3-0-0	3
8.	TTL764	Process Control in Spinning and Weaving	3-0-0	3
9.	TTL765	Product Development	2-1-0	3
10.	TTL772	Computer Programming and its Applications	2-0-2	3
11.	TTL866	Functional and High Performance Textiles	2-0-1	3
12.	TTS891	Independent Study	0-3-0	3

Name of the M.Tech. Programme	Radio Frequency Design and Technology

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
41	15	6	62

Scheduling of Courses

S.No.	Course No.	Title	Type	L-T-P	Credits
		Semester I			
1.	CRL711	CAD of RF and Microwave Devices	PC	3-0-2	4
2.	CRL713	Fundamental of RF Electronics	PC	2-0-2	3
3.	CRP723	Fabrication Techniques for RF and Microwave Devices	PC	1-0-4	3
4.	EEL762	Digital Communication	PC	3-0-0	3
5.		Program Elective - I	PE		3
6.		Open Elective - II	PE		3
		Total Credits			19
		Semester II			
1.	CRL702	Architectures and Algorithms for DSP Systems	PC	2-0-4	4
2.	CRP718	RF and Microwave Measurement Lab	PC	0-0-6	3
3.	CRL724	RF and Microwave Measurement System Techniques	PC	3-0-0	3
4.		Programme Elective - III	PE	3-0-0	3
5.		Programme Elective - IV	PE		3
6.		Open Elective - I	OE		3
		Total Credits			19
		Semester III			
1.	CRD811	Major Project Part 1	PC	0-0-12	6
2.		Programme Elective - V	PE		3
3.		Open Elective - II	OE		3
		Total Credits			12
		Semester IV			
1.	CRD812	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

List of Programme Electives

S.No.	Course No.	Title	L-T-P	Credits
1.	CRL704	Sensor Array Signal Processing	3-0-0	3
2.	CRL705	Advanced Sensor Array Signal Processing	3-0-0	3
3.	CRL707	Human and Machine Speech Communication	3-0-0	3
4.	CRL712	RF and Microwave Active Circuits	3-0-0	3
5.	CRL715	Radiating Systems for RF Communication	3-0-0	3
6.	CRL720	SAW Devices and Applications	3-0-0	3
7.	CRL721	Analog/RF IC Modelling and Design	2-0-2	3
8.	CRL722	RF and Microwave Solid State Devices	3-0-0	3
9.	CRL725	Technology of RF and Microwave Solid State Devices	3-0-0	3
10.	CRL726	RF MEMS Design and Technology	3-0-0	3
11.	CRL728	RF Electronic System Design Techniques	3-0-0	3
12.	CRL731	Selected Topics in RFDT-I	3-0-0	3
13.	CRL732	Selected Topics in RFDT-II	3-0-0	3
14.	CRL733	Selected Topics in RFDT-III	3-0-0	3
15.	CRL737	Selected Topics in Radars and Sonars	3-0-0	3
16.	CRD802	Minor Project	0-0-6	3
17.	EEL731	Digital Signal Processing	3-0-0	3
18.	EEL765	Sonar System Engineering	3-0-0	3
19.	EEL711	Signal Theory	3-0-0	3
20.	EEL768	Detection and Estimation	3-0-0	3
21.	IDL712	Electronic Techniques for Signal Conditioning and Interfacing	3-0-0	3
22.	CRS735	Independent Study	0-3-0	3

Name of the M.Tech. Programme	Computer Applications

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
42	12	6	60

Scheduling of Courses

		Semester I			
S.No.	Course No.	Course Title	Type	L-T-P	Credits
1.	MAL701	Introducation to Programming & Data Structures (Non CS Background)	PC	3-0-2	4
2.	CSL630	Data Structures and Algorithm (CS Background)			
3.	MAL705	Discrete Mathematical Structures	PC	3-0-0	3
4.	MAP707	Programming Language Lab (Using High level languages)	PC	0-0-4	2
5.	EEL702 CSL665	System Software (Non CS Background) Introducation to Logic and Functional Programming (CS Background)	PC	3-0-2	4
6.		Programme Elective - 1	PE	3-0-0	3
		Total Credits			16
		Semester II			
1.	MAL710	Data Base Management Systems	PC	3-0-2	4
2.	MAL708	Computer Organisation & Operating Systems (Non CS Background)	PC	3-0-2	4
4.	MAL704	Numerical Optimization (CS Background)			
4.	MAP706	Scientific Software Lab	PC	0-0-6	3
5.		Program Elective - 2	PE	3-0-0	3
6.		Open Elective - 1	OE	3-0-0	3
		Total Credits			17
		Semester III			
1.		Program Elective - 3	PE	3-0-0	3
2.		Program Elective - 4	PE	3-0-0	3
3.		Open Elective - 2	OE	3-0-0	3
4.	JCD801	Major Project, Part I	PC	0-0-12	6
		Total Credits			15
		Semester IV			
1.	JCD802	Major Project Part II	PC	0-0-24	12
		Total Credits			12

List of Program Electives for M Tech Programme in Computer Applications

S.No.	Course No.	Title	L-T-P	Credits
1.	MAL702	File Systems and Data Management	3-0-0	3
2.	CSL740/ MAL745	Software Engineering/ Software Engineering	3-0-2	4
3.	CSL665	Introduction to logic and Functional Programming (Non-CS background)	3-0-2	4
4.	CSL672/ EEL703	Computer Networks	3-0-2 3-0-0	4 3
5.	CSL781 EEL754/ MAL754	Computer Graphics Principle of Computer Graphics	3-0-3 3-0-2	4.5 4
6.	EEL758/or SML815/ CSL671	Intelligent Knowledge Based System Design Decision Support and Expert Systems Artificial Intelligence	3-0-0 2-0-2 3-0-2	3 3 4
7.	CSL783/ EEL715	Digital Image Analysis / Image Processing	3-0-3	4.5
8.	CSL840 EEL706	Computer Vision	3-0-2	4
9.	MAL823/ CSL865	Special Topics in Computer Applications	3-0-0	3
10.	CSL758	Advanced Algorithms	3-0-0	3
11.	CSL862	Special Topics in Software Systems	3-0-0	3
12.	CSL868	Special Topics in Database Systems	3-0-0	3
13.	CSL864	Special Topics in Artificial Intelligence	3-0-0	3
14.	EEL707	Multimedia Systems	3-0-2	4
15.	EEL708	Information Retrieval	3-0-0	3
16.	EEL751	Computer System Software (CS Background)	3-0-2	4
17.	EEL709/ MAL803	Pattern Recognition	3-0-0	3
18.	EEL804	Scintific Visualization	3-0-0	3
19.	MAL715	Statistical Computing	3-0-0	3
20.	MAL717	Fuzzy Sets and Applications	3-0-0	3
21.	MAL724	Cryptology	3-0-0	3
22.	MAL720	Neuro-Computing & Applications	3-0-0	3
23.	MAL703	Numerical Algorithms for Parallel Computing	3-0-0	3
24.	MAL711	Algorithmic Combinatorics	3-0-0	3
25.	MAL714/ AML707	Finite Elements Techniques and Computer Implementation	3-0-0	3
26.	ASL850	Numerical Modeling of Atmospheric Processes	3-0-0	3
27.	JCD799	Minor Project	0-0-6	3
28.	JCS800	Independent Study	0-3-0	3
29.	EEL853	Agent Technology	3-0-0	3

Name of the M.Tech. Programme	Energy Studies

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
42	12	06	60

Scheduling of Courses

Semester I					
S.No.	Course No.	Title	Type	L-T-P	Credits
1.	ESL740	Non-conventional Sources of Energy	PC	3-0-0	3
2.	ESL711	Fuel Technology	PC	3-0-0	3
3.	ESL760	Heat Transfer	PC	3-0-0	3
4.	ESP713	Energy Laboratories	PC	0-0-6	3
5.		Programme Elective - 1	PE	3-0-0	3
6.		Open Elective - I	OE	3-0-0	3
				Total	18
Semester II					
1.	ESL720	Energy Conservation	PC	3-0-0	3
2.	ESL710	Energy, Ecology & Environment	PC	3-0-0	3
3.	ESL750	Economics & Planning of Energy Systems	PC	3-0-0	3
4.	ESL730	Direct Energy Conversation	PC	3-0-0	3
5.		Programme Elective - 2	PE	3-0-0	3
6.		Open Elective - 2	OE	3-0-0	3
				Total	18
Semester III					
1.		Programme Elective - 3	PE	3-0-0	3
2.		Programme Elective - 4	PE	3-0-0	3
3.	JED801	Major Project Part 1	PC	0-0-12	6
				Total	12
Semester IV					
1.	JED802	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

List of Programme Electives

S.No.	Course No.	Title	L-T-P	Credits
1.	ESL718	Power Generation, Transmission & Distribution	3-0-0	3
2.	ESL770	Solar Energy Utilisation	3-0-0	3
3.	ESL715	Applied Physics	3-0-0	3
4.	ESL732	Bio-conversion & Processing of Waste	3-0-0	3
5.	ESL870	Fusion Energy	3-0-0	3
6.	ESL714	Power Plant Engineering	3-0-0	3
7.	ESL860	Power System Analysis	3-0-0	3
8.	ESL840	Solar Architecture	3-0-0	3
9.	ESL810	MHD Power Generation	3-0-0	3
10.	ESL850	Solar Refrigeration & Air-conditioning	3-0-0	3
11.	ESL722	Integrated Energy Systems	3-0-0	3
12.	ESL768	Wind Energy & Hydro Power Systems	3-0-0	3
13.	JED799	Minor Project	3-0-0	3
14.	ESL774	Quantitative Methods on Energy Management & Planning	0-0-6	3
15.	ESL784	Cogeneration & Energy Efficiency	3-0-0	3
16.	ESL880	Advanced Energy Studies	3-0-0	3
17.	ESL875	Alternative Fuels for Transportation	3-0-0	3
18.	JES800	Independent Study	0-3-0	3

Name of the M.Tech. Programme	Energy & Environmental Management

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
45	9	6	60 + 3 Bridge courses

Scheduling of Courses

Semester I					
S.No.	Course No.	Course Title	Type	L-T-P	Credits
1.	ESL740	Non-conventional Sources of Energy	PC	3-0-0	3
2.	ESL711	Fuel Technology	PC	3-0-0	3
3.	ESL777	Environmental Science & Engineering	PC	3-0-0	3
Compulsory Bridge Audit Courses					
1.	ESL791	Applied Mathematics & Computational Methods		1-0-0	1
2.	ESL704	Basic Electrical Engineering (For Non-Mechanical Engineering)		1-0-0	1
3.	ESL712	Basic Electrical Engineering (For Non-Electrical Engineering)		1-0-0	1
		Total Credits			9
Semester II					
1.	ESP700	Energy Laboratories	PC	0-0-6	3
2.	ESL720	Energy Conservation	PC	3-0-0	3
3.	ESL774	Quantitative Methods for Energy Management & Planning	PC	3-0-0	3
Compulsory Bridge Audit Courses					
4.	ESL725	Energy Auditing		1-0-0	1
5.	ESL794	Principles of Chemical Processes & Combustion		1-0-0	1
		Total Credits			9
Semester III					
1.		Programme Elective - 1	PE	3-0-0	3
2.		Programme Elective - 2	PE	3-0-0	3
3.		Programme Elective - 3	PE	3-0-0	3
				Total	9
Semester IV (Any one of the Modules A,B,C, & D)					
Module – A					
1.	ESL776	Industrial Energy and Environmental Analysis	PC	3-0-0	3
2.	ESL784	Cogeneration and Energy Efficiency	PC	3-0-0	3
3.	ESL778	Industrial Waste Management and Recycling	PC	3-0-0	3
Module – B					
1.	ESL756	Energy Policy & Planning	PC	3-0-0	3
2.	ESL764	Environmental Economics	PC	3-0-0	3
3.	ESL766	Environmental Regulation	PC	3-0-0	3
Module – C					
1.	ESL718	Power Generation, Transmission and Distribution	PC	3-0-0	3
2.	ESL860	Electrical Power System Analysis	PC	3-0-0	3
3.	ESL804	Pollution Control in Power Plants	PC	3-0-0	3

Module – D					
1.	ESL788	Industrial and Commercial Applications of Renewable Energy Sources	PC	3-0-0	3
2.	ESL736	Power from Renewable and Environmental Impacts	PC	3-0-0	3
3.	ESL742	Economics and Financing of Renewable Energy Systems	PC	3-0-0	3
		Total Credits			9
Semester V					
Programme and Open Electives					
1.	JSD801	Major Project Part 1	PC	0-0-12	6
2.		Programme Elective - 4	PE	3-0-0	3
3.		Programme Elective - 5	PE	3-0-0	3
		Total Credits			12
Semester VI					
1.	JSD802	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

A. List of Program Electives

S.No.	Course No.	Title	L-T-P	Credits
1.	ESL710	Energy, Ecology & Environment	3-0-0	3
2.	ESL722	Intergrated Energy Systems	3-0-0	3
3.	ESL730	Direct Energy Conversion	3-0-0	3
4.	ESL735	Hazardous Waste Management	3-0-0	3
5.	ESL738	Power Systems Planning & Operation	3-0-0	3
6.	ESL745	Environmental Audit and Impact Assessment	3-0-0	3
7.	ESL768	Wind Energy and Hydro Power Systems	3-0-0	3
8.	ESL771	Instrumentation and Control in Energy Systems	3-0-0	3
9.	ESL785	Energy Analysis	3-0-0	3
10.	ESL792	Advanced Energy Systems	3-0-0	3
11.	ESL795	Project Evaluation and Management	3-0-0	3
12.	ESL796	Operation and Control of Electrical Energy Systems	3-0-0	3
13.	ESL870	Fusion Energy	3-0-0	3
14.	ESL875	Alternative Fuels for Transportation	3-0-0	3
15.	JSS800	Independent Study	0-3-0	3

Name of the M.Tech. Programme	Industrial Tribology and Maintenance Engineering

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
43	12	6	61

Scheduling of Courses

Semester I					
S.No.	Course No.	Title	Type	L-T-P	Credits
1.	ITL711	Reliability, Availability and Maintainability (RAM) Engineering	PC	3-0-0	3
2.	ITL703	Fundamentals of Tribology	PC	3-0-2	4
3.	ITL705	Materials for Tribological Applications	PC	3-0-0	3
4.	ITL709	Maintenance Plannning and Control	PC	3-0-0	3
5.		Programme Elective I / Programme Elective II / Open Elective I	PE PE / OE	3-0-0 3-0-0	3 -
		Total Credits			19
Semester II					
1.	ITL702	Diagnostic Maintenance and Monitoring	PC	3-0-2	4
2.	ITL714	Failure Analysis and Repair	PC	3-0-2	4
3.	ITL710	Design of Tribological Elements	PC	3-0-2	4
4.		Programme Elective II / III	PE	3-0-0	3
5.		Programme Elective IV / Open Elective	PE	3-0-0	3
		Total Credits			18
Semester III					
1.	JID801	Major Project Part 1	PC	0-0-12	6
2.		Open Elective I / Programme Elective III	OE / PE	3-0-0	3
3.		Open Elective - III	OE	3-0-0	3
		Total Credits			12
Semester IV					
4	JID802	Major Project Part 1	PC	0-0-24	12
		Total Credits			12

Programme Elective Courses

S.No.	Course No.	Title	L-T-P	Credits
1.	ITL716	Computer Application in Maintenance Management	2-0-2	3
2.	ITL717	Corrosion and its Control	3-0-0	3
3.	ITL730	Lubricants	2-0-2	3
4.	ITL740	Risk Analysis and Safety	2-1-0	3
5.	ITL752	Bulk Materials Handling	2-0-2	3
6.	ITL760	Noise Monitoring and Control	2-0-2	3
7.	ITL770	Design for Maintenance	2-0-2	3
8.	ITL810	Bearing Lubrication	2-0-2	3
9.	JIS800	Independent Study	0-3-0	3

Name of the M.Tech. Programme	Instrument Technology

Distribution of Total Credits

Program Core	Program Elective	Open Elective	Total Credits
40	12	9	61

Scheduling of Courses

S.No.	Course No.	Title	Type	L-T-P	Credits
		Semester I			
1.	IDP703	Instrument Technology Laboratory - I	PC	0-0-6	3
2.	IDL711	Instrumentation Transducers	PC	3-0-0	3
3.		Programme Elective - 1	PE	3-0-0	3
4.		Programme Elective - 2	PE	3-0-0/2	3/4
5.		Open Elective - 1	OE	3-0-0	3
		Total Credits			15/16
		Semester II			
1.	IDP704	Instrument Technology Laboratory - II	PC	0-0-6	3
2.	IDL712	Electronic Techniques for Signal Conditioning and Interfacing	PC	3-0-0	3
3.	IDL714	Instrument Design and Simulations	PC	2-0-2	3
4.	IDL734	Laser Based Instrumentation	PC	3-0-0	3
5.		Programme Elective - 3	PE	3-0-0	3
6.		Open Elective - 2	OE	3-0-0	3
		Total Credits			18
		Semester III			
1.	IDP705	Advanced Instrument-Technology Lab	PC	0-0-8	4
2.	JTD801	Major Project Part 1	PC	0-0-12	6
3.		Programme Elective - 4	PE	$-$-0*	3
4.		Open Elective - 3	OE	3-0-0	3
		Total Semester Credits			16
		Semester IV			
1.	JTD802	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

* LTP may be 3-0-0 or 0-3-0

Programme Elective Courses

S.No.	Course No.	Title	L-T-P	Credits
1.	IDL713	Advanced Electronic Components and Circuits (for non-Electrical/Electronic students only)	3-0-0	3
2.	IDL716	Quality Control and Standardisation	3-0-0	3
3.	IDL721	Materials and Mechanical Design (for non-Mechanical students only)	3-0-2	4
4.	IDL722	Precision Measurement Systems	3-0-0	3
5.	IDL724	Advanced Fabrication and Finishing	3-0-0	3
6.	IDL730	Photochemical Machining	2-0-2	3
7.	IDL731	Optical Components and Basic Instruments	3-0-0	3
8.	IDL732	Optical Materials and Techniques	3-0-0	3
9.	IDL735	Scientific and Engineering Applications of Moire Patterns	2-0-2	3
10.	IDL741	Instrument Organisation and Ergonomics	2-0-2	3
11.	IDP742	Industrial Design Practice	1-0-4	3
12.	IDL811	Selected Topics in Instrumentation	3-0-0	3
13.	IDC812	Term Paper & Seminar	3-0-0	3
14.	EEL723	Microprocessor Based Industrial Control	3-0-0	3
15.	EEL801	Microprocessor Based System Design	3-0-0	3
16.	EEL836	Biomedical Electronics	3-0-0	3
17.	MEL731	Design of Mechanisms and Manipulators	3-0-2	4
18.	MEL786	Metrology	2-0-2	3
19.	AML710	Computer Aided Design	3-0-2	4
20.	PHL790	Integrated Optics (PH)	3-0-0	3
21.	PHL754	Optical Instrumentation & Metrology	3-0-0	3
22.	JTS801	Independent Study	0-3-0	3

Name of the M.Tech. Programme	Optoelectronics & Optical Communication

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
42	9	9	60

Scheduling of Courses

Semester I					
S.No.	Course No.	Title	Type	L-T-P	Credits
1.	PHL791	Fibre Optics	PC	3-0-0	3
2.	PHL793	Semiconductor Optoelectronics	PC	2-0-2	3
3.	EEL714	Digital Communication and Information Systems	PC	3-0-0	3
4.	JOP791	Fiber Optics and Optical Communication Lab-I	PC	0-0-6	3
5.		Programme Elective-1	PE	3-0-0	3
6.		Open Elective-1	OE	3-0-0	3
		Total Credits			18
Semester II					
1.	PHL792	Optical Electronics	PC	3-0-0	3
2.	EEL895	Broadband Communication and Information Systems	PC	3-0-0	3
3.	EEL712	Optical Communication Systems	PC	3-0-0	3
4.	JOP792	Fiber Optics and Optical Communication Lab-II	PC	0-0-6	3
5.		Programme Elective-2	PE	3-0-0	3
6.		Open Elective-2	OE	3-0-0	3
		Total Credits			18
Semester III					
1.		Programme Elective-3	PE	3-0-0	3
2.		Open Elective-3	OE	3-0-0/(0-3-0)	3
3.	JOD801	Major Project Part 1	PC	0-0-12	6
		Total Credits			12
Semester IV					
1.	JOD802	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

List of Program Electives

S.No.	Course No.	Title	L-T-P	Credits
1.	PHL755	Statistical Quantum Optics	3-0-0	3
2.	PHL790	Integrated Optics	3-0-0	3
3.	PHL795	Optics and Lasers	3-0-0	3
4.	PHL797	Selected Topics I	3-0-0	3
5.	PHL798	Selected Topics II	3-0-0	3
6.	PHL891	Guided Wave Optical Components and Devices	3-0-0	3
7.	EEL790	Optoelectronic Instrumentation	3-0-0	3
8.	EEL813	Selected Topics III	3-0-0	3
9.	ELL814	Selected Topics IV	3-0-0	3
10.	EEL890	Photonic Switching and Networking	3-0-0	3
11.	JOS800	Independent Study	0-3-0	3

Name of the M.Tech. Programme	Polymer Science and Technology

Distribution of Total Credits

Program Core	Program Elective	Open Elective	Total Credits
42	12	6	60

Scheduling of Courses

S.No.	Course No.	Title	Type	L-T-P	Credits
		Semester I			
1.	PTL701	Polymer Chemistry	PC	0-0-3	3
2.	PTL703	Polymer Physics	PC	3-0-0	3
3.	PTL705	Polymer Characterization	PC	2-0-2	3
4.	PTL707	Polmer Engineering & Rheology	PC	3-0-0	3
5.	PTL709	Polymer Technology	PC	3-0-0	3
6.	PTP710	Polymer Science Lab	PC	0-0-4	2
		Open Elective**	OE	3-0-0	3
		Total Credits			17/20
		Semester II			
1.	PTL702	Polymer Processing	PC	0-0-6	3
2.	PTL706	Polymer Testing & Properties	PC	3-0-0	3
3.	PTP720	Polymer Engineering Lab	PC	0-0-2	1
4.		Program Elective-I	PE	3-0-0	3
5.		Program Elective-II	PE	3-0-0	3
6.		Program Elective-III	PE	3-0-0	3/4
7.		Open Elective-I	OE	3-0-0	3
		Total Credits			19/20
		Semester III			
1.		Program Elective-IV	PE	3-0-0	3
2.		Open Elective-II	OE	3-0-0	3
3.	JPD801	Major Project Part 1	PC	0-0-12	6
		Total Credits			12
		Semester IV			
1.	JPD802	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

** Optional

Programme Elective Courses

S.No.	Course No.	Title	L-T-P	Credits
1.	PTL711	Engineering Plastics & Specially Polymer	3-0-0	3
2.	PTL712	Polymer Composites	3-0-0	3
3.	PTL714	Polymer Blends & Alloys	3-0-0	3
4.	PTL716	Rubber Technology	3-0-0	3
5.	PTL718	Polymer Reaction Engineering	2-1-0	3
6.	PTL720	Polymer Product & Mould Design	2-0-2	3
7.	PTL722	Polymer Degradation & Stabilization	3-0-0	3
8.	PTL724	Polymeric Coatings	3-0-0	3
9.	BML820	Bio Materials	3-0-0	3
10.	BML710	Industrial Biomaterial Tech.	3-0-0	3
11.	BML830	Biosensor Technology	3-0-2	4
12.	MEL791	Composit Materials and Processing	3-0-2	4
13.	MEL792	Injection Moulding & Mould Design	2-0-2	3
14.	CYL716	On-line Methods of Chemical Analysis	3-0-0	3
15.	CYL704	Chemical Computations	2-0-2	3
16.	ITL705	Material for Tribo-Applications	3-0-0	3
17.	DIP752	Computer Aided Product Design	1-0-4	3
18.	AML705	Finite Element Methods	3-0-2	4
19.	BEL708	Bioseparation	3-0-4	5
20.	CHL701	Process Engineering	3-0-2	4
21.	CHL603	Advanced Transport Phenomena	3-0-0	3
22.	CHL723	Chemical Reaction Engineeing	3-0-0	3
23.	CH626N	Fluid Flow in Process Equipment	3-0-0	3
24.	CHL724	Environmental Engineering & Waste Management	3-1-0	4
25.	CHL743	Petrochemical Technology	3-0-0	3
26.	JPD799	Minor Project	0-0-6	3
27.	JPS800	Independent Study	0-3-0	3

Name of the M.Tech. Programme	VLSI Design Tools & Technology

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
43	12	06	61

Scheduling of Courses

Semester I					
S.No.	Course No.	Title	Type	L-T-P	Credits
1.	EEL734	MOS VLSI	PC	3-0-0	3
2.	CSL719	Synthesis of Digital Systems	PC	3-0-2	4
3.	CSP745	Digital Systems Design Lab	PC	0-0-6	3
4.		Elective-I	OEI/PE	3-0-0	3
5.		Elective-II	OEII/PE	3-0-0	3
		Total Credits			16
Semester II					
1.	EEL832	Computer Aided VLSI Design	PC	3-0-0	3
2.	EEL784	IC Technology	PC	3-0-0	3
3.	EEL731	Digital Signal Processing-I	PC	3-0-0	3
4.	CRL702	Architectures & Algorithms for DSP Systems	PC	2-0-4	4
		Elective-3	OEI/PE	3-0-0	3
5.	EEP736	Physical Design Lab	PC	0-0-6	3
		Total Credits			19
		Semester III			
1.	JVD801	Major Project Part 1	PC	0-0-12	6
2.		Elective-4	OEI/PE	3-0-0	3
3.		Elective-5	OEII/PE	3-0-0	3
4.		Elective-6	PE	3-0-0	3
5.	EEP788	IC Processing Lab*	PC	0-0-6	3
		Total Credits			18
		Semester IV			
1.	JVD802	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

* The course will be registered in the 3rd semester. The Laboratory will be run in the summer between the second and third semester.

List of Programme Elective

S.No.	Course No.	Title	L-T-P	Credits
1.	CSL672/ EEL703	Computer Networks	3-0-2	4
2.	CSL718	Architecture of High Performance Computer Systems	3-0-2	4
3.	CSL812	System Level Design & Modelling of Digital Systems	3-0-0	3
4.	CSL821	Reconfigurable Computing	3-0-0	3
5.	EEL781	Neural Networks	3-0-0	3
6.	EEL782	Analog ICS	3-0-0	3
7.	EEL802	Testing and Fault Tolerance	3-0-0	3
8.	EEL831	Digital Signal Processing-2	3-0-0	3
9.	EEL786	Mixed Signal Circuit Design	3-0-0	3
10.	EEL833	Selected Topics in IEC	3-0-0	3
11.	EEL787	Memory Design and Testing	3-0-0	3
12.	EEL881	Issues in Deep Submicron CMOS IC Design	3-0-0	3
13.	CRL702	Advanced IC Technology	3-0-0	3
14.	CRL704	Advanced Process and Devices Characterization (Measurement)	3-0-0	3
15.	CSL633/ EEL602	Resource Management in Computer Systems or Operating Systems	3-0-2	4
16.	JVD801	Minor Project	0-0-6	3
17.	JVS802	Independent Study	0-3-0	3
18.	CSL858	Advanced Computer Networks	3-0-2	4
19.	MAL701	Introduction of Programming and Data Structure	3-0-2	4

* Registration upto 5 students of VDTT with the consent of Course Coordinator.

Name of the M.Tech. Programme	Power Generation Technology (For Sponsored NTPC Engineers)

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
45	9	6	60

Scheduling of Courses

		Semester I			
S.No.	Course No.	Course Title	Type	L-T-P	Credits
1.	ITL702	Diagnostic Maintenance and Monitoring	PC	3-0-2	4
2.	MEL626	Mechanical Equipment in Power Plants	PC	3-0-0	3
3.	EEL641	Electrical Equipment in Power Plants	PC	3-0-0	3
4.	MEP691/ EEP691	Basic Mechanical Laboratory (For EE & C&I)/ Basic Electrical Laboratory (For ME)	PC	0-0-2/ 0-0-2	1/1
5.	MEL725/ EEL743/ EEL721	Power Plant Steam Generators (For ME)/ Power Electronic Devices & D.C. Converters (For EE)/ Linear System Theory (Fro C&I)	PC	3-0-0/ 3-0-0 3-0-0	3/3/3
6.	MEL727/ EEL791 EEL772	Power Plant Turbo machinery (For ME)/ Power System Analysis (For ME)/ Optimal Control Theory (For C&I)	PC	3-0-0/ 3-0-0 3-0-0	3/3/3
		Total Credits			17
		Semester II			
1.	MEL740	Instrumentation & Automatic Control Systems	PC	3-0-2	4
2.	JGL710	Power Plant Performance and Economics	PC	3-0-0	3
3.	MEP720/ EEP790	Advanced Mechanical Laboratory/ Advanced Electrical Laboratory	PC	0-1-4/ 0-1-4	3/3
4.		Program Elective-1	PE	3-0-0	3
5.		Program Elective-2	PE	3-0-0	3
6.		Open Elective-1	OE	3-0-0	3
		Total Credits			19
		Semester III			
1.		Program Elective - 3	PE	3-0-0	3
2.		Open Elective - 2	OE	3-0-0	3
3.	JGD801	Major Project Part 1	PC	0-0-12	6
		Total Credits			12
		Semester IV			
1.	JGD802	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

List of Program Electives

S.No.	Course No.	Title	L-T-P	Credits
1.	ITL760	Noise Monitoring & Control	2-0-2	3
2.	ITL714	Failure Mechanism Analysis & Repair	3-0-2	4
3.	ITL717	Corrosion & its Control	3-0-0	3
4.	MEL708	Combustion Generated Pollution and Control	3-0-2	4
5.	MEL709	Heat Exchangers	3-0-2	4
6.	MEL712	Advanced Power Plant Cycles	2-0-4	4
7.	MEL730	Hydroelectric Power Plants	3-0-0	3
8.	MEL806	Thermal Systems Simulation and Design	2-0-2	3
9.	MEL807	Computational Heat Transfer	2-0-4	4
10.	MEL811	Steam and Gas Turbines	3-0-2	4
11.	MEL812	Combustion	3-0-2	4
12.	MEL733	Vibration Engineering	3-0-2	4
13.	MEL741	Blade and Disc Dynamics	3-0-2	4
14.	MEL838	Rotor Dynamics	3-0-2	4
15.	MEL760	Project Management	2-0-2	3
16.	ESL711	Fuel Technology	3-0-0	3
17.	EEL745	Electrical Drives System	3-0-0	3
18.	EEL792	Power Systems Protection	3-0-0	3
19.	EEL797	Power Systems Dynamics	3-0-0	3
20.	EEL796	Power Systems Control & Instrumentation	3-0-0	3
21.	EEL799	Power Systems Reliability	3-0-0	3
22.	EEL823	Discrete Time Systems	3-0-0	3
23.	EEL824	Non-linear Systems	3-0-0	3
24.	EEL744	AC Controllers	3-0-0	3
25.	EEL841	Solid State Controllers of Drives	3-0-0	3
26.	EEL746	Non-conventional Energy Systems & Energy Conservation	3-0-0	3
27.	EEL894	Flexible AC Transmission Systems (FACTS)	3-0-0	3
28.	IDL811	Selected Topics in Instrumentation	3-0-0	3
29.	JGL712	Power Plant Control & Instrumentation	3-0-0	3
30.	JGS800	Independent Study	0-3-0	3

Name of the M.Tech. Programme	Telecommunication Technology and Management

Distribution of Total Credits

Program Core (PC)	Program Elective (PE)	Open Elective (OE)	Total Credits
45	09	06	60

Scheduling of Courses

		Semester I			
S.No.	Course No.	Title	Type	L-T-P	Credits
1.	EEL711	Signal Theory	PC	3-0-0	3
2.	EEL762	Digital Communications	PC	3-0-0	3
3.	EEL767	Telecommunication Systems	PC	3-0-0	3
4.	EEP773	Telecommunication Software Laboratory	PC	0-1-4	3
5.	EEP776	Wireless Communication Laboratory	PC	0-1-4	3
6.	SML723	Telecommunication Systems Management	PC	3-0-0	3
		Total Credits			18
		Semester II			
1.	EEL818	Telecommunication Technologies	PC	3-0-0	3
2.	EEP775	Telecommunication Networks Lab-I	PC	0-1-4	3
3.	SMD792	Minor Project	PC	0-3-0	3
4.	SML726/728	Program Elective - I (Management Elective)	PE	3-0-0	3
5.		Program Elective - II	PE	3-0-0	3
6.		Open Elective - I	OE	3-0-0	3
		Total Credits			18
		Semester III			
1.	JMD801	Major Project Part 1	PC	0-0-12	6
2.		Open Elective - II	OE	3-0-0	3
4.		Program Elective - III	PE	3-0-0	3
		Total Credits			12
		Semester IV			
1.	JMD802	Major Project Part 2	PC	0-0-24	12
		Total Credits			12

List of Program Electives

S.No.	Course No.	Title	Type	L-T-P	Credits
1.	EEL703	Computer Networks	PE	3-0-0	3
2.	EEL707	Multimedia Systems	PE	3-0-2	4
3.	EEL716	Telecommunication Transmission & Switching	PE	3-0-0	3
4.	EEL731	Digital Signal Processing	PE	3-0-0	3
5.	EEL817	Access Networks	PE	3-0-0	3
6.	EEL854	Protocol Engineering	PE	3-0-2	4
7.	EEL855	Internet Technologies	PE	3-0-2	4
8.	EEL857	Network Security	PE	3-0-2	4
9.	EEL858	Mobile Computing	PE	3-0-0	3
10.	EEL859	Network Management	PE	3-0-2	3
11.	EEL860	Wireless Communication Networks	PE	3-0-2	4
12.	EEL861	Selected Topics in Telecommunication Engineering I	PE	3-0-0	3
13.	EEL862	Selected Topics in Telecommunication Engineering II	PE	3-0-0	3
14.	EEL882	Introduction to Telecommunication Systems (Audit/Bridge)	PE	3-0-0	3
15.	EEP757	Embedded Telecommunication Systems Laboratory	PE	0-1-4	3
16.	EEP858	Telecommunication Networks Lab-II	PE	0-1-4	3
17.	EEP881	Network Software Laboratory	PE	0-1-4	3
18.	SML726	Telecommunication Systems Analysis, Planning & Design	PE	3-0-0	3
19.	SML728	International Telecommunication Management	PE	3-0-0	3
20.	JMS800	Independent Study	PE	0-3-0	3

Note: For further details/clarifications, the concerned Department/centre may be contacted.

DEPARTMENT OF APPLIED MECHANICS

D.I.I.T. (Naval Construction)

This Postgraduate Diploma Programme in Naval Construction is open to the sponsored candidates from Indian Navy only. The semester schedule of credit requirements is as follows:

I Semester Courses			
AML713	Applied Fluid Mechanics	4 credits	(3-1-0)
AML701	Engg. Mathematics & Mechanics	3 credits	(3-0-0)
AML732	Solid Mechanics	3 credits	(3-0-0)
AML791	Ship Resistance and Propulsion	3 credits	(3-0-0)
AML792	Structural Design of Ships	3 credits	(3-0-0)
AM L832	Application of Theory of plates & shells	2 credits	(2-0-0)
II Semester Courses			
AML702	Applied Computational Methods	4 credits	(3-0-2)
AML751	Materials for Marine Vehicles	3 credits	(3-0-0)
AML793	Ship Dynamics	3 credits	(3-0-0)
AML794	Warship Design	3 credits	(3-0-0)
AML795	Submarine Design	3 credits	(3-0-0)
AML706	Finite Element Methods and its Applications to Marine Structures	3 credits	(3-0-0)
III Semester Courses			
AML733	Dynamics	3 credits	(3-0-0)
AMD899	Design Project	10 credits	(0-0-20)

AML 700 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.

AML 701 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.

AML 702 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.

AM 704 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.

AML 705 Finite Element Methods:

4 credits (3-0-2)

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.

AML 706 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.

AML 710 Computer Aided Design:

4 credits (3-0-2)

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.

AML 711 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.

AML 712 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.

AML 713 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.

AML 714 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).

AML 715 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.

AML 730 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.

AML 731 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.

AML 732 Solid Mechanics:
3 credits (3-0-0)
Elementary theory of elasticity and plasticity. Theory of plates. Instability of rectangular plates. Stiffened plates. Anisotropic plates.

AML 733 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.

AML 734 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.

AML 750 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.

AML 751 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.

AML 771 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.

AMP 772 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.

AML 773 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.

AML 774 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.

AML 775 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.

AMP 776 Product Design Project I:
3 credits (1-0-4)

AMP 777 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.

AML 791 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.

AML 792 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.

AML 793 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.

AML 794 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.

AML 795 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.

AMS 801 Independent Study:
3 credits (0-3-0)

AMS802 Independent Study:
3 credits (0-3-0)

AML 803 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.

AML 805 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.

AML 811 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 finite element 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.

AMD 811 Major Project Part-I:
6 credits (0-0-12)

AML 812 Turbulent Shear Flows:
3 credits (3-0-0)
Origin of turbulence. Review of phenomenological theories. Structure of wall-turbulence and free-turbulence. Turbulent boundary layers. Plane and axisymmetric jets and wakes.

AMD 812 Major Project Part-II:
12 credits (0-0-24)

AMD 813 Major Project Part-I:
6 credits (0-0-12)

AML 813 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.

AMD 814 Major Project Part-II:
12 credits (0-0-24)

AML 814 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.

AML 815 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.

AML 816 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.

AML 820 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.

AML 821 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.

AML 831 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.

AML 832 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.

AML 833 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.

AML 834 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.

AML 835 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.

AML 836 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.

AML 837 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.

AML 838 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 auto-nomous, resonant and non-resonant systems and asymptotic methods. Application to beams, plates and shells.

AML 840 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.

AML 841 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.

AML 851 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.

AML 852 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 mechanismsductile 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.

AML 854 Advances in Physical Metallurgy:
3 credits (3-0-0)
Recent developments in phase transformations. Phase equilibrium in ternary alloys. Fracture resistant design.

AML 855 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.

AML 856 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.

AML 857 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.

AML 871 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.

AML 872 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 enginee- ring design.

AML 873 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.

AML 874 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.

AML 883 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.

AMD 897 Minor Project:
4 credits (0-0-8)

AMD 899 Design Project:
10 credits (0-0-20)

BIOCHEMICAL ENGINEERING & BIOTECHNOLOGY

For dual degree courses, old numbering scheme is applicable.

BE 703F Bioprocess Engineering – II:
3 credits (3-0-0)
Non ideality and RTD in bioreactors; stability analysis; analysis of multiple interacting microbial populations; stability of recombinant cells; physiology of immobilised cells; packed-bed bioreactors; fluidized-bed bioreactors; air lift bioreactors; bubble column bioreactors; immobilized enzyme bioreactors; special reactors for animal and plant cells; integrated systems of bioreaction and bioseparation; biosensors.

BE 704F Bioprocess Plant Design:
5 credits (3-1-2)
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 application; Design of fermenters; Design considerations for maintaining sterility of process streams processing equipment; Selection and specification of equipment for handling fluids and solids; Selection, specification 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.

BE 708F Bioseparation:
5 credits (3-0-4)
Characteristics of bioproducts; Flocculation and conditioning of broth; Mechanical separation; Cell disruption; Protein precipitation and its separation; Aqueous two phase extraction; Adsorption-desorption processes; Chromatographic methods of separation based on size, charge hydrophobic interactions, biological affinity methods etc.; Membrane based separation; Electrophoresis and Electrodialysis; Crystallization; Case studies.

Laboratory: Conventional filtration; Centrifugation; Cell disruption; Protein precipitation and its recovery; Aqueous two phase separation; Ion-exchange chromatography; Gel filtration; Membrane based filtration, i.e. microfiltration and ultrafiltration in cross flow modules.

BE 710F Biotechnology Resource Planning:
3 credits (3-0-0)
An overview of commercial products/ services through process biotechnology; Issues pertaining to development of biotechnology; General aspects related to the quality control of bioprocesses; Quality criterion for representative bioprocesses: Bioinoculants, Antimicrobial agents, metabolites, enzymes, therapeutic proteins; Health hazards in biotechnology and containment; Biosafety considerations and containments; Biotechnology and intellectual property rights; Bioinformatics and databases in biotechnology; Academia-industry interaction and technology transfer; Social and ethical issues related to biotechnology.

BE 711 Biological Waste Treatment:
4 credits (3-1-0)
Definition of waste, Physical, Chemical and Biological characteristics of waste water, BOD, COD and TOD- their estimation and correlation; BOD progression curve and kinetics; Effect of reaction rate constant on short term BOD, Determination of BOD rate constants; Effect of temperature on BOD; Nitrification and Denitrification and their kinetics; Activated sludge process (ASP), Biological solid retention time, Mixing regime in ASP, Kinetic model of ASP, Sludge volume index (SVI); relation between recycle ratio and biological solid retention time in ASP, minimum biological and solid retention time, Aeration system in ASP, Step aeration, extended aeration, contact stabilization, Loading criteria, excess sludge production, sludge viability, O_2 requirement in ASP, nutrient requirement in ASP; Solid liquid separation in secondary clarifier; Mass balance in secondary clarifier, evaluation of kinetic parameters in ASP, nitrification and biological denitrification in ASP; Anaerobic treatment of wastes, fundamental microbiology, Process kinetics; Rate limiting step approach, Gas production, process design consideration, case study; Attached growth of biological treatment process, Trickling filter, anaerobic digestion, kinetic relationships, sludge characteristics and design considerations, process modelling and control, case study; Aerobic digestion – kinetic relationships and design consideration, case study.

BE 714 Recombinant DNA Technology:
4 credits (2-0-4)
Introduction to r-DNA technology; Vectors-definition and types. Construction and properties of plasmid, phage, cosmid and phagemid vectors; Restriction enzymes and other enzymes-properties and uses in cloning; Gene cloning-genomic and cDNA cloning, chromosome walking; Expression of genes in recombinant cells; Stability of recombinant cells in the production of biochemicals; DNA sequencing, Gene mapping; polymerase chain reaction.

Laboratory: Isolation and purification of eukaryotic chromosomal DNA; demonstration of promoter activity; determination of plasmid copy number and stability; construction of genomic library, Nucleic acid sequering PCR.

BE 717 Animal Cell Technology:
4 credits (3-0-2)
Animal cell metabolism, regulation and nutritional requirement; Animal cell growth characteristics and kinetics; Nutrient, substrate and product transport through mammalian cell; Micro carrier attached growth; Cell culture in continuous, perfusion and hollow-fiber reactor; Mass transfer in mammalian cell culture; Scale-up of cell culture processes; Case studies.

Laboratory: Cell culture in static phase (T-flask); and in spinner flasks; microcarrier and perfusion cell culture in spinner flask; growth kinetics; study of shear sensitivity of cell culture; metabolic study of culture cell; antibody production; cell culture in biroeactor.

BE 720 N Combinatorial Biotechnology:
3 credits (3-0-0)
Introduction to combinatorial chemistry and biology; Combinatorial molecules peptides, proteins, molecules, oligonucleotides; Combinatorial methods: solid phase synthesis, phage display, DNA shuffling; Synthesis of high affinity antibodies; RNA-DNA aptamer; Synthesis of pharmaceutically potent agonists and antagonists; Invitro evolution of ribozymes; screening strategies; High throughput screening.

BE 722 Protein Engineering:
3 credits (3-0-0)
Protein structure and folding; Mechanism of folding, chaperonins and other

proteins, shape size and conformation; Motifs of protein structure, Alpha domain, Beta domain and Alpha/Beta domain; X-ray analysis of proteins:Mathematical principles, Bragg's Law, NMR; Strategies for protein engineering; Random, site directed, catalytic effectivity; Structure prediction and modelling of proteins: Molecular graphics in protein engineering, Dynamics and mechanics; Drugs-protein interactions and Design; Protein engineering benefits: Industry, Medicine; Engineering Antibodies.

BE 723 Plant Cell Technology:
3 credits (2-0-2)
Special features and organization of plant cells; totipotency, regeneration of plants, concept of totipotency, examples of regeneration from leaves, roots, stem etc; Plant products of industrial importance; Biochemistry of major metabolic pathways and products; Cell suspension culture development, characterization, Kinetics of growth, production formation, examples; Large scale production of secondary metabolites from suspension cultures-Nutrient optimization, Cell growth regulators, Biological and technological barriers; Mutation, somaclonal variation, genetic engineering of plant cells; Plant cell reactors-types of reactors, Comparison of reactor performances, Immobilized plant cell reactors; Novel design concepts.

Laboratory: Development of callus and suspension cultures of plant cells; Shear sensitivity; Growth and product fromation kinetics in suspension cultures; Production of secondary metabolites in bioreactors using suspension cultures/ immobilized cells.

BE 725 Current Topics in Biochemical Engineering & Biotechnology:
3 credits (3-0-0)
The course will cover areas of current research interest in biochemical engineering and biotechnology. Representative areas include upstream and downstream processing, media engineering and process analysis and control.

BE 731 High Resolution Methods in Biotechnology:
3 credits (3-0-0)
Need for high resolution separation for biologicals; Difficulties with traditional methodologies; Affinity precipitation and partitioning; MF/UF/NF for high resolution separation; Chromatographic techniques; Affinity chromatography and electrophoresis, Separation by gene amplification (PCR), Molecular imprinting.

BE 891S Major Project I:
6 credits (0-0-12)

BE 892S Major Project II:
12 credits (0-0-24)

M.S. (Research) in Biochemical Engineering & Biotechnology:

Minimum requirement of credits for this programme is 60;20 credits of course work to be completed normally during first semester of admission and 40 credits of research work spread over three semesters.

CORE COURSES

BEL 810 Enzyme and Microbial Technology:
3 credits (3-0-0)

BEL 820 Downstream Processing:
3 credits (3-0-0)

BEL 830 Microbial Biochemistry :
3 credits (3-0-0)

BEP 840 Lab Techniques in Microbial Biochemistry:
2 credits (0-0-4)

BEL 850 Advanced Biochemical Engineering:
5 credits (3-0-4)

BED 800 Major Project:
40 credits (0-0-80)

COURSE DETAILS

BEL 810 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.

BEL 820 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.

BEL 830 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.

BEP 840 Lab 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.

BEL 850 Advanced Biochemical Engineering:
5 credits (3-0-4)

Lectures

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.

BED 800 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.

BEL 860 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.

BEL 880 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.

BEL 890 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.

BEL 895 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

CHL 603 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.

CHL 604 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.

CHL 626 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 contractors; 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.

CHL 634 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.

CHL 653 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.

CHL 701 Process Enginering:
*4 credits (3-0-2)**

CHL 702 Plant Design:
4 credits (3-0-2)
Plant layout, auxiliaries, materials handling, offsite facilities, selection and detailed design of equipments, e.g., mixers, conveyers, heat exchangers, separation equipments, pumps, compressors, etc.

CHL 705 Electrokinetic Transport in Chemical Engineering:
4 credits (3-0-2)
Definition of colloidal state and implications, intermolecular and surface forces, electrostatics, transport equations in electrolytic solution, electrokinetic phenomena, electro-phoresis, sedimentation potential, coagulation of particles, Particle deposition and aggregation.

CHL 707Absorption Seperation Process (3-0-0)*

CHL 710 Process Dynamics and Control:
5 credits (3-1-2)
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.

CHL 711 Numerical Methods in Chemical Engineering:
4 credits (3-0-2)
Efficient and recent numerical techniques applied to problems of chemical engineering interest. Basic methods and their applications. Solution of simultaneous linear and non-linear algbraic equations. Numerical differentiation and integration, ordinary and partial differential equations.

CHL 714 Advanced Heat Transfer:
3 credits (3-0-0)
Formulation and solution of transient and steady-state conduction. Heat transfer analogies. Direct contact heat transfer. Radiative heat transfer from surfaces and flames. Combined convective and radiative heat transfer. Application to furnaces and kilns.

CHL 717 Mechanical Design of Process Equipment:
4 credits (3-0-2)
Design of distillation columns operating under pressure or vacuum; design of tanks for storage of liquids and gases including the selection of accessories; design of tall absorption or strippling columns subjected to seismic and wind loading.

CHL 723 Chemical Reaction and Reactor Engineering:
3 credits (3-0-0)
Theory of mass transfer with reaction. Enhancement factor for single irreversible and reversible reactions. Modelling of mass transfer accompained by complex gas-liquid reactions.

Gas liquid reactor design.

Stability and control of chemical reactors. Runaway and parametric sensitivity of batch reactors; Modelling of solid catalyse gas-liquid reactors; Design of trickle bed and slurry reactors.

CHL 724 Environmental Engineering & Waste Management:
4 credits (3-1-0)
Ecology and Environment. Sources of air, water and solid Wastes. Air Pollution: Micrometeorology 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.

CHL 727 Heterogeneous Catalysis and Catalytic Processes:

4 credits (3-0-2)

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.

CHL 735 Design of Separation Processes:

4 credits (3-0-2)

Brief description of different processes (e.g., distillation, absorption, extraction, adsorption, drying, ion-exchange, membrane processes, chromatographic techniques, molecular sieves, foam fractionation, zone refining, multicomponent distillation, mass transfer with chemical reaction, etc.). Design principles.

Sizing of equipment and their design including fabrication details (plate tower, packed tower, bubble and sieve trays, evaporator).

CH 740 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.

CH 743 Petrochemical Technology:

3 credits (3-0-0)

Introduction composition of petroleum laboratory tests, refinery products, characterization of crude oil.

CHD 760 Minor Project:

3 credits (0-0-6)

M.S. (Research) in Chemical Engineering

Minimum requirement of credits for this programme is 60. 20 credits of course work to be completed normally during first semester of admission and 40 credits of research work spread over two or more subsequent semesters.

CHD 770 Major Project Part-I (0-0-12)

CHD 780 Major Project Part-II (0-0-24)

CHL 751 Multicomponent Mass Transfer (3-0-0)*

CHL 761 Chemical Engineering Mathematics. (3-0-0)*

CHL 766 Interfacial Engineering (3-1-0)*

CHL 773 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 equations…Estimations of parameters in equations of second order with interaction factor.Case studies on application to research and industrial data analysis.

CHL 793 *Membrane Science and Engineering (3-1-0)**

CHL 794 Petroleum Refinery Engineering (3-0-2)*

CHL 795 Agro Process Technology:

3 credits (3-0-0)

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.

CHD 801 Major Project (Part-I):

6 credits.

CHD 802 Major Project (Part-II):

12 credits

CHL 807 Population Balance Modelling:

3 credits (3-0-0)

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, Comminution Processes, Microbial population, Residence-time distribution, Dispersed-phase mixing.

CHL 813 Thermodynamics and Process Design:
3 credits (2-0-2)
Thermophysical properties of pure fluids : Equilibrium properties such as vapour pressure, latent heats, critical constant and PVT behaviour. Transport properties such as viscosity, thermal conductivity and diffu- sivity, estimation and correlation methods. Properties of multicom- ponent systems : V-L-E using equations and state and group contri- bution methods. L-L-E correlation and prediction.

Homogeneous and heterogeneous chemical equilibria with competing chemical reactions.

CHD 895 Major Project (M.S. Research):
40 credits (0-0-80)

CHP 711 Process Development Lab (0-0-6)*

CHS 780 Independent Study: (0-3-0)

* Course details may be seen from UG/Dual Degree Courses of Study.

DEPARTMENT OF CHEMISTRY

CYL 701 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.

CYL 702: 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.

CYL 703 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.

CYL 704 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

CYL 705 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.

CYL 707 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.

CYL 711 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).

CYL 712 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.

CYL 713 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.

CYL 714 NMR and Mass Spectrometric Methods:
3 credits (3-0-0)
Modern NMR and mass spectrometry including fundamentals, instrumentation, and analytical applications.

CYL 715 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

CYL 716 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.

CYL 717 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

CYL 718 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

CYD 799: Minor Project:
3 credits (0-0-6)

CYS 800 Independent Study:
3 credits (0-3-0)

CYD 801 Major Project I:
6 credits (0-0-12)

CYD 802 Major Project II:
12 credits (0-0-24)

CYP 803 Glass Blowing:
1 credit (0-0-2)
Experiments in glass blowing using burner, hand torch and lathe.

CYC 805 Seminar:
2 credits (0-2-0)

DEPARTMENT OF CIVIL ENGINEERING

CEL 610 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.

CEL 612 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, de-watering.

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.

CEL 614 Geoenvironmental and Geo-hazard 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.

CEL 651 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.

CEP 701 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.

CEL 701 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.

CED 701 Minor Project in Geotechnical and Geoenvironmental Engineering :
3 credits (0-0-6)

CEP 702 Geoenvironmental & 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.

CEL 702 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.

CEL 703 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.

CEL 704 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. Consolidation settlement in clays (with correction factors). Immediate settlement. 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.

CEL 705 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.

CEL 706 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.

CEL 707 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 straind 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.

CEL 708 Earth Pressure 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.

CEL 709 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.

CEL 712 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.

CEL 714 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.

CEL 715 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.

CEL 717 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.

CEL 718 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.

CEL 719 Structural Dynamics:

3 credits (3-0-0)

Free and forced vibration of single degree of freedom (SDOF) system, response to harmonic, periodic, inpulsive and general dynamic loading, response of SDOF to earthquake. Free vibration of lumped multidegree of freedom system. 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 of soil-structure interaction.

CEL 721 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.

CEL 722 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 models; Superposition and correspondance principles. Viscoplasticity

CEP 724 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.

CEL 724 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.

CEP 726 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.

CEL 727 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.

CEL 729 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.

CEL 731 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.

CEL 733 Finite Element Method in Structural Engineering:
3 credits (2-1-0)
Review of principles of virtual work and minimum potential energy. Elements 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.

CEL 734 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.

CEL 735 Hydrologic Processes and Modeling:
3 credits (3-0-0)
Land surface processes. Subsurface and channel processes. Unit Hydrograph and GIUH, Flood Propagation and Rooting, Frequency Analysis, Watershed Model, Conceptual Models. Hydrologic Forecasting.

CEL 736 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, Environmental impact of water resources projects, Assessment of hydrological hazards, Environmental management, Case studies.

CEL 737 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.

CEL 738 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.

CEL 739 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.

CEP 740 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.

CEL 741 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.

CEL 742 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.

CEL 743 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.

CEL 744 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.

CEL 745 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.

CEL 746 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.

CEL 747 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.

CEL 748 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.

CEL 749 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.

CEP 751 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 sheor test. Slake durability and Permeability tests. Compilation of test data. Classification. Codal Provisions.

CEL 751 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.

CEP 752 Rock Mechanics Laboratory II:
3 credits (0-0-6)
Prerequisite: (CEP751) Project based Laboratory.

CEL 752 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.

CEL 753 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.

CEL 754 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.

CEL 756 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.

CEL 757 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.

Logging, stratigraphic profile, scan line survey, oriented cores, 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.

CEL 758 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.

CED 760 Minor Project in Rock Engineering Under Ground Structures:
3 credits (0-0-6)

CEL 760 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.

CEL 761 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.

CEL 762 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.

CEL 763 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.

CEL 766 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.

CEL 767 Construction and Contract Management:
3 credits (3-0-0)
Project cost estimation, rate analysis, overhead charges, bidding models and bidding strategies. Qualification of bidders.

Tendering and contractual procedures, Indian Contract Act1872, Definition of Contract and its applicability, Types of contracts, International contracts, Conditions and specifications of contract. Contract administration, Claims, compensation and disputes, Dispute resolution techniques, Arbitration and Conceliation Act 1996, Arbitration case studies, Professional ethics, Duties and responsibilities of parties.

Management Information systems, Risk analysis, Value engineering.

CEL 768 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.

CEL 769 Project Planning and control:

3 credits (2-1-0)

Work-study, work breakdwon structure, Time estimates, Applications of CPM/ PERT, statical 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.

CEP 770 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.

CEL 771 Civil Engineering Materials:

3 credits (3-0-0)

Cement selection for civil works. Concrete making materials. Fresh concret 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.

CEL 772 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.

CEL 773 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.

CEL 774 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 valiey projects.

Safety measures, Quality management, Reliability.

CEP 775 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.

CEL 776 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.

CEL 777 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.

CEL 778 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.

CEL 779 Construction Economics and Finance:

3 credits (3-0-0)

Construction accounting, Income statement. Depreciation and amortization. Engineering economics, Time value of money, discounted cash flow, NPV, ROR, PI, Bass 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.

CEL 781 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 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. 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.

CEL 782 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.

CEL 783 Traffic Engineering

4 credits (3-0-2)

Traffic studies: Survey and analysis. types 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, signal co-ordination. Traffic flow, delay models. Highway Capacity.

CEL 784 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.

CEL 785 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.

CEL 786 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.

CEL 787 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.

CEL 788 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.

CEL 789 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.

CEP 789 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.

CEP 790 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.

CEL 793 Air Pollution and Control:
4 credits (3-0-2)
Air-pollution – definition, sources, classification. Dynamics of pollutant dispersan 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.

CEL 794 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. Economics of the on-site v/s off site waste management options. Integrated waste management.

CEL 795 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 a sludge management.

CEL 796 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.

CEL 797 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.

CEL 801 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.

CES 810 Independent Study (Geotechnical & Geoenviron-mental Engineering):
3 credits (0-3-0)

CED 811 Major project in Geotechnical and Geoenvironmental Engineering Part I:
6 credits (0-0-12)

CED 812 Major Project in Geotechnical and Geoenvironmental Engineering Part II:
12 credits (0-0-24)

CEL 817 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.

CEL 818 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.

CEL 819 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.

CES 820 Independent Study (Structural Engineering):
3 credits (0-3-0)

CED 821 Major Project Part-1 (Structural Engineering):
6 credits (0-0-12)

CED 822 Major Project Part-2 (Structural Engineering):
12 credits (0-0-24)

CEL 822 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 in Stability analysis of Steel Concrete and masonry structures.

CEL 824 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.

CEL 826 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.

CEL 828 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.

CEL 832 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.

CEL 840 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.

CEL 843 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.

CEL 844 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.

CEL 845 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).

CES 840 Independent Study (Water Resources Engineering):
3 credits (0-3-0)

CED 841 Major Project Part-1 (Water Resources Engineering):
6 credits (0-0-12)

CED 842 Major Project Part-2 (Water Resources Engineering):
12 credits (0-0-24)

CES 850 Independent Study (Rock Engineering & Underground Structures):
3 credits (0-3-0)

CED 851 Major Project Part-1 (Rock Engineering & Underground Structures):
6 credits (0-0-12)

CED 852 Major Project Part-2 (Rock Engineering & Underground Structures):
12 credits (0-0-24)

CED 870 Independent Study (Construction Engineering & Management):
3 credits (0-3-0)

CED 871 Major Project Part-1 (Construction Engineering & Management):
6 credits (0-0-12)

CED 872 Major Project Part-2 (Construction Engineering & Management):
12 credits (0-0-24)

CES 874 Independent Study (Construction Technology & Management):
3 credits (0-3-0)

CED 875 Major Project Part-1 (Construction Technology & Management):
6 credits (0-0-12)

CED 876 Major Project Part-2 (Construction Technology & Management):
12 credits (0-0-24)

CEL 879 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.

CED 881 Major Project Part-1
6 credits (0-0-12)

CEL 882 Major Project Part-2
12 credits (0-0-24)

CEL 886 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.

CEL 889 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.

CES 890 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.

CEL 891 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 gasses, liquids and solids. Production of combustion. Low Temperature Techniques: Autoclaving, Wet Air Oxidation, Microwaving. High Temperature Techniques : Incineration, Gasification, Pyrolysis. Advanced Technologies : Circulating, Fluidized Bed Systems, Plasmas 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.

CED 891 Major Project Part-1 (Environmental Engineering and Management):
6 credits (0-0-12)

CEL 892 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.

CED 892 Major Project Part-2 (Environmental Engineering and Management):
12 credits (0-0-24)

CEL 894 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 aspects., 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 surveillance 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.

CEL 895 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 Degraded or Destroyed Ecosystems.

CED 895 Major Project (M.S. Research):
40 credits (0-0-80)

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.

CEL 897 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.

CEL 898 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.

CEL 899 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.

CSP 601 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.

CSL 630 Data Structures and Algorithms:
4 credits (3-0-2)
Review of basic data structures and their realization in object oriented environment. 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.

CSL 632 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.

CSL 633 Resource Management in Computer Systems:
4 credits (3-0-2)
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 management including virtual memory 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.

CSL 665 Introduction to Logic and Functional Programming:
4 credits (3-0-2)
Introduction to declarative programming paradigms. The functional style of programming, paradigms of developments of functional programs, use of higher order functionals and pattern-matching. 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. Laboratory exercises will focus on the following: unification, resolution, theorem proving and pattern matching and type inferencing.

CSL 671 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 formalism.Planning. Handling uncertainty: Bayesian Networks, Dempster-Shafer theory, certainity factors. Fuzzy logic, Learning through Neural nets - Back propagation, radial basis functions, Neural computational models - Hopfield Nets, Boltzman machines. PROLOG programming. Expert Systems.

CSL 672 Computer Networks:
4 credits (3-0-2)
Networks, goals, applications, classifications, 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. Network: routing, Congestion control, Internet protocols; Multicast Routing and reliable Multicast. Mobile IP. Laboratory exercises will focus on the students ability to use this protocols in practical systems.

CSL 718 Architecture of High Performance Computer Systems:
4 credits (3-0-2)
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.

CSL 719 Synthesis of Digital Systems:
4 credits (3-0-2)
Hardware description languages; RT level, gate level and system level modeling; Synthesis of control and data paths; Behavioral Synthesis; Logic Synthesis; State assignment problem; PLA realization; Microprogrammed control realization; Technology mapping; FPGA technology mapping; Low power issues.

CSL 728 Compiler Design:
4.5 credits (3-0-3)
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.

CSL 740 Software Engineering:
4 credits (3-0-2)
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.

CSD 745 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).

CSL 750 Foundations of Automatic Verification:
4 credits (3-0-2)
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).

CSL 755 Mathematical Foundation of Computer Science:
3 credits (3-0-0)

CSL 758 Advanced Algorithms:
3 credits (3-0-0)
Topics from some or all of the following areas:

Advanced data structures: self-adjustment, persistence and multi-dimensional trees.

Randomized algorithms: Use of probabilistic inequalities in analysis, applications using examples.

Geometric algorithms: Point location, Convex hulls and Voronoi diagrams, Arrangements.

Graph algorithms: Matching and Flows.

Approximation algorithms: Use of Linear programming and primal dual, Local search heuristics.

Parallel algorithms: Basic techniques for sorting, seraching, merging, list ranking in PRAMs and Interconnection networks.

CSL 771 Data Base Implementation:
4 credits (3-0-2)
Basic file organization techniques, indexing, hashing, index structures for multiple imensions, algorithms for database operations. Recovery techniques, concurreny control — models and algorithms. Information integration.

CSL 781 Computer Graphics:
4.5 credits (3-0-3)
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.

CSL 783 Digital Image Analysis:
4.5 credits (3-0-3)
Digital Image Fundamentals; Image Enhancement in Spatial Domain: Gray Level Transformation, 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; Representation 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.

CSS 799 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.

CSL 812 System Level Design and Modelling:
3 credits (3-0-0)
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.

CSL 821 Reconfiguration Computing:
3 credits (3-0-0)

CSL 830 Distributed Computing:
3 credits (3-0-0)
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.

CSL 831 Semantics of Programming Languages:
3 credits (3-0-0)
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.

CSL 832 Proofs and Types:
3 credits (3-0-0)
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.

CSL 840 Computer Vision:
4 credits (3-0-2)
Camera models, Calibration, Multi-views projective geometry and invariants Edge/feature extraction, Correspondence and tracking, 3D structure/motion estimation, Object recognition.

CSL 847 Distributed Algorithms :
3 credits (3-0-0)
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.

CSL 851 Algorithmic Graph Theory:
3 credits (3-0-0)
Introduction 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 arboresecnce. 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.

CSL 852 Computational Geometry:
4 credits (3-0-2)
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

CSL 853 Complexity Theory:
3 credits (3-0-0)
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.

CSL 854 Approximation Algorithms:
3 credits (3-0-0)
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.

CSL 855 Mathematical Foundations of Computing:
3 credits (3-0-0)
Computing and the notion of an effective procedure. RAM model, Primitive and partial recursive functions, Lambda-calculus, 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.

CSL 856 Mathematical Programming:
4 credits (3-0-2)
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.

CSL 858 Advanced Computer Networks:
4 credits (3-0-2)
Prerequisite : Permission of the instructor required. Should have done a course or have knowledge equivalent to CS372N or CSL672.
Flow and Congestion Control: Window and Rate Based Schemes, Decbit, TCP, ATM ABR, hop-by-hop schemes. Quality of Service: in ATM, IETF integrated services model, Differentiated Services Model. Flow Identification, Packet Classifiers and Filters. Scheduling.

Network Management: ASN, SNMP, CMIP. Issues in the management of large networks. Multicast: IGMP, PIM, DVMRP. Mobility: IP.

CSL 859 Advanced Computer Graphics:
4 credits (3-0-2)
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.

CSL 860 Special Topics in Parallel Computation:
3 credits (3-0-0)
The course will focus on research issues in areas like parallel computation models, parallel algorithms, Parallel Computer architectures and inter-connection network, 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. In addition we will study performance evaluation and benchmarking on today's high-performance computers.

CSL 861 Special Topics in Hardware Systems:
3 credits (3-0-0)
Under this topic one of the following areas will be covered :

Fault Detection and Diagnosability. Special Architectures. Design Automation Issues. Computer Arithmetic, VLSI.

CSL 862 Special Topics in Software Systems:
3 credits (3-0-0)
Under this topic one of the following areas will be covered: Design, Implementation and issues of Semantics of Programming Languages. Distributed Programming and Operating Systems.

CSL 863 Special Topics in Theoretical Computer Science :
3 credits (3-0-0)
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)
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.

CSL 865 Special Topics in Computer Applications:
3 credits (3-0-0)
Under this topic one of the following areas will be covered :

Issues in Database Management Systems, Robotics, Computer Networks, Computer Graphics, VLSI Signal Processing.

CSL 866 Special Topics in Algorithms:
3 credits (3-0-0)
The course will focus on specialized topics in areas like Computational Topology, Manufacturing processes, Quantum Computing and Computational Biology, Randomized algorithms and other research intensive topics.

CSL 867 Special Topics in High Speed Networks:
3 credits (3-0-0)
Prerequisite : Permission of the instructor required.
The course will focus on one or more of the following advanced topics in the area of high speed integrated networks. Traffic management, flow control, advisory control, signaling and quality of service issues. Routing, SOS Routing, Routing in VPS mobility, stability. Wireless Networks: Issues in wireless networks, third generation wireless systems, Media excess control issue, mobility, WAP. Network Management & Performance Analysis Techniques Security issues in modern computer networks, Multimedia communication.

CSL 868 Special Topics in Database Systems:
3 credits (3-0-0)
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.

CSL 869 Special Topics in Concurrency:
3 credits (3-0-0)
Prerequisite: Permission of the instructor required.
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 and 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.

CSV 880 Special Module in Parallel Computation:
1 credits (1-0-0)
Special module that focuses on special topics and research problems of importance in the area of Parallel Computation.

CSV 881 Special Module in Hardware Systems:
1 credits (1-0-0)
Special module that focuses on special topics and research problems of importance in the area of Hardware Systems.

CSV 882 Special Module in Software Systems:
1 credits (1-0-0)
Special module that focuses on special topics and research problems of importance in the area of Software Systems.

CSV 883 Special Module in Theoretical Computer Science:
1 credits (1-0-0)
Special module that focuses on special topics and research problems of importance in the area of Theoretical Computer Science.

CSV 884 Special Module in Artificial Intelligence:
1 credits (1-0-0)
Special module that focuses on special

topics and research problems of importance in the area of Artificial Intelligence.

CSV 885 Special Module in Computer Applications:
1 credits (1-0-0)
Special module that focuses on special topics and research problems of importance in the area of Computer Applications.

CSV 886 Special Module in Algorithms:
1 credits (1-0-0)
Special module that focuses on special topics and research problems of importance in the area of Algorithms.

CSV 887 Special Module in High Speed Networks:
1 credits (1-0-0)
Special module that focuses on special topics and research problems of importance in the area of High Speed Networks.

CSV 888 Special Module in Database Systems:
1 credits (1-0-0)
Special module that focuses on special topics and research problems of importance in the area of Database Systems.

CSV 889 Special Module in Concurrency:
1 credits (1-0-0)
Special module that focuses on special topics and research problems of importance in the area of Concurrency.

CSD 893 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.

CSD 894 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.

CSD 895 Major Project (M.S. Research):
40 credits (0-0-80)

DEPARTMENT OF ELECTRICAL ENGINEERING

EEL 601 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.

EEL 602 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.

EEL 641 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.

EEP 691 Basic Electrical Engineering Lab:
1 Credit (0-0-2)
Basic experiments related to basic electrical networks, electrical machines, power systems and power electronics..

EED 701 Minor Project (Computer Technology):
2 credits (0-0-4)

EEP 701 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.

EEL 702 System Software:
4 credits (3-0-2)
Introduction to Object Oriented Programming and Object Oriented Design. System Software design issues. Language Translators, Assemblers, Linkers and loaders. Run-time environment management. Lab exercises related to these topics.

EEP 702 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..

EEL 703 Computer Networks:
3 credits (3-0-0)
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, formating, data compression, data security.

EEP 703 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.

EEL 704 Robotics and Automation:
3 credits (3-0-0)
Basic components of robotic systems. Kinematics for manipulators, selection of coordinate frames. Homogenous transformation. Solution of kinematics and manipulator dynamics. Iterative Newton-Euler Dynamic formulation. Dynamic simulation and animation. Path planning, position, velocity and force control,computed torque control. Linear and non-linear controller design of robot. Application of computer controlled robots in manufacturing and programmable automation. Robot vision.

EEL 705 Embedded Systems and Applications:
3 credits (3-0-0)
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.

EEL 706 Computer Vision:
4 credits (3-0-2)
What is Vision; Overview of Applications; Camera: Physics of Image Formation, Geometric 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.

EEL 707 Multimedia Systems:
4 credits (3-0-2)
Multimedia streams, multimedia signal conditioning, compression standards, storage mechanisms, multimedia databases, multimedia document management-hypertext and hyper-media, distributed multimedia, data networks for multimedia distribution, content and media stream synchronizations, virtual reality and teleprescence, contemporary multimedia systems, case studies.

EEL 708 Information Retrieval:
3 credits (3-0-0)
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.

EEL 709 Pattern Recognition:
3 credits (3-0-0)
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-Likehood and Bayesian Parameter Estimation, Component Analysis, E-M technique, Hidden Markov Model, Non-Parametric Techniques: Nearest Neighbour, K-NN. Non-metric Methods: Decision Trees, ID3, Grammer based Methods. Neural Network Based Approaches, Fuzzy Logic Based Techniques, Support Vector Machine, Applications.

EEL 710 Coding Theory:
3 credits (3-0-0)
Measures of Information, Information contents of discrete sources, the entropy function, Communication channel Models, Source coding: Prefix codes, Block codes and Tree codes for data compaction, Discrete-time Channels and their capacity, the Random Coding Band, Block Codes and tree for data transmission. Alegebraic codes; Hamming, BCH, Reed-Solomon and Reed-Muller Coes, Algebraic Geometric Codes: Goppa codes and Codes over eliptic curves, signaling with and without bandwidth constraint, combined coding and Modulation: Trellis Coded Modulation (TCM, One and two dimensional modulations for TCM, Multidimensional TCM,Lattice Codes.

EEL 711 Signal Theory:
3 credits (3-0-0)
Representation of deterministic signals : Orthogonal representation of signals. Dimensionality of signal spaces. Construction of orthogonal basis functions. Time-bandwidth relationship : RMS duration and bandwidth, uncertainty relations.

Random Processes : Definition and classification, stochastic integrals, Fourier transforms of random processes, stationary and non-stationary processes, correlation functions. Ergodicity, power spectral density, transformations of random processes by linear systems. Representation of random processes (via sampling, K-L expansion and narrow band representations), special random processes (white Gaussian noise, Wiener-Levy processes, shot-noise processes, Markov processes).

Optimum Filtering : Matched filters for deterministic signals in white and coloured Gaussian noise. Wiener filters for random signals in white and coloured Gaussian noise. Discrete and continuous time filters.

EEL 712 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.

EE L713 Microwave Theory and Circuits:
3 credits (3-0-0)
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 and other parameters, signal flow graphs and network representation. Impedance matching and tuning. Analysis of planar transmission lines. Analysis and design of passive components.

EEL 714 Digital Communication and Information Systems:
3 credits (3-0-0)
Review of Fourier Transforms, Random Processes Probability, 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 Connecting Codes, Parity Check, Block Codes, Cyclic Redundancy Check, Coding strength, Bit Error Rate Calculations.

EEL 715 Image Processing:
4 credits (3-0-2)
Characterisation of images as two-dimensional discrete fields, unitary transforms-DFT. Hadamard, slant and cosine transforms, compression schemes Karhunen Loeve compression predictive coding schemes. Image enhancementgray scale modification, edge enhancement, restoration Wiener filtering, constrained deconvolution, recursive filtering, segmentation edge detection, thresholding, textural properties, geometry and shape description.

EEL 717 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.

EEL 716 Telecommunication Switching & Transmission:
3 credits (3-0-0)
Introduction: Basicline circuits in telephony and telegraphy; long-haul communication circuits; principles of circuits switching, & signalling: schemes, CCS7; Review of transmission systems - cable, radio, microwave optical, satelite, troposcatter.

Review: Strowger's and crossbar switches; space-time-and space time division switching; single stage and multi-stage switching network + example,principles of large scale switch design.

Properties of connecting networks: mathematical models of network states, rearrangeability: wide-sense and strict sense non-blocking criteria, slepian-Duguid Theorem, Paull's Theorem.

Traffic Engineering and Teletraffic Theory: Markov processes representing traffic, calculation of blocking probability, stationary probability measures for ergocic Markov processes, combinatorial interpretation, calculation of blocking probability.

Switching Network Control and management, data networks and protocols, ISDN, Message Handling systems/intelligent networks, multiservice bradband switching fabrics-ATM

EEP 717 Communication Laboratory I:
2 credits (0-0-4)
Experiments related to Communication.

EEL 718 Statistical Signal Processing:
3 credits (3-0-0)
Mathematical preliminaries. Wiener flitering and MMSE estimates. Linear prediction, Levinson-durbin algorithm and lattice. Filters: Overview of Spectral Estimation Methods. Adaptive Algorithms: 1. LMS Algorithm, Conveargence Analysis, Adaptive Noise Cancellar; 2. Least Squares Algorithm: General Weighted Least Squares Methods, Recursive Least Squares Algorithm,Fast Least Squares Algorithm for AR modelling case. Special Topics.

EEP 719 Communication Laboratory II:
2 credits (0-0-4)
Experiments related to Microwaves.

EES 720 Independent Study (Control & Automation):
3 credits (0-3-0)

EEL 721 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.

EEL 723 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.

EEP 725 Control Laboratory:
3 credits (0-0-6)

EEL 731 Digital Signal Processing:
3 credits (3-0-0)
Discrete time signals and systems Z-transforms. Structures for digital filters. Designs procedures for FIR and IIR Filters.

Frequency Transformations : Linear phase design. Introduction to DFT. Errors in digital filtering. Hardware implementation considerations.

EEL 732 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 Semiconductorcontacts (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.

EEL 734 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.

EEP 735 I.E.C. Laboratory I:
3 credits (0-0-6)
Design and development of electronic circuits using analog and digital ICs (Application Lab).

EEP 736 Physical Design Lab:
3 credits (0-0-6)

EEL 741 Modelling and Analysis of Electrical Machines:
3 credits (3-0-0)
Energy state functions. Modelling of electromechanical systems. Matrix methods and use of generalised circuit theory of machines. Different methods of transformation d.c., phase variable, instantaneous symmetrical component techniques. Reference frames. Development of basic performance equations 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 transient in induction machines. Relevant computer techniques for mahcine analysis. Modelling of special electrical machines

EEL 742 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.

EEL 743 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.

EEL 744 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 techniquessingle 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.

EEL 745 Electrical Drives System:
3 credits (3-0-0)
Basic ConceptsCharacteristics 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.

EEL 746 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.

EEL 747 Electrical Systems for Cons-truction Industries:
4 credits (3-0-2)
Elements of Distribution System : Distribution transformer circuit breakers, Cables, Fuses and protection schemes, Rectifiers, Batery 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.

EEL 754 Computer Graphics:
4 credits (3-0-2)
Elements of a computer graphics system. Graphic-primitive generation algorithms. Transformations – viewing and modelling, 3D curve and surface modelling schemes. Solid modelling. Rendering: hidden surface elimination, illumination model, ray tracing, shading, transparency, shadows, textures, colour. Introduction to graphics hardware.

EEL 758 Intelligent and Knowledge Based Systems:
3 credits (3-0-0)
Problem solving: state space representation, problem reduction, constraint satisfcation 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. Diagnostic reasoning. Structured Knowledge Representation Schemes: Semantic networks, Frames, Inheritance and default reasoning. Expert Systems: Architecture of the expert systems. Expert system shells. Knowledge acquisition. Consistency of the knowledge base. Case studies. Distributed AI and agent based systems.

EEL 760 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.

EEL 761 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.

EEL 762 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.

EEL 763 Monolithic Microwave Integrated Circuits & Technology:
3 credits (3-0-0)
History of Monolithic Microwave Integrated circuits. Monolighic 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 asisted 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-parameaters of Active Devices.On wafer S-parameter measurements; utilisation 'of. S-parameters in circuit Design.

Gaas Mesfet Circuit Design.

Amplifiers (Narrow band/Board band) Oscillators, Misers, Active & Passive Phase shifters. Monolithic Microwave Integrated circuit process. Optical Control of MMIC's.

EEL 764 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.

EEL 765 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 consi- derations. 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.

EEL 766 Numerical Techniques in Electromagnetics:
3 credits (3-0-0)
Review of analyitical methods: Separation of variables conformal transformation: Green's function. Finite difference method: Iterative solution: relaxation and acceleration crocesses: 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; numerial integration.

EEL 767 Telecommunication Systems:
3 Credits (3-0-0)
Fundamentals of singals, signal transmission and media, modulation techniques, equalization, amplification, crosstalk, attenuation, switching principles, telephony, signaling, transmission systems-DSL, optical radio.

EEL 768 Detection and Estimation Theory:
3 credits (3-0-0)
Hypothesis testing Bayes, Minimax and Neyman-Pearson criteria. Types of estimates and error bounds. General Gaussian problem. Detection and estimation in coloured noise. Elements sequential and non-parametric detection. Wiener-Hopf and Kalman filtering. Applications to communication, radar and sonar systems.

EEL 771 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.

EEL 772 Optimal Control Theory:
3 credits (3-0-0)
Calculus of variation based techniques. Pontryagin's principle and control problems with constraints on control function. Dynamic programming. Numerical techniques. Optimal control of distributed parameter systems.

EEP 773 Telecommunication Software Laboratory:
3 credits (0-1-4)
CASE tools, object-oriented program development, use of Telecommunication network simulator, implementation using C/C++/Java, newwork management software design, V.5 test and simulation.

EEP 775 Telecommunication Networks Lab-1:
3 credits (0-1-4)
Use of laboratory and Telecommunication field test instrumnents 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, Ethemet, 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.

EEP 776 Wireless Communication Laboratory:
3 credits (0-1-4)
Characterization of fading effects, Delay Spread Measurement, Fading Countermeasures 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.

EEL 774 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, Nonliner Least Squares. Model Structures and Predictors. Recursive Indentification 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.

EEL 781: Neural Networks:
3 credits (3-0-0)
Introduction & Motivation; Biological Neural Networks and simple models; The Artifical Neuron Model; Hopfield Nets; Energy Functions and Optimization; Perceptrons & Threshold Logic machines; Multilayer Networks-their variants and Applications; Capacity of Mutilayer Networks; Backpropagation; Recurrent Nets; Tree Structured Networks; Unsupervised Learning; Hebbian Learning, Principal Component Analysis; Competitive Learning, Feature Mapping, Self Organizing Maps, Adaptive Resonance Theory. Hardware Realization of ANNs. Recent Trends and Future Directions.

EEL 782 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 amplifier, timers, Function generators. Multipliers, PLL.

EEL 783 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.

EEL 784 I.C. Technology:
3 credits (3-0-0)
Basic I.C. processing step, 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. 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.

EEP 785 I.E.C. Laboratory II:
3 credits (0-0-6)
Introduction to processing of ICs.

EEL 786 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. ADB and DAC's: Nyquist and Oversampled Converters. Analog VLSI Interconnects: Physics and Scaling of Inter Connects. Statistical Modelling of Devices and Circuits. Analog Computer Aided Design. Analog and Mixed Analog and Digital Circuits' Layout.

EEL 787 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.

EEP 788 IC Processing Lab:
3 credits (0-0-6)

EEP 790 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.

EED 790 Minor Project:
3 credits (0-0-6)

EEL 790 Optoelectronic Instrumen-tation:
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.

EEP 791 Power System Lab.I:
2 credits (0-0-4)

EEL 791 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.

EEL 792 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.

EEL 793 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 recolsing. 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.

EEL 794 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.

EEL 796 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.

EEL 797 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.

EEP 798 Power System Lab. II:
2 credits (0-0-4)

EEL 799 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.

EES 800 Independent Study (Computer Technology):
3 credits (0-3-0)

EED 801 Major Project Part-1 (Computer Technology):
6 credits (0-0-12)

EED 802Major Project Part-2 (Computer Technology):
12 credits (0-0-24)

EEL 802 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.

EEL 804 Scientific Visualization:
3 credits (3-0-0)
Use of Computer Graphics and Image Processing for Scientific Visualisation. Introduction to numerical modelling techniques: Element band discretization. Scalar field visualisation, flow visualisation, volume display techniques. Animation. Visualisation System Design. Use of multimedia and virtual reality.

EES 810 Independent Study (Communications Engineering):
3 credits (0-3-0)

EEL 811 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.

EEL 812 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.

EEL 813 Selected Topics I:
3 credits (3-0-0)

EEL 814 Selected Topics II:
3 credits (3-0-0)

EEL 817 Access Network:
3 credits (3-0-0)
The access loop, wired and wireless access, radio access, optical access networks, PONs, access standards, V5.x standards, service provisioning and inter-networking.

EEL 818 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.

EED 820 Minor Project (Control and Automation)

EEL 823 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.

EEL 824 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.

EEL 829 Selected Topics in Advanced Control & System Theory-I:
3 credits (3-0-0)

EED 830 Minor Project (Integrated Electronics & Circuits):
3 credits (0-0-6)

EEL 831 Digital Signal Processing-II:
3 credits (3-0-0)
Prerequisite : 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.

EEL 832 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 ProgramGeneration; Combinational testing D Algorithm and PODEM algorithm; Scan-based testing of sequential circuits.

EEL 833 Selected Topics in I.E.C.:
3 credits (3-0-0)

EEL 834 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.

EEP 835 I.E.C. Project Laboratory:
3 credits (0-0-6)

EEL 836 Biomedical Electronics:
3 credits (3-0-0)
The need to study biological instrumentation; biological amplifiers and their interfacing with electrodes for activity monitoring solid state transducers for pressure flow, temperature and other physiological parameters and related instrumentation for long-term use. Low

power consuming circuits especially for implantable pacemakers; drift problem and its compensation, telemetry of biological signals.

Digital signal processing and imagery-construction suitable for scanning, for example, CAT, PET, NMR and ultrasonics with a special reference to instrumentation principles.

Biomedical applications of thin film and thick film technologies and fibre optics. Microminiaturisation for rehabilitation instrumentation.

EES 837 Independent Study (Integrated Electronics & Circuits):
3 credits (0-3-0)

EET 841 Industrial Training and Seminar:
3 credits(3-0-0)

EEL 841 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.

EES 841 Independent Study (Power Electronics, Electrical Machines & Drives):
3 credits (0-3-0)

EEP 841 Electrical Machines Lab:
1.5 credits (0-0-3)
EED 841 Minor Project:
3 credits (0-0-6)

EEP 842 Power Electronics Lab:
1.5 credits (0-0-3)
Advanced experiments in electrical machines and power electronics.

EEL 842 Power Conditioning:
3 credits (3-0-0)
Concepts of non-linear loads and electric power conditioning, unity power factor ractifier, 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 supressors, compensation of arc furnace and traction loads. Microwave ovens, light and temprature controllers, power supplies for appliances such as camera, X-Ray equipments. Case studies on microcomputer and DSP control in active filters and power supplies.

EED 842 Major Project Part-1 (Power Electronics, Electrical Machines & Drives):
6 credits (0-0-12)

EED 843 Major Project Part-2 (Power Electronics , Electrical Machines & Drives):
12 credits (0-0-24)

EEP 843 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.

EEL 843 Computer Aided Simulation & Design of Power Electronics systems:
3 credits (3-0-0)

EEL 844 Advanced or Selected Topics in Power Electronics:
3 credits (3-0-0)
Advanced topics in power electronics. Analysis and design of power electronic circuits.

EEP 844 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.

EEL 845 Special Electro-mechanical Devices:
3 credits (3-0-0)
Linear induction motors and actuators. Permanent magnet motors. Disc motors, stepper motors: brushless motors. High performance energy efficient machines. Special induction generators and control. Servo motors, special duty motors. Special electrical machines associated with wind, solar, tidal, wave, micro hydal and other non-conventional energy sources.

EEL 846 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.

EEL 847 Selected Topics in Machines & Drives:
3 credits (3-0-0)

EEL 851 Special Topics in Computers I:
3 credits (3-0-0)
Topics of current interest.

EEL 852 Special Topics in Computers II:
3 credits (3-0-0)
Topics of current interest.

EEL 853 Agent Technology:
3 credits (3-0-0)
Introduction: what are agents? Motivating Applications Agent Architecture. Multi-agent Systems and Agent Societies Distributed Problem Solving and Planning Search Algorithms Distributed Rational Decisions Making Probabilistic Reasoning Implementing Agent Systems Development Environments Programming issues Mobility and Security Applications Information Retrieval, E-Commerce, Industrial Control, Telecommuni-cation System

EEL 854 Protocol Engineering:
4 credits (3-0-2)
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 orienterd techniques in protocol development.

EEL 855 Internet Technologies:
4 credits (3-0-2)
Introduction to the basics of networks, introduction to the Internet, comparison of Internet architectures, network applications, encryption, e-commerce,

Web enabled systems, virtual reality, multimedia applications over Internet.

EEL 857 Network Security:
4 credits (3-0-2)
Practical topics in network security and cryptography, cryptographic protocols, inter-networking security mechanisms, private and public key encryption, IPSEC-Internet Protocol security architecture.

EEP 757 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 stack design, real-time programming, lightweight wireless protocols/Bluetooth.

EEP 858 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.

EEL 858 Mobile Computing:
3 credits (3-0-0)
Overview of mobile computing, wireless and mobile computation – SS7 and GSM, mobile IP, wireless mobile ATM, multicast routing protocols, location management, mobile agents, mobility management.

EEL 859 Network Management:
4 credits (3-0-2)
Network planning, network initialisation and configuration management, fault management, usage accounting, and security. Current network and management products. Development of network management systems and the role played by network management protocols and products.

EEL 860 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.

EED 860 Minor Project (Communications Engineering):
3 credits (0-0-6)

EEL 861 Selected Topics in Communication Engineering I:
3 credits (3-0-0)

EED 861 Major Project Part-1 (Communications Engineering) :
6 credits (0-0-12)

EED 862 Major Project Part-2 (Communications Engineering) :
12 credits (0-0-24)

EEL 862 Selected Topics in Communication Engineering II:
3 credits (3-0-0)

EEL 863 Selected Topics in Communication Engineering III:
3 credits (3-0-0)

EEL 864 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.

EEL 865 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.

EEL 866 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.

EEL 867 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.

EEL 869 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.

EEP 874 Project Laboratory:
3 credits (0-1-6)

EED 875 Major Project Part-1 (Control & Automation):
6 credits (0-0-12)

EED 876 Major Project Part-2 (Control & Automation):
12 credits (0-0-24)

EEL 878 Artificial Intelligence in Control Applications:
3 credits (3-0-0)
An overview of the filed of Artificial Intelligence. Neural Networks : Fundamentals, Backpropagation 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.

EEL 879 Selected Topics in Advanced Control & Systems Theory-II:
3 credits (3-0-0)

EEL 881 Issues in Deep Submicro CMOS IC Design:
3 credits (3-0-0)

EEP 881 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 fesign for networks, optimization tools, visualization techniques.

EEL 882 Introduction to Telecommuni-cation 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.

EEL 885 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.

EED 888 Major Project Part-1 (Integrated Electronics & Circuits):
6 credits (0-0-12)

EED 889 Major Project Part-2 (Integrated Electronics & Circuits):
12 credits (0-0-24)

EEL 890 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.

EED 890 Major Project Part-1 (Power Systems):
6 credits (0-0-12)

EEL 891 Selected Topics in Power System:
3 credits (3-0-0)

EEL 892 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)

EEL 894 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.

EEL 895 Broadband Communi-cation & 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.

EED 895 Major Project (M.S. Research):
40 credits (0-0-80)

EEL 896 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.

EEL 897 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.

EED 898 Major Project Part-2 (Power Systems):
12 credits (0-0-24)

EEL 899 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

HUL 701 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; towards uniparadigm/ multiparadigm sociology. 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.

HUL 706 Language, Society and Culture:
3 credits (2-1-0)
Psych-linguistics and socio-linguistics; culture-personality studies; studies in expressive culture: idea-system, myths and archtypes.

HUL 707 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.

HUL 709 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.

HUL 710 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.

HUC 722 Seminar (Case Material-based) Minor Project:
3 credits (2-1-0)
(In lieu of any one of the courses.)

HUL 736 Planning and Economic Development:
3 credits (2-1-0)
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.

HUL 738 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.

HUL 745 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.

HUL 748 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.

HUL 754 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.

HUL 755 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.

HUL 759 Urban Social System:
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.

HUL 760 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.

HUL 761 Sociology of India:

3 credits (2-1-0)

Approaches and the concepts: Institutions, Caste and kinship; Religion; Marriage and family. Agrarian social structure : Land reforms; Dimensions of social change; Sanskritisation and embourgeoisement and Industrialization. A profile of modern India.

HUL 762 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 if 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.

HUL 810 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.

HUL 812 Grammar and Rhetoric:

3 credits (3-0-0)

Two complementary aspects of studies in linguistics and literary theory and 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'.

HUL 823 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.

HUL 840 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.

HUL 841 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.

HUL 843 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 such 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 tonics are considered in depth and short papers are prepared by students.

HUL 845 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 the '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.

HUL 846 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, Podovkin, 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.

HUL 873 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.

HUL 881 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 :

Different types of narrative; point of view; plot; characterization; setting; time and place; language of narrative; figures of speech.

HUL 882 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.

HUL 883 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.

HUL 884 Indian Writing in English:

3 credits (3-0-0)

History of Indian writing in English. Social, political and Economic factors responsible for its quick coming of age. Review of the formal critical attention paid to the various genra to date. Analysis of the most recurrent themes.

HUL 885 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.

HUL 886 American Fiction II:

3 credits (3-0-0)

It is another 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.

HUL 888 Applied Linguistics:

3 credits (3-0-0)

Notion of applied linguistics; pedagogic linguistics; psycholinguistics; socio-linguistics; language learning; language teaching; contrastive analysis; error analysis; pedagogic grammars; applied lexicology; communicative teaching; discourse analysis; stylistic and literature.

HUL 889 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.

DEPARTMENT OF MATHEMATICS

The Department of Mathematics offers a postgraduate programme leading to the degree of M.Sc. (Mathematics), the details of which are given separately in the Publication under the chapter "M.Sc. Programmes". It also participates in the Interdisciplinary M.Tech. Programme in Computer Applications.

The Department offers the following pre-Ph.D. courses :

MAL 701 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.

MAL 702 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.

MAL 703 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 diffrential equations, etc.

MAL 704 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.

MAL 705 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.

MAP 706 Scientific Software Laboratory:
3 credits (0-0-6)
Implementation/development of scientific software.

MAP 707 Programming Languages Laboratory:
2 credits (0-0-4)
Development and implementation of programs using high level languages.

MAL 708 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 management including virtual memory and paging techniques; i/o architecture and device management; file systems.

MAL 710 Database Management Systems:
3 credits (3-0-2)
Database organisations and structure : relational, hierarchical network implementation issues and query languages. Methods to gain reliability, protection and integrity of database operation and management, Distributed Databases, Concurrency Control, Consistency and Introduction to Recovery in Distributed Databases.

MAL 711 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.

MAL 712 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.

MAL 713 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.

MAL 714 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.

MAL 715 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.

MAL 716 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.

MAL 717 Fuzzy Sets and Applications:
3 credits (3-0-0)
Elementary operations on fuzzy sets : union, intersection, complementation, cartesian products, relations and composition, similarity and equivalence relations, reational equations ; t- norms and conorms ; Fuzzy arithmetic, Zadeh extension principle ; Fuzzy logic : R-implications, S-implications and Q-implications ; Belief, plauibility, probability and possibility; Applications : Fuzzy logic controller, fuzzy pattern recognition, cluster analysis, rule based system, decision making, fuzzy optimization.

MAL 718 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.

MAL 720 Neuro Computing and Applications:
3 credits (3-0-0)
Biological and Artificial Neuron, Perceptron model, Adaline model, Different types of Activation functions, Learning Techniques: Supervised and Unsupervised , Multilayered feedforward Networks, Backpropagation algorithm and its improvements, Applications of Backpropagation 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 map, Self organizing maps with quadratic functions and its applications medical imaging, Adaptive Resonance, Theory model, Applications of Art model for knowledge acquisition, Extensive sessions in MATLAB for solving statistical pattern recognition, classification, regression and prediction problems using different kinds of Neural Network models.

MAL 724 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.

MAL 803 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.

MAL 805 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.

MAL 807 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.

MAL 809 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.

MAL 811 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.

MAL 819 Statistical Simulation on Computers:
3 credits (3-0-0)
Random number generation tests for randomness, random variate generation, rejection principle, composition, variance reduction techniques, simulation from multivariate distributions. Analysis of simulation with general purpose languages. A minor application.

MAL 823 Special Topics in Computer Applications:
3 credits (3-0-0)

MAL 851 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.

MAL 853 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.

MAL 854 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.

MAL 855 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.

MAL 856 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.

MAL 860 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.

MAL 863 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.

MAL 874 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.

MAL 883 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.

MAL 888 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.

MAL 890 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.

MAL 899 Selected Topics (Self-study):
3 credits (3-0-0)

DEPARTMENT OF MECHANICAL ENGINEERING

MEC 601 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.

MEP 601 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 programming: 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. Mathematical Software. Modeling and drafting software. Data acquisition softwares. Specialist softwares: property tables, CFD, FEM. Post-processing and plotting softwares.

MEL 626 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.

MEL 661 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.

MEL 667 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.

MEL 671 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.

MEL 674 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.

MEP 691 Basic Mechanical Laboratory:
1 credit (0-0-2)
Basic experiments related to thermodynamics, fluid mechanics and heat transfer.

MED 700 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.

MEL 727 Power Plant Turbomachinery:
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 correlation. 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.

MEL 703 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.

MEL 705 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.

MEL 707 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.

MEL 708 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.

MEL 709 Heat Exchangers:
4 credits (3-0-2)
Applications. Basic design methodologies – LMTD and effectiveness-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.

MEL 710 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.

MED 710 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.

MEL 711 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.

MEL 712 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.

MEL 713 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.

MEL 714 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.

MEL 715 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.

MEP 720 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.

MEL 725 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.

MEL 727 Power Plant Turbo-machinery
3 credit (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.

MEL 730 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.

MEL 731 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 trans-formations, 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.

MEL 732 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.

MEL 733 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.

MEL 734 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.

MEL 735 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.

MEL 736 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.

MEL 737 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 corrossion, 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.

MEL 738 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.

MEL 739 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.

MEL 739 Vibrations and Rotordynamics:

4 credits (3-0-2)

Vibrations of single degree of freedom system; free and forced vibration with and without damping. Eigen value analysis of multi-degree freedom systems and systems with distributed mass and elasticity. Techniques for vibration isolation and control. Analysis techniques for steady and ransient vibrations - Rayleigh's and Dunkerley's methods for estimation of fundamental natural frequency, Myklestad-Prohl and Holzer's transfer matrix methods, matrix inversion method and method of modal analysis. Modelling of rotor-bearing system by various techniques - transfer matrix, finite element, influence coefficients and modal methods. Stiffness and damping of fluid film and rolling element bearings. Critical speed maps. Unbalance response and orbital analysis. Disc gyroscopics. Rotor instability due to fluid film forces, hysteretic effects and parametric excitations. Rigid rotor balancing. Influence coefficient and modal balancing techniques for flexible rotors. Balancing standards. Torsional vibration analysis of rotating machines including branched systems-response to steady state and transient excitations. Instrumentation for bending and torsional vibration measurements on rotor-bearing systems. Case studies on turbo-generator (TG), boiler feed pumps, gas turbines etc.

MEL 740 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.

MEL 741 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.

MEL 742 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.

MEL 743 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.

MEL 744 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.

MEL 746 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. Balanicing 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.

MEL 748 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.

MEL 749 Mechatronic Product Design:

4 credit (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.

MEL 751 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.

MEL 752 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.

MEL 754 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.

MEL 756 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.

MEL 760 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.

MEV 760 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).

MEL 761 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

MEL 762 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.

MEL 763 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.

MEL 764 Human Factors Engineering:
3 credits (2-0-2)
Introduction to Basic Ergonomics its physiological & psychological Aspects. Physical & Mental fatigue and measurement 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

MEL 765 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.

MEL 768 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.

MEL 769 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.

MEL 772 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.

MEL 775 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.

MEL 778 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

MEL 780 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.

MEL 781 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.

MEL 783 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.

MEL 784 CNC Technology & 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.

MEL 786 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.

MEL 787 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.

MEP 790 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.

MEL 791 Composite Materials & 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.

MEL 792 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.

MEL 794 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.

MEL 801 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

MEL 802 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.

MEL 804 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.

MEL 806 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.

MEL 807 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.

MEL 808 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.

MEL 809 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.

MES 810 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.

MEL 811 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.

MED 811 Major Project Part–I:
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.

MED 812 Major Project Part–II:
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.

MEL 812 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.

MEL 813 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.

MEL 814 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.

MEL 815 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.

MEL 816 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.

MEL 818 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.

MES 830 Independent Study (Design of Mechanical Equipment):
4 credits (0-4-0)

MEL 831 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.

MED 831 Major Project Part –1 (Design of Mechanical Equipment):
6 credits (0-0-12)

MED 832 Major Project Part-2 (Design of Mechanical Equipment):
12 credits (0-0-24)

MEL 832 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.

MEL 833 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.

MEL 835 Special Topics:
4 credits (3-0-2)
Contents of this course may vary from time-to-time.

MEL 836 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-Pan-elrod 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.

MEL 837 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.

MEL 838 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.

MEL 839 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.

MEL 840 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.

MEL 841 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.

MEL 842 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.

MEL 844 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.

MEL 850 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.

MEL 851 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.

MEL 852 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.

MES 860 Independent Study (Industrial Engineering):

3 credits (0-3-0)

MEL 861 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.

MED 861 Major Project Part–1 (Industrial Engineering):

6 credits (0-0-12)

MED 862 Major Project Part-2 (Industrial Engineering):

12 credits (0-0-24)

MEL 865 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.

MEL 866 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.

MEL 868 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.

MEL 870 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.

MEL 871 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.

MEL 875 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.

MES 880 Independent Study (Production Engineering):
3 credits (0-3-0)

MED 881 Major Project Part –1 (Production Engineering):
6 credits (0-0-12)

MED 882 Major Project Part-2 (Production Engineering):
12 credits (0-0-24)

MED 895 Major Project (M.S. Research):
40 credits (0-0-80)

DEPARTMENT OF PHYSICS

PHL 701 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

PHL 702 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.

PHL 703 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.

PHL 704 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.

PHL 705 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.

PHL 707 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.

PHP 711 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 measure-ments, 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.

PHP 712 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.

PHL 721 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.

PHL 722 Analytial 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 Spectroscopy; Resonance Spectroscopies, Mossbauer Spectroscopy, Magnetic & Dielectric Analysis.

PHL 723 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.

PHL 724 Magnetism and Super-conductivity:
3 credits (3-0-0)
Demagnetisation factor, Antiferromagnetism, 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.

PHL 725 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.

PHL 726 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.

PHL 727 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.

PHS 731 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.

PHL 751 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; Inc andescent, 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.

PHL 752 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.

PHL 753 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.

PHL 754 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.

PHL 755 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.

PHL 756 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.

PHL 757 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 photo-refractive; 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.

PHL 758 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.

PHL 759 Selected Topics in Applied Optics:
3 credits (3-0-0)
The course would cover topics of current interest, not covered in other courses.

PHP 761 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.

PHP 762 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.

PHP 763 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.

PHP 764 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.

PHL 790 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.

PHL 791 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.

PHL 792 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.

PHL 793 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.

PHL 795 Optics & 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.

PHL 797 Selected Topics-I:
3 credits (3-0-0)

PHL 798 Selected Topics-II:
3 credits (3-0-0)

PHL 800 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.

PHD 801 Major Project Part I:
6 credits (0-0-12)

PHD 802 Major Project Part II:
12 credits (0-0-24)

PHL 810 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.

PHD 851 Major Project Part-I:
6 credits (0-0-12)

PHD 852 Major Project Part-II:
12 credits (0-0-24)
This major project is for two semesters, but iis 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.

PHP 853 Advanced Optical Workshop II:
3 credits (0-0-6)
Fabrication of precision optical components/instruments.

PHS 855 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.

PHL 891 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.

TTL 711 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 manu-facturing. Chain growth polymerization, Free radical polymerization, Kinetics of free-radical polymerization, initiator, 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. Copolyrher equation, reactivity ratio, tailor making of copolyrner properties. Techniques of chain polymerization. Bulk, solution, emulsion, microemulsion and suspension polymerization. Chemical Modification of fibres. Polymer solution, Floras theory. Interaction parameter. Molecular weight and its distribution by End group analysis, osmometry, light scattering, ultra centrifugation, gel permeation chromato-graphy, intrinsic viscosity. Spectroscopic methods of polymer characterization such as, PTIR. UV, NMR.

TTP 711 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 poly-merization, radiation induced polymerization. Condensation poly-merization and interfacial polymerization of nylon-6, Molecular weight measurement. Intrinsic viscosity and end group analysis, preparation of phenol-formaldehyde resin,. Analysis of chemical structure by FTIR, UV spectroscopy.

TTP 712 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 Analyser (TMA), Dynamic Mechanical Analysis (DMA), Sonic modulus , X-ray diffraction studies, Birefringence measurement, Optical microscopy studies, Scanning Electron Microscopy (SEM) of fibres.

TTL 712 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.

TTL 713 Technology of Melt Spun Fibres:

4 credits (3-1-0)

TTL 714 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 visco-etasticity. 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.

TTL 715 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.

TTP 716 Fibre production and post-spinning operations Laboratory:

2 Credits (0-0-4)

Experiments related to fibres production processes. Effect of moisture and temperature on MFI of PET and PP. Mett spinning of PET, PP &nylon-6 filament yams on laboratory spinning machines. Single and two stage drawing of the as-spun yams 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 yams 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 yam under microscope.

TTL 717 Advances in Manufactured Fibres:
3 credits (3-0-0)
Profile fibres, hollow & porous fibres, spandex fibres. Biodegradable fibres, polyglycilic 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.

TTL 718 High Performance Fibres and Composits:
3 credits (3-0-0)

TTL 721 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.

TTL 722 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.

TTL 723 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.

TTL 724 Textured Yarn Technology:
3 credits (3-0-0)

TTL 731 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.

TTL 732 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.

TTL 733 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.

TTL 741 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. Physicochemicalz 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.

TTL 742 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.

TTL 743 Principles of Colour Measurement and Communication:
3 credits (2-0-2)

TTL 744 Environmental Management in Textile & Allied Industries:
3 credits (3-0-0)
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 Manage-ment 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 characterization. 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 labeling schemes. Industrial hygiene and safe working practices. Analytical testing of eco and environmental parameters. Eco friendly textile processing: waste minimization. standardisation and optimisation, process modification. safe & ecofriendly dyes and auxiliaries. Organic cotton, natural dyes, naturally coloured cotton, Solid (fibre & polymer waste) recycling-recovery of monomers, energy recovery and chemical modification of fibre waste.

TTL 751 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.

TTL 761 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 anlysis, 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).

TTP 761 Evaluation of Textile Material – I:

1 credits (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.

TTP 762 Evaluation of Textile Material – II:

1 credits(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 U-V protective character of textile material.

TTL 762 Management of Textile Production:

3 credits (2-1-0)

Indian Textile Industry: Structure, production and exports. Textile Policy. Sickness of Textile Industry- Analysis and options. Essentials of production management, production systems, classification. Material management: Role of material management techniques, purchase management, acceptance sampling and inspection, vendor rating system, inventory management. Production, planning and control: types of production systems and problems of planning and control, product section design, process planning, forecasting, planning of batch, mass and job shop system. Machine balancing. Layout and material handling. Machine assignment and allocation of jobs. Maintenance management: maintenance concepts, maintenance strategies, maintenance planning. Productivity and improvement techniques. Quality management: Introduction to TQM, concepts of value and quality assurance, total quality control, quality circles, ISO 9000. Marketing management: fundamental of industrial marketing, industrial buyer behaviour model. Marketing: systems selling, role of service, marketing planning and marketing strategies. Enterprise resource planning: Role of information in managerial decision making, information needs for various levels of management, decision makers, management information system, resource monitoring and control. Product mix. Case studies.

TTL 763 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.

TTL 764 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. Mininising 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.

TTL 765 Product Development:

3 credits (2-1-0)

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.

TTL 771 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.

TTL 772 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++.

TTL 773 Design of Experiments and Analytical Techniques:
3 credits (3-0-0)
Sampling techniques, sample size, Principles of experimental design. Selecting a statistical design. Running experiments in Blocks, Latin squares. Factorial Designs & Analysis. Fractional factorial experiments. Use of replicates. Techniques of optimisation. Response surface designs. Statistical principles in data analysis. Fitting data. Linear regression with one, and several variables. Polynomial models. ANOVA. Use of Computers. software packages.

Rank correlation, Coefficient of concordance. Sampling inspection. Acceptance sampling : OC curve, Acceptance sampling by variables, Producer risk condition.

Control Chart: Average run length, Modified control limits for averages, Cusum chart.

TTL 866 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 performs 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.

TTS 890 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.

TTS 891 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.

TTD 891 Major Project Part-I (Fibre Science & Technology):
6 credits (0-0-12)

TTD 892 Major Project Part-II (Fibre Science & Technology):
12 credits (0-0-24)

TTD 893 Major Project Part-I (Textile Engineering):
6 credits (0-0-12)

TTD 894 Major Project Part-II (Textile Engineering):
12 credits (0-0-24)

CRL 702 Architectures and Algorithms for DSP Systems:
4 credits(2-0-4)
Introduciton to Digital Signal Processing System (DSP tasks; DSPprocessors and embodiments; Representation of DSP algorithms -block diagram, signal flow graph, data flow graph, dependence graph). 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.) Analysis and Optimization of DSP Algorithms and Systems (Loop bound and iteration bound; Retiming transformation; Unfolding transformation from data flow graph- folding transformation; Performance optimization using pipleining and / or parallel processing,) Software Design for Low power (Sources of power consumption in a programmable DSP;) Software power estimation; Softwae 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.

CRL 704 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; filter and sum beam forming; frequency domain beam forming; optimum beam forming: MVDR beam former, Generalized side-lobe canceller; Adaptive beam forming.)

CRL 705 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.

CRL 707 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.)

CRL 711 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.

CRL 712 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.

CRL 713 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.

CRL 715 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.

CRP 718 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.

CRL 720 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.

CRL 721 Analog/RF IC Modeling and Design:

3 credits (2-0-2)

Amplifier fundamentals 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.

CRP 722 RF and Microwave Solid State Devices:

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.

CRP 723 Fabrication Techniques for RF & Microwave Devices:
3 credit (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.

CRL 724 RF and Microwave Measurement System Techniques:
3 credit (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.

CRL 725 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.

CRL 726 RF MEMS Design and Technology:
3 credit (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.

CRL 728 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.

CRL 731 Selected Topics in RFDT- I:
3 credts (3-0-0)

CRL 732 Selected Topics in RFDT- II:
3 credts (3-0-0)

CRL 733 Selected Topics in RFDT- III:
3 credts (3-0-0)

CRS 735 Independent Study:
3 credts (0-3-0)

CRL 737 Selected Topics in Radars and Sonars:
3 credts (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.

CRD 802 Minor Project:
3 credits (0-0-6)

CRD 811 Major Project-I:
6 credits (0-0-12)

CRD 812 Major Project-II:
12 credits (0-0-24)

NATIONAL RESOURCE CENTRE FOR VALUE EDUCATION IN ENGINEERING

The following two courses are offered by the Centre for postgraduate students.

VEL 700 Human Values & 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.

VED 750 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

M.S. (Research)

SIL 801 Special Topics in Multimedia Systems:
3 credits (3-0-0)

SIL 802 Special Topics in Web Based Computing:
3 credits (3-0-0)

SID 880 Minor Project in Information Technology:
3 credits (0-0-6)

SID 890 Major Project for M.S. (Research):
40 credits (0-0-80)

CENTRE FOR ATMOSPHERIC SCIENCES

ASL 710 Atmospheric Physics:
3 credits (3-0-0)
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. The 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 parameterisation schemes, the monsoon and its simulation by numerical models.

ASL 800 Tropical Meteorology:
3 credits (3-0-0)
Tropical Weather Systems: Wind systems and general circulation in the tropics. Distribution of temperature, moisture, radiation, precipitation and evaporation in the tropics. Convective systems, Inter tropical convergence zone, 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.

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.

ASL 830 General Meteorology:
3 credits (3-0-0)
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.

ASL 831 Introduction to Micrometeoro-logy:
3 credits (3-0-0)
Effects and sources of Air Pollutants, Air Quality Standards, solar Radiation, Wind system, Stability conditions, Mixing Height, Turbulence, Heat Island Effect, Land Sea Breeze, Puffs and Plumes, Nuclear Power Plants, Thermal Power Plants, Land Use Planning. An introduction to viscous flow. Atmospheric Surface Boundary layer, Momentum and Heat exchanges with homogeneous Surfaces, building Wakes and other Topographical Effect and, drag & Heat Transfer Coefficients, Experimental Implication of Meteorological Instruments Various Techniques of Sampling and Standarisation, dispersion Mechanism of Air Pollutants,The Eddy Diffusion Models, Gaussian Models,Evaluation of Dispersion parameters, optimal Stack height by using Nomograms, Long term and Short term Dispersion models, dry and Wet deposition, precipitation Chemistry, The Monin- Obukhov Similarity Theory , Modern Automatic Air Sampling and Monitoring Techniques, Siting Criteria for Meteorological Instruments and tracer Techniques, Statistical analysis of Meteorological and Air Quality Data.

ASL 832 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 uncetainty.

ASL 840 Dynamic Meteorology:
3 credits (3-0-0)
Fundamental forces, equation 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, atmospheric waves, quasi- geostrophic equations, omega equation, hydrodynamic instability, available potential energy.

ASL 850 Numerical Modelling of the Atmospheric Processes:
3 credits (3-0-0)
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, dynamics of limited area and global models.

Cloud radiation, interaction, convective adjustment processes, cumulus convection and large scale atmospheric variables, land surface processes and surface fluxes, parameterisation of physical processes, design of optimal parameterisation schemes,interaction of sub-grid scale processes with environment.

ASL 860 Synoptic Meteorology:
3.5 credits (3-0-1)
Introduction, Meteorological charts and diagrams-map projections, plotting of the synoptic map, synoptic cross sections,time sections. Theory and practice of scaler analysis. Analysis of sea level pressure pattern. Analysis of pressure tendency fields, surface temperature and dew point. Kinematic analysis - stream line analysis, isotac analysis, analysis of upper-level wind and temperature. Analysis of the vertical structure of the atmosphere- vertical time section. Brief survey of analysis in the tropics.

ASL 870 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: The 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 K]CKd, 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, 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.

ASL 880 Dynamic Oceanography:
3 credits (3-0-0)
General introduction. Basic hydrodynamic equations of motion and continuity. Mass transport and free surface equation. Steady motion in the sea. Unsteady motions and their solution. 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 longshore 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.

ASL 890 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;The Rossby waves; Quasigeostrophic sealing 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.

CENTRE FOR BIOMEDICAL ENGINEERING

BML 700 Introduction to Basic Medical Sciences for Engineers:
3 credits (3-0-0)
Anatomical and morphological study of human system, Tissue cellular metabolic kinetics, Hemodynamics and cardiovascular system, Transport phenomena of gases in human system, Soft and hard tissues and joints, Nutrition and gastrointestinal system, Secretions and excretions, Regulation of body homeostasis and tissue response system, Sense organs, Brain and behaviour and neural system, Growth and Reproductive system.

BML 710 Industrial Biomaterial Technology:
3 credits (3-0-0)
Good manufacturing practice regulation, Quality control, Equipment calibration, Validation, Manufacturing and Process control, Packaging, Labeling, Device classification, Device failure, standards, and other aspects related to GMP.

Materials used in Medicine **:** Synthetic polymers, Biopolymers, Bio-resorbable and bioerodible materials, metals, thin films, Grafts and coatings, Biologically functional materials. Host reactions to biomaterials and their evaluation.

Technologies related to sterilization: Definition, Understanding concepts, Methods of sterilization, New technologies, Advantages and disadvantages, Packaging of sterile medical devices. Microbiology of sterilization: Basic concepts, Growth and death of micro organisms contamination, Sensitivity, sterility, Biological sensors, D value, Bioburden and technology of clean room.

Innovative technologies: Polymeric materials for drug delivery systems (Biodiodegrable, Biostable), Rate controlling systems for drug release, Site specific drug delivery using polymeric carriers, Temperature responsive polymers and intelligent materials.

BML 800 Research Techniques in Biomedical Engineering:
3 credits (3-0-0)
Simulation and analysis of physiological systems by upto date computer techniques and development of physical models : Network representation and biomechanical analysis. Experimental approach to the measurement of electrical, mechanical and chemical parameters of human body. Biomedical signal processing and imaging modalities Research planning and interpretation of biomedical data.

BML 820 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.

BML 830 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.

CENTRE FOR ENERGY STUDIES

The Centre for Energy Studies participates in the Interdisciplinary M.Tech. Programme in Energy Studies and also floats elective courses for M.Tech. programmes of other departments.

ESP 700 Energy Laboratories:
3 credits (0-0-6)

ESL 704 Basic Thermal Engineering:
1 credit (1-0-0)
First and second law of thermodynamics, Thermal fluid systems, Standard cycles, Mixtures of gases, Heat transfer, Fluid mechanics, Working examples, Laboratory work.

ESL 710 Energy, Ecology & Environment:
3 credits (3-0-0)
Origin of the earth. Earth's temperature and atmosphere. Sun as a source of energy, nature of its radiation. Biological processes, photo-synthesis. Food chains. Marine ecosystem. Ecosystem theories. Autecology, sources of energy, classification of energy sources, quality and concentration of an energy source, characteristics temperature. Fossil fuels : coal, oil, gas, geothermal, tidal and nuclear energy. Solar, wind, hydropower, biomass. Resources of energy and energy use pattern in different regions of the world. Environmental degradation, primary and secondary pollutants. Thermal and radioactive pollution, air and water pollution. Micro climatic effects of pollution. Pollution from stationary and mobile sources. Biological effects of radiation, heat and radioactvity disposal. Pollution abatement methods.

ESL 711 Fuel Technology:
3 credits (3-0-0)
Principle of combustion. Solid, liquid and gaseous fuels. Coal as a source of energy and chemicals in India. Coal preparation. Car- bonisation, gasification and liquification of coal and lignite. Petroleum and its derived products. Inter-conversion of fuels. Natural gases and its derivatives, sources and potential. Combustion appliance for solid, liquid and gaseous fuels. Introduction to nuclear fuel.

ESL 712 Basic Electrical Engineering:
1 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.

ESP 713 Energy Laboratories:
3 credits (0-0-6)

ESL 714 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, superheaters, economizers, condensers, combustion chamber and gas loop, turbines etc. Gas turbine power stations, steam gas power stations, peak load generating sets. Elements of hydropower generation. Recent advances in power plants. Elements of nuclear power plants. Nuclear reactors and fuels. Hazards due to buclear power plant. Instrumentation.

ESL 715 Applied Physics:
3 credits (3-0-0)
(Except for Physicists)

Uncertainty principle elements of quantum mechanies, particle in a box, quantization of energy, density of energy states. Basic concepts of free electron theory of metals, band theory of solids and energy band diagrams for metals, insulators and semiconductors. Effects of impurities on semiconductors. P-n junction. Principle of a solar cell. Elements of statistical mechanics, F-D and B-E statistics, degenerate electron gas. Radiation: Plank's formula. Kirchoff's laws and Stefan- Boltzmann's low. Principles of relativity, mass-energy relation, applications. Nuclear structures and statiligy. Radioactivity. Fission and fusion nuclear energy Plasma characteristics and generation-applications. Principle of MHD power genration. Meteorology: Atmospheric physics, stratosphere, ionospher etc.

ESL 718 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 modelling of synchronous machines, Excitation systems, Prime-mover governing systems, Automatic generation control, Auxiliaries.

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, Multiterminal DC system.

Distribution: Distribution systems, Conductors size, Kelvin's law performance calculations and analysis, Distribution inside industrial and commercial buildings entrance terminology, Substation and feeder circuit design considerations, Distributions automation.

ESL 720 Energy Conservation:
3 credits (3-0-0)
Thermodynamics of Energy Conservation Basic principles. Irreversibility and second law efficiency analysis of systems such as mixing, throttling, drying, solar thermal systems. Thermal power plant cycles. Refrigeration and airconditioning cycle. Thermal insulation in energy conservation. Energy conservation through controls. Maintenance engineering friction, lubrication and tribological innovations. Predictive and preventive maintenance. Signature analysis. Electric energy conservation in building heating and lighting. Energy efficient motors. Tariffs and power factor improvement in power systems. Energy conservation in domestic gadgets, transport. Energy auditing and case studies.

ESL 722 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 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.

ESL 725 Energy Audit:
1 credit (1-0-0)
Energy Audit concepts, Elements, Measurements, Mass and energy balances, Evaluation of energy conserving opportunities, Presentation of reports case study, Laboratory work .

ESL 730 Direct Energy Conversion:
3 credits (3-0-0)
Survey of energy conversion problem. Basic science of energy 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 photo voltaic power generation systems. Technology and physics of thermo-electric generators. Thermo-electric materials and optimization studies. Basic concepts and design considerations of MHD generators. Cycle analysis of MHD systems. Thermionic power conversion and plasma. Thermodynamics and performance of fuel cells and their applications.

ESL 732 Bioconversion and Processing of Waste:
3 credits (3-0-0)
Production of biomass,photosynthesis. Broad classification. Agro and forestry residues utilisation through conversion routes: biological, chemical and thermochemical.

Bioconversion mechanism, sources of waste undergoing bio-treatment, biogas. Energetics and rate processes of major biological significance.

Bioconversion of substrates into alcohols,organic acids, solvents,amino acids, antibiotics etc.

Thermochemical conversion of biomass. Energy balance. Conversion to solid,liquid and gaseous fuels, pyrolysis, gasification and their economics.

Chemical conversion process, hydrolysis and hydrogenation, solvent extraction of hydrocarbons.

ESL 735 Hazardous Waste Management:
3 credits (3-0-0)
Sources and classification of hazardous wastes, Assessment of exposure potential: Transport processes, Overview of waste management problem, Energy from organic wastes, Chemical waste treatment processes, Physical waste treatment processes, Biological waste treatment processes, Thermal Waste treatment processes, Waste elimination option, Hazardous waste management options, Remediation of hazardous waste contaminated soils, Engineering issues in waste remediation case studies - Hydrocarbon remediation.

ESL 736 Power from Renewables & Environmental Impacts:
3 credits (3-0-0)
Renewable electricity and key elements, Hydropower and its constraints, Environmental Impacts of coal based power generation, Wind energy: Technology and economics, Resources, Systems and regional strategies, Solar thermal power, Photovoltaic technology, Biomass power ocean and power, Social cost estimates, Duel fuel cycles, Global climate change, CO2 reduction potential of renewable energy, Social considerations.

ESL 738 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 energyforecasting 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 techniques for solution by linear and dynamic programming approaches-case studies.

ESL 740 Non-Conventional Sources of Energy:
3 credits (3-0-0)
Biogas : Aerobic and anaerobic bio-conversion processes, raw materials, properties of biogas (calorific value and composition), biogas plant technology and status.

Geothermal Energy : Hot springs and steam ejection, site selection, power plants, advanced concept.

Solar Energy : Principles, scope and applications.

Fusion : Nuclear reactions. Fuels ignition temperature.

Confinement schemes. Current status.

Wind Energy : Wind energy potential measurement, aerofoil design; wind mill and wind electric generator.

Mini and micro-hydel.

ESL 742 Economics & Financing of Renewable Energy Systems:
3 credits (3-0-0)
Economic growth, Characteristics of developing countries, Structural changes in the process of development, Relationship between agriculture & industry, Energy planning, Input output model, Financial and economic evaluation of Non-conventional systems. Case studies.

ESL 745 Environmental Audit & Impact Assessment:
3 credits (3-0-0)
Pollution sources, Classification and their effect on environment air pollution sampling and measurement, Waste water sampling and analysis, Instrumentation, Detailed procedure, Energy and environmental correlation, Case studies on power plants, Cement industry, Iron & Steel, Chemical & Refinery.

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.

ESL 750 Economics & Planning of Energy System:
3 credits (3-0-0)
System Economics : Basic concepts. National accounting framework. Criteria for economic growth. Model types and philosophy. Production functions. Input-output economics, macro-economic growth models. “Econometric” models, policy options and budgetary implications, some illustrations of econometric research for identifying demand functions, supply functions, cost functions, production functions, utility functions and Engel curves. Dynamic models of the economy and “simple” theory of business fluctuations. Multiple linear and non- linear regression analysis, energy per unit monetary value of consumer needs and services. Energy efficiency, cost benefit risk

analysis. Environmental repercussions and the economic structure. Conflict between energy consumption and pollution. Systems design and quantitative economic policy with particular reference to energy. Econometry in the context of multiple objectives, conflicting goals and decisions under uncertainty.

ESL 756 Energy Policy & Planning:
3 credits (3-0-0)
Energy (and power) policies in the country, Tarrifs and Subsidies. Energy utility interface. Private sector participation in power generation. State role and fiscal policy. Energy and development; National energy plan; Role of modelling 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.

ESL 760 Heat Transfer:
3 credits (3-0-0)
Theory of heat conduction. Mathematical and numerical analysis of two dimensional heat conduction problems with and without internal heat generation and extended surfaces. Mathematical and numerical analysis of transient and periodic state heat conduction. Theory of convective heat transfer. Boundary layer theory. Heat transfer in duct flows laminar and turbulent. Boiling, condensation and heat exchangers. Radiation heat transfer between black and grey bodies. Laws of radiation heat transfer. Numerical solution of radiation network analysis.

ESL 764 Environmental Economics:
3 credits (3-0-0)
Relevance of environmental economics and the environment, Benefits and Costs, Supply and demand, Economic efficiency and markets, The economics of environmental quality, Frameworks of analysis, Benefit - cost analysis: Benefits, Benefit-costa: Costs, Criteria for evaluating environmental, Decentralized policies, Command and control strategies, Incentive based strategies, - emission taxes and subsidies, Transferable discharge permits, Environmental policies, Economic development and the environment, The global environment, International environmental agreements.

ESL 766 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, Regulations regarding Pb-free petrol and catalytic converts, vehicle in metropolitons.

ESL 768 Wind and Small Hydro Energy Systems:
3 credits (3-0-0)
Introduction

General theories of wind machines, basic laws and concepts of aerodynamics.

Description and performance of the horizontal–axis wind machines.

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.

ESL 770 Solar Energy Utilization:
3 credits (3-0-0)
Solar radiation, its measurement and prediction. Flat plate collectors : liquid and air type. Theory of flat plate collectors, advanced collectors, optical design of concentrators, selective coatings, solar water heating, solar dryers, solar stills, solar cooling and refrigeration. Thermal storage. Conversion of heat into mechanical energy. Active and passive heating of buildings. Solar cells.

ESL 771 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, Solar radiation measuring instruments, Meteorological data measurements, Energy auditing instruments.

Probe measurements in plasmas, General plasma spectroscopy, Laser interferometery developments, Plasma density and temperature measurements, Mass spectroscopy for plasma species.

Characterisation 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 perticulates, SOx, NOx, CO, O_3, hydrocarbons, Waste water sampling, Determination of organic and in-organic substances, Physical characteristic and bacteriological measurements, Solid waste measurements and disposal.

ESL 774 Quantitative Methods for Energy Management & Planning:
3 credits (3-0-0)
A review of probability concepts;

Forecasting; Decision making using probabilities. 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.

ESL 776 Industrial Energy & Environment Analysis:
3 credits (3-0-0)
Energy and the environment, The greenhouse effect, Global energy an environmental management, Energy management and conservation, Energy in manufacture, Energy technologies, Instrumentation measurement and control, Energy management information systems, Hazardous waste management, Conta-mination of ground water, Treatment & disposal, Pollution from combustion and atmospherical pollution control methods.

ESL 777 Environmental Science and Engineering:
3 credits (3-0-0)
Environmental chemistry and biology, Environmental engineering and hydraulics, Air quality modelling, Waste water treatment, Sludge treatment & disposal, Advance waste water treatment, Solid waste management, Air pollution control, Risk assessment, Emission and effluent analysis.

ESL 778 Industrial Waste Management & Recycling:
3 credits (3-0-0)
Industrial wastes, Potential and perspectives, Waste management in different industries-steel, Aluminium, Chemical, Paper, Distilleries, Economic and system models of industrial waste management, Resource recovery, Municipal waste, Chemical analysis, Effluent treatment, Waste recycling, Waste management, Agriculture pollution, Insecticides and pesticides etc.

ESL 784 Cogeneration & Energy Efficiency:
3 credits (3-0-0)
The cogeneration concept, Cogeneration alternatives, Gas turbine Steam turbine, Diesel engine, Bottoming cycles, Industry/utility cogeneration, Thermodynamic evaluation, Technoeconomic evaluation, Environmental evaluation.

Cogeneration in sugar and steel industry, Case studies.

ESL 785 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 & frieght 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 concept.

ESL 788 Industrial & Commercial Applications of Renewable Energy Sources:
3 credits (3-0-0)
Commercial and industrial energy demand; Qualitative and quantitative features and characteristics. Renewable & electricity for a growing economy.

Water heating, process heating and drying applications; Solar, Biomass and geothermal energy based systems, Combined space and building service hotwater 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 levelling, lighting and space heating and cooling.

Economics of renewable energy based commercial and industrial installations case studies.

ESL 791 Applied Mathematics & Computational Methods:
1 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, Optimization techniques.

Introduction to Computers, DOS. Windows, working processing and graphics. Familiarity with the spread and database packages. Special packages for energy systems.

ESL 792 Advanced Energy Systems:
3 credits (3-0-0)
Integrated Gasification combined cycle (IGCC), Fuels for power generation, Advanced energy storage systems, Hydrogen power, clean coal technologies, Pressurized fluidised bed combustion, Natural gas cycles, Integrated generation, Fuel cells, Energy conservation in power plant.

ESL 794 Principles of Chemical Processes & Combustion:
1 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.

Principles of combustion, Combustion calculations and mechanism of combustion.

ESL 795 Project Evaluation & 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 evaluation techniques, Funds planning, Project material management, Evaluation & Analysis, Implementation & monitoring, Performance indices, Case studies.

ESL 796 Operation & 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, 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 and economics: 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 voltages, 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.

ESL 804 Pollution Control in Power Plants:
3 credits (3-0-0)
Pollutants in power plants, Particulate, Gaseous pollutants, Thermal pollution, Solid waste pollution strategies to control pollution from coal based thermal plants. 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 disulfurization (FGD) systems, CSR reduction applications of electron beam and non thermal plasmas for SOx and NOx treatments. Cooling towers for thermal pollution and solid waste treatment plants, fly ash disposal and utilization.

Efficiency improvement of power plants, Combined cycle, Integrated gasification combined cycle (IGCC).

ESL 810 MHD Power Generation:
3 credits (3-0-0)
Principles of MHD generator, properties of working fluids, MHD equation and types of MHD duct, losses in MHD generators, diagnostics of parameters. MHD components (air heater, combustion chamber, heat exchanger, diffuser, insulating and electrode walls, magnetic field etc.) MHD cycles, economics and applications.

ESL 840 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 modelling of passive concepts; evaporative cooling, monitoring and instrumentation of passive buildings; illustrative passive buildings.

ESL 850 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 airconditioning. Solar operation of vapour absorption and compression refrigeration cycles and their assessment. Thermal modelling and computer simulation for continuous and intermittent solar refrigeration and airconditioning systems. Solar dessicant cooling systems. Open cycle absorption/ desorption solar cooling alternatives. Advanced solar cooling systems. Refrigerant storage for solar absorption cooling systems. Solar thermoelectric refrigeration and airconditioning. Solar economics of cooling systems.

ESL 860 Electrical Power System Analysis:
3 credits (3-0-0)
Network modelling 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.

ESL 870 Fusion Energy:
3 credits (3-0-0)
Fission and fusion, Lawson criterion, confinement problem. Laser- driven fusion, magnetic confinement, equilibrium and stability, cross- field transport. Important heating schemes. Tokamak and magnetic mirror, reactor concepts, current status.

ESL 871 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.

ESL 873 Coal Utilization:
3 credits (3-0-0)
Pre-requisite : ES 711
Coal as a capital Resource of India, occurence and distribution, Characterisation methodologies. Mineral matter in coal and coal cleaning. Industrial utilisation, Power generation (combustion). Gasification, Pyrolysis, Briquetting, Liquefaction, Metallurgical coke production. Problems arising in industrial coal utilisation, Pollution, Pollution abatement, Research activities

in various R&D institutions. (Case studies and current scenario). Emerging areas for technology development.

ESL 875 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, transesterification, application in diesel engines. CME (Di-methyl ether), properties Fuel injection consideration General introduction to LPG and LNG. Compressed Natural Gas compoenents, 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.

ESL 880 Advanced Energy Studies:

3 credits (3-0-0)

Latest selected topics in the field of energy.

CENTRE FOR RURAL DEVELOPMENT & TECHNOLOGY

RDL 700 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.

RDL 710 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.

RDL 720 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.

RDL 730 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.

RDL 740 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.

RDD 750 Minor Project: Intensive Study on Topics of Specific Interest:
3 credits (3-0-0)

RDP 750 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 & MAINTENANCE ENGINEERING CENTRE

The Industrial Tribology, Machine Dynamics & Maintenance Engineering Centre (ITMMEC) participates in the Interdisciplinary M.Tech. Programme in Industrial Tribology & Maintenance Engineering.

COURSE DETAILS:

ITL 702 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.

ITL 703 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.

ITL 705 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.

ITL 709 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.

ITL 710 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.

ITL 711 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.

ITL 714 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.

ITL 716 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.

ITL 717 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.

ITL 730 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.

ITL 740 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.

ITL 752 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.

ITL 760 Noise Monitoring & 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.

ITL 770 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.

ITL 810 Bearing Lubrication:

3 credits (2-0-2)

Prerequisite : ITL 703

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 & DEVELOPMENT CENTRE

IDP 703 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.

IDP 704 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.

IDP 705 Advanced Instrument Technology Lab:
4 credits (0-0-8)

IDL 711 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.

IDL 712 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.

IDL 713 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.

IDL 714 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.

IDL 716 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.

IDL 721 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. Introduction to vibrations and its isolation. Mechanical Fabrication techniques used in instruments.

Practical sessions on basic mechanical fabrication processes. Design and drawing sessions.

IDL 722 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.

IDL 724 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.

IDL 730 Photochemical Machining:
3 credits (2-0-2)
Introduction: What is PCM, Design and manufacture of Photo-tools, Microphotography, 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.

IDL 731 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.

IDL 732 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.

IDL 734 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.

IDL 735 Scientific and Engineering Applications of Moire Patterns:
3 credits (2-0-2)
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.

IDL 741 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.

IDP 742 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.

IDL 811 Selected Topics in Instrumentation:
3 credits (3-0-0)

(No prescribed course contents)

IDC 812 Term and Seminar:
3 credits (3-0-0)

CENTRE FOR POLYMER SCIENCE AND ENGINEERING

PTL 701 Polymer Chemistry::
3 credits (3-0-0)
General characteristics of chain growth polymerisation, alkene polymerisation by free radical, anionic and cationic initiators, ring opening polymerization of ethers, acetals, lactones, lactams, copoly merisation, cyclopolymerisation, metathesis polymerisation. General characteristics of step growth polymerisation, synthesis by step polymerisation - polyesters, polycarbonates, polyamides, heteromatic polymers, poly ether ketones, polyphenylene oxide, polyphenylene sulphide, polysulphones, polysiloxanes, liquid crystalline polymers.

PTL 702 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.

PTL 703 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.

PTL 705 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.

PTL 706 Polymer Testing and Properties:
2 credits (2-0-0)
Properties of polymer and their measurement by standard test methods: tensile, flexural and impact properties.Crystallinity bydensity measurements.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.

Practical on Polymer Properties and Testing.

PTL 707 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.

PTL 709 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.

PTP 710 Polymer Science Lab:
2 credits (0-0-4)
List of Experiments:

(a) Polymer Chemistry

1. Identification of polymers.
2. Preparation of modified cellulose.
3. Thermosetting resins.
4. Suspension polymerisation of styrene.
5. Emulsion polymerisation of vinyl acetate, butyl acrylate.
6. Bulk and solution polymerisation of methyl methacrylate.
7. Preparation and testing of epoxy resins.
8. Unsaturated polyester resin technology.
9. Preparation of Nylon 6, 10 by interfacial polymerisation.
10. Copolymerisation and determination of reactivity ratios.
11. Prepration of polyvinyl alcohol.
12. Preparation of polyvinyl butyral.

(b) Polymer Physics Experiments on Polymer Characterisation.

PTL 711 Engineering Plastics & 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, polystyrene, polyphenylene, sulfide, PEK and Engg. Thermosets such as USP, Epoxy, phenolics and melamines.

Materials selection for engineering plastics for various application based on mechanical properties. High temperature stability, electrically 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.

PTL 712 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 dsize 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 performance of composites Applications.

PTL 714 Polymer Blends and Alloys:

3 credits (3-0-0)

Definition of Polymer blends and Alloys General behaviour or polymer mixture Thermodyamic 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.

PTL 716 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, miscellaneious 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.

PTL 718 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.

PTP 720 Polymer Engineering Lab:

1 credit (0-0-2)

(a) Processing

1. Compounding of additives in roll-mill with fillers and reinforcing agents.
2. Compression moulding
3. Injection moulding
4. Extrusion on single screw and twin screw extruders.
5. Thermoforming.
6. Melt flow index measurement
7. Melt rheology on Rheograph
8. Mechanical Properties of Polymers.
9. Mould flow demonstration.

(b) Industry visit for demonstration of specific processing and testing operations.

PTL 720 Polymer Product & 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.

PTL 722 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.

PTL 724 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.

COURSE DETAILS

M. Tech. Programme in Computer Applications

JCD 799 Minor Project:
3 credits (0-0-6)
JCS 800 Independent Study:
3 credits (0-3-0)
JCD 801 Major Project (Part-I):
6 credits (0-0-12)
JOD 802 Major Project (Part-II):
12 credits (0-0-24)

M. Tech. Programme in Energy Studies

JED 799 Minor Project:
3 credits (0-0-6)
JES 800 Independent Study:
3 credits (0-3-0)
JED 801 Major Project Part-1:
6 credits (0-0-12)
JED 802 Major Project Part-2:
2 credits (0-0-24)

M. Tech. Programme in Energy & Environmental Management

JSS 800 Independent Study:
3 credits (0-3-0)
JSD 801 Major Project (Part-I):
6 credits (0-0-12)
JSD 802 Major Project (Part-II):
12 credits (0-0-24)

M. Tech. Programme in Industrial Tribology & Maintenence Engineering

JIS 800 Independent Study:
3 credits (0-3-0)
JID 801 Major Project (Part-I):
6 credits (0-0-12)
JID 802 Major Project (Part-II):
12 credits (0-0-24)

M. Tech. Programme in Opto-electronics and Optical Communications

JOS 800 Independent Study:
3 credits (0-3-0)
JOD 801 Major Project (Part-I):
6 credits (0-0-12)
JOD 802 Major Project (Part-II):
12 credits (0-0-24)
JOP 791 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.

JOP 792 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

JGL 710 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.

JGL 712 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.

JGL 716 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.

JGS 800 Independent Study:
3 credits (0-3-0)
JGD 801 Major Project (Part-I):
6 credits (0-0-12)
JGD 802 Major Project (Part-II):
12 credits (0-0-24)

M. Tech. Programme in Polymer Science & Technology

JPD 799 Minor Project:
3 credits (0-0-6)
JPS 800 Independent Study:
3 credits (0-3-0)
JPD 801 Major Project (Part-I):
6 credits (0-0-12)
JPD 802 Major Project (Part-II):
12 credits (0-0-24)

M. Tech. Programme in Telecommunication Technology & Management

JMS 800 Independent Study:
3 credits (0-3-0)
JMD 801 Major Project (Part-I):
6 credits (0-0-12)
JMD 802 Major Project (Part-II):
12 credits (0-0-24)

M. Tech Programme in VLSI Design Tools & Technology

JVS 800 Independent Study:
3 credits (0-3-0)
JVD 801 Major Project (Part-I):
6 credits (0-0-12)
JVD 802 Major Project (Part-II):
12 credits (0-0-24)

M. Tech. Programme in Instrument Technology

JTS 800 Independent Study:
3 credits (0-3-0)
JTD 801 Major Project (Part-I):
6 credits (0-0-12)
JTD 802 Major Project (Part-II):
12 credits (0-0-24)

INTERDISCIPLINARY M.DES. (Industrial Design) PROGRAMME

Scheduling of Courses

Semester I

Course No.	Title	Credits	L-T-P
DIC701	Seminars	1 Credits	0-0-2
DIL711	Framework of Design	4 Credits	2-0-4
DIP721	Exploratory Product Design Methods	3 Credits	1-0-4
DIL731	Applied Ergonomics	3.5 Credits	2-0-3
DIP781	Engg. Function, Materials & Processes	3 Credits	1-0-4
DIP751	Communication & Presentation Skills	4 Credits	1-0-6
DIP741	Product Form & Aesthetics	3 Credits	1-0-4
DIP791	Product Interface Design (Project-I)	4 Credits	1-0-6
	Total	24.5 Credits	9-0-31

Semester II

Course No.	Title	Credits	L-T-P
DIL782	Adv. Materials, Mfg. Process & Finishes	3.5 Credits	2-0-3
DIP742	Studies in Product Config. & Detailing	3.5 Credits	1-0-5
DIL752	Computer Aided Product Design	3 Credits	1-0-4
DIL762	Prototype & Die Development	2.5 Credits	1-0-3
DIC702	Seminar (Product in Usage)	Credits	0-0-2
DID792	Project-II	5.5 Credits	0-1-9
	Outside Elective\In Depth Study	3 Credits	
	Total	23 Credits	6-1-32

Semester III

Course No.	Title	Credits	L-T-P
	Elective\In Depth Study (INTERNAL)	2.5 Credits	1-0-3
	Elective/In Depth Study (EXTERNAL)	2.5 Credits	1-0-3
	Elective/In Depth Study (EXTERNAL)	2.5 Credits	1-3
DIR853	Computer Aided Industrial Design	2.5 Credits	1-0-3
DIR843	Exhibitions & Environment Design	2.5 Credits	1-0-3
DIR855	Creative Marketing Communication	2.5 Credits	1-0-3
DIR857	Animation	2.5 Credits	1-0-3
DIR859	Media Studies	2.5 Credits	1-0-3
DIR813	Designing for Sustainable Development	2.5 Credits	1-0-3
DIR833	Designing for Export	2.5 Credits	1-0-3
DIR821	Design Management and Profess. Practise	2.5 Credits	1-0-3
DIP811	Product Systems Services & Environment	3 Credits	1-0-4
DIP841	Advanced Form Studies	3.5 Credits	1-0-5
DID891	Project -III	8.5 Credits	0-1-15
	Total	22.5 Credits	

Semester IV

Course No.	Title	Credits	L-T-P
DIS802	Invited Faculty Seminars	1 Credits	0-0-2
DIS812	Placement\Degree Show	2 Credits	0-0-4
DID892	Major project	19 Credits	0-1-36
	Total	22 Credits	

DIC 701 Seminars:

1 credit (0-0-2)

Objective : To develop self study habit 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.

2nd Semester

Objective : To intensify design thinking & enhance design capabilities.

DIC 702 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.

DIL 711 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.

DIP 721 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.

DIL 731 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 seminars on critical ergonomical study of an existing product/ service.

Exercise in form design for ergonomic optimality.

DIP 741 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 compo- sition 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.

DIP 742 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.

DIP 751 Communication and Presentation Skills:
4 credits (1-0-6)
Objective : To develop communication/ expression skills in visual presentation and provide opportunity for bridge studies.

The students will be required to elect modules so as to make up deficiency and enhance their proficiency.

Module Set 1

Lectures will be compulsory for all students. There are five compulsory advanced modules which all students are required to complete. The supervisor will advise preliminary level modules to those students who have inadequate previous exposure.

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.

Module Set 2

Lectures will be compulsory for all students. There are five compulsory advanced modules which all students are required to complete. The supervisor will advise preliminary level

modules to those students who have inadequate previous exposure. Autocad and page composition will be common to all students.

Isometric, Axonometric, perspective and exploded views and general assembly drawing as per BIS standards.

Exercises to represent products.

Learning Autocad : Exercises to produce engineering drawings.

Elements of word processing and desk-top publishing systems.

Visual fundamentals of page design.

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.

DIP 752 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.

DIP 762 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 principles. Die and tool design for different manufacturing processes.

Advanced manufacturing and its implications in Design.

Visits to factories and tool rooms.

Product design task.

DIP 781 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.

The students will be required to elect modules so as to make up deficiency and enhance their proficiency.

Module Set 1

Lectures will be compulsory for all students. There are five compulsory advanced modules which all students are required to complete. The supervisor will advise preliminary level modules to those students who have inadequate previous exposure.

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.

Module Set 2

Lectures will be compulsory for all students. There are five compulsory advanced modules which all students are required to complete. The supervisor will advise preliminary level modules to those students who have inadequate previous exposure.

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.

DIL 782 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.

DIP 791 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.

DID 792 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.

3rd Semester

Objective : To relate oneself with the larger institutional/social network in which the designer operates and to design/function accordingly.

DIS 802 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.

DIP 811 Product Systems Services and Environment:
3 credits (1-0-4)
Objective: To relate/realize designing in a corporate indentity framework.

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, presentation. Package design advertising and sales promotion : all visual media.

Signage and vehicle identification and uniforms. Exhibition and displays; design control manual.

DIS 812 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.

DIR 813 Designing for Sustainable Development:
2.5 credits (1-0-3)
Objective : To study the concept of sustainable development and propose products for a sustainable lifestyle.

DIR 821 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, controlling costs and enhancing quality.

Pre-degree show presentation.

DIR 833 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.

DIP 841 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.

DIR 843 Exhibitions and Environmental Design:
2.5 credits (1-0-3)
Objective : To research and design environmental space for communication and pleasure.

DIR 853 Computer Aided Industrial Design:
2.5 credits (1-0-3)
Objective : To develop proficiency of use of computers for industrial design.

DIR 855 Creative Marketing Communication:
2.5 credits (1-0-3)
Objective : To develop understanding of packaging, advertising, display.

DIR 857 Animation:
2.5 credits (1-0-3)
Objective : To create computer animation strip of high professional standard.

DIR 859 Media Studies:
2.5 credits (1-0-3)
Objective : To explore and work with some media and produce an original design.

DID 891 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.

4th Semester

Objective : To groom oneself to face the challenge as an industrial designer of excellence.

DID 892 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.

MASTER OF SCIENCE (M.Sc.) PROGRAMMES

M.Sc. (Chemistry) Programme

Credit requirements for completion of the Programme are :

Core Courses	: 72 credits	Programme Elective	: 12 credits
Open Elective	: 6 credits	**Total: 90** credits (Grade 'D' or above)	

Semester I	Semester II	Semester III	Semester IV
23 credits	**26** credits	**21** credits	**20** credits

CORE COURSES

Semester I

CYL501	Molecular Thermodynamics	3 credits	3-0-0
CYL502	Stereochemistry and Organic Reaction Mechanisms	3 credits	3-0-0
CYL503	Main Group Chemistry and Inorganic Solids	3 credits	3-0-0
CYL504	Biochemistry I	3 credits	3-0-0
CYL505	Instrumental Methods of Analysis	3 credits	3-0-0
CYP501	Physical Chemistry Laboratory Course I	2 credits	0-0-4
CYP502	Organic Chemistry Laboratory Course I	2 credits	0-0-4
CYP503	Inorganic Chemistry Laboratory Course I	2 credits	0-0-4
CYP504	Biochemistry Laboratory Course I	2 credits	0-0-4
	Total credits	**23 credits**	

Semester II

CYL561	Quantum Chemistry	3 credits	3-0-0
CYL562	Organic Synthesis	3 credits	3-0-0
CYL563	Transition and Inner Transition Metal Chemistry	3 credits	3-0-0
CYL564	Biochemistry II	3 credits	3-0-0
CYL565	Chemical Dynamics and Surface Chemistry	3 credits	3-0-0
CYL566	Physical Methods of Structure Determination of Organic Compounds	3 credits	3-0-0
CYP561	Physical Chemistry Laboratory Course II	2 credits	0-0-4
CYP562	Organic Chemistry Laboratory Course II	2 credits	0-0-4
CYP563	Inorganic Chemistry Laboratory Course II	2 credits	0-0-4
CYP564	Biochemistry Laboratory Course II	2 credits	0-0-4
	Total credits	**26 credits**	

Semester III

CYL601	Group Theory & Spectroscopy	3 credits	3-0-0
CYL602	Pericyclic Reactions and Photochemistry	3 credits	3-0-0
CYL603	Basic Organometallic Chemistry	3 credits	3-0-0
CYL604	Biochemistry III	3 credits	3-0-0
	Program Elective I	3 credits	3-0-0
	Program Elective II	3 credits	3-0-0
CYD660	Project Part 1	3 credits	0-0-6
	Total credits	**21 credits**	

Semester IV

	Program Elective III	3 credits	3-0-0
	Program Elective IV	3 credits	3-0-0
	Open Elective I	3 credits	3-0-0
	Open Elective II	3 credits	3-0-0
CYD670	Project Part 2	8 credits	0-0-16
	Total credits	**20 credits**	

PROGRAM ELECTIVE COURSES

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

Course Details

CYL 501 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.

CYL 502 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.

CYL 503 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.

CYL 504 Biochemistry I:

3 credits (3-0-0)

Cell evolution. Structure and function of proteins, carbohydrates, nucleic acids and lipids. Biological membranes. Enzymes: kinetics and control and applications.

CYL 505 Instrumental Methods of Analysis:

3 credits (3-0-0)

UV, visible spectroscopy. IR spectrometry. Atomic absorption and emission spectrometry. Fluorescence and phosphorescence based nethods. Chromatographic methods of separation. Gas chromatography. HPLC. Potentiometric methods. ISE. Thermal analysis and voltammetric methods of analysis. Data evaluation.

CYP 501 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.

CYP 502 Organic Chemistry Laboratory I:
2 credits (0-0-4)
Experiments involving basic techniques in organic chemistry will be introduced.

CYP 503 Inorganic Chemistry Laboratory I:
2 credits (0-0-4)
The laboratory course teaches experimental techniques in synthesis and charaterization of metal complexes.

CYP 504 Biochemistry Laboratory I:
2 credits (0-0-4)
Quantitative and qualitative estimation/ tests of biomolecules. Enzyme assay and studies of their properties.

CYL 561 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.

CYL 562 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.

CYL 563 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.

CYL 564 Biochemistry II:
3 credits (3-0-0)
Metabolism: basic concepts and design. Bioenergetics. Biosynthesis and degradation of carbohydrates (including photosynthesis). Lipids and amino acids.

CYL 565 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.

CYL 566 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.

CYP 561 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.

CYP 562 Organic Chemistry Laboratory II:
2 credits (0-0-4)
Synthesis and characterization of organic molecules will be given in this course.

CYP 563 Inorganic Chemistry Laboratory II:
2 credits (0-0-4)
Developing experimental skills in inorganic chemistry applied to organometallics and bioinorganic chemistry.

CYP 564 Biochemistry Laboratory I:
2 credits (0-0-4)
Enzyme characterization and applications; DNA & RNA isolation.

CYL 601 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.

CYL 602 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.

CYL 603 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.

CYL 604 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]

CYL 665 Solid State Chemistry:
3 credits (3-0-0)

CYL 666 Chemistry of Macromolecules:
3 credits (3-0-0)

CYL 667 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.

CYL 668 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.

CYL 669 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.

CYL 675 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.

CYL 676 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 L 677 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.

CYL 678 Recent Trends in Organic Chemistry:
3 credits (3-0-0)
Recent advances in Organic Synthesis, spectroscopy and reaction mechanisms.

CYL 685 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.

CYL 686 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.

CYL 687 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.

CYL 688 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).

CYL 695 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.

CYL 696 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.

CYL 697 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.

Outside Electives (Any two to be selected).

M.Sc. (Mathematics) Programme

Credit requirements for completion of the Programme are :

Core Courses	: 72 credits	Programme Elective	: 12 credits
Open Elective	: 6 credits	**Total**	**: 90** credits

Semester I	**Semester II**	**Semester III**	**Semester IV**
20 credits	**24** credits	**25/26**credits	**21/22** credits

Semester I

MAL 503	Linear Algebra	4 credits	3-1-0
MAL 509	Probability Theory	4 credits	3-1-0
MAL 513	Real Analysis	4 credits	3-1-0
MAL 517	Differential Equations	4 credits	3-1-0
MAL 519	Introduction to Computers & Programming	4 credits	3-0-2
	Total credits	**20 credits**	

Semester II

MAL 514	Complex Analysis	4 credits	3-1-0
MAL 516	Algebra	4 credits	3-1-0
MAL 518	Methods of Applied Mathematics	4 credits	3-1-0
MAL 522	Statistical Inference	4 credits	3-1-0
MAL 524	Numerical Analysis	4 credits	3-1-0
MAL 526	Computer Oriented Operations Research	4 credits	3-0-2
	Total credits	**24 credits**	

Semester III

MAL 601	Topology	4 credits	3-1-0
MAL 609	Basic Computer Science	4 credits	3-0-2
MAL 630	Partial Differential Equations	4 credits	3-1-0
MAP 701	Computing Lab. I	2 credits	0-0-4
MAD 703	Project Part 1*	4 credits	0-0-8
	Program Elective-I	4 credits	3-1-0
	Open Elective-I	4 credits or	3-1-0 or
		3 credits	3-0-0
	Total credits	**25/26 credits**	

***Minimum 35 credits to be cleared**

Semester IV

MAL 602	Functional Analysis	4 credits	3-1-0
MAP 702	Computing Lab-II	2 credits	0-0-4
MAD 704	Project Part 2*	4 credits	0-0-8
	Program Elective-2	4 credits	3-1-0
	Program Elective-3	4 credits	3-1-0
	Open Elective-2	3 credits or	3-0-0 or
		4 credits	3-1-0
	Total credits	**21/22 credits**	

PROGRAM ELECTIVE COURSES

MAL 607	Mathematical Logic	4 credits	3-1-0
MAL 611	Principles of Fluid Mechanics	4 credits	3-1-0
MAL 614	Advanced Matrix Theory	4 credits	3-1-0
MAL 617	Combinational Methods	4 credits	3-1-0
MAL 621	Computational Methods for Ordinary Differential Equations	4 credits	3-1-0
MAL 638	Applied Nonlinear Programming	4 credits	3-1-0
MAL 656	Graph Theory	4 credits	3-1-0
MAL 658	Programming Languages	4 credits	3-1-0
MAL 725	Stochastic Processes and Applications	4 credits	3-1-0
MAL 726	Principles of Optimization Theory	4 credits	3-1-0
MAL 727	Applied Multivariate Data Analysis	4 credits	3-1-0
MAL 728	Category Theory	4 credits	3-1-0
MAL 729	Computational Algebra and its Applications	4 credits	3-0-2
MAL 730	Cryptography	4 credits	3-1-0
MAL 731	Introduction to Chaotic Dynamical Systems	4 credits	3-1-0
MAL 732	Financial Mathematics	4 credits	3-1-0
MAL 733	Stochastic of Finance	4 credits	3-1-0
MAL 734	Algebraic Geometry	4 credits	3-1-0
MAL 735	Number Theory	4 credits	3-1-0
MAL 736	Differential Geometry	4 credits	3-1-0

MAL 503 Linear Algebra:

4 credits (3-1-0)

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.

MAL 509 Probability Theory :

4 credits (3-1-0)

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.

MAL 513 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.

MAL 517 Differential Equations :

4 credits (3-1-0)

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.

MAL 514 Complex Analysis:

4 credits (3-1-0)

Study of functions of a single Complex variable.

MAL 516 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 theory, nilpotent and solvable groups.Galois theory. Splitting fields, Normal extensions. The fundamental theorem of Galois theory.

MAL 518 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.

MAL 519 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++.

MAL 522 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.

ÄMAL 524 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.

MAL 526 Computer Oriented Operation Research

4 credits (3-0-2)

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.

MAL 601 Topology:

4 credits (3-1-0)

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.

MAL 602 Functional Analysis:

4 credits (3-1-0)

Basic functional Analysis Link.

Between Algebra Analysis. Same as listed in the courses of study.

MAL 607 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.

MAL 609 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.

MAL 611 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.

Equation of continuity, Navir-Stokes equations, boundary layer flows, similarity transformations, wave propagation and shocks, method of characteristics, basic equations of hydro-magnetic flows, Hartman flow, Reynolds equation for turbulent flows, empirical velocity profiles.

MAL 614 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.

MAL 617 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.

MAL 621 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.

MAL 638 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.

MAL 656 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 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 representation; Graph searching: BFS,DFS Basic Graph Algorithms: MST, shortest paths, biconnectivity, Strong connectivity, etc.

MAL 658 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.

MAP 701 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.

MAL 725 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.

MAL 726 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 duality, Fractional programming, Nonlinear Lagrangian and nonconvex duality, Monotone and generalized monotone maps.

MAL 727 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.

MAL 728 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.

MAL 729 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.

MAL 730 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.

MAL 731 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.

MAL 732 Financial Mathematics:
4 credits (3-1-0)
Basic objective is to introduce the mathematical option theory, asset pricing and its dynamics. Basic theory of interest, Fixed income securities, Applied interest rate analysis, Mean-variance portfolio theory, Capital asset pricing models, Derivative securities and Models of asset dynamics, Basic options theory, Optimal portfolio growth and utility based optimization, General investment evaluation.

MAL 733 Stochastics of Finance :
4 credits (3-1-0)
Basic stochastic process involved in the study of mathematics of finance Regression analysis and its application to the capital asset and multifactor pricing models, smoothing techniques and estimation of yield curves; Statistical analysis of econometric modeling of financial time series; Classification and credit risk forecasting; Theory of Martingales; Martingale measures, Hedging strategies and Measurement of risk; Stochastic integration; Ito's formula and stochastic differential equations; Application to option pricing models.

MAL 734 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.

MAL 735 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.

MAL 736 Differential Geometry:
4 credits (0-0-8)
To introduce the students to geometry of hypersurfaces. Curves in plane and space, curvature, isoperimetric inequality, surfaces in three dimensions, First fundamental form, curvature of surfaces, Geodesics, Gauss's Theorem.

MAD 703 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.

MAD 704 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.

MAP 702 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.

M.Sc. (Physics) Programme

Credit requirements for completion of the Programme are :

Core Courses	: 69 credits	Programme Elective	: 15 credits
Open Elective	: 06 credits	Total	: 90 credits

Semester I	Semester II	Semester III	Semester IV
22 (12-4-12) credits	**25** (15-4-12) credits	**25 (15-3-14)** credits	**18 (12-0-12)** credits

Semester I			
PHL551	Classical Mechanics	4 credits	3-1-0
PHL553	Mathematical Physics	4 credits	3-1-0
PHL555	Quantum Mechanics	4 credits	3-1-0
PHL557	Electronics	4 credits	3-1-0
PHP561	Laboratory I	6 credits	0-0-12
	Total credits	**22 credits**	
Semester II			
PHL552	Electrodynamics	4 credits	3-1-0
PHL554	Concepts of Solids	4 credits	3-1-0
PHL556	Statistical Mechanics	4 credits	3-1-0
PHL558	Applied Optics	4 credits	3-1-0
PHP562	Laboratory II Elective (PE/OE)	3 credits	3-0-0
	Total credits	**25 credits**	
Semester III			
PHP563	Advanced Laboratory	4 credits	0-0-8
PHL565	Cooperative Phenomena in Solids	4 credits	3-1-0
PHL567	Atomic & Molec. Spectroscopy	4 credits	3-1-0
PHL569	Nuclear Physics	4 credits	3-1-0
PHD651	Project I	4 credits	0-0-6
	Elective (PE)	4 credits	3-0-0
	Elective (OE/PE)	4 credits	3-0-0
	Total credits	**25/28 credits**	
Semester IV			
	PHD652 Project II	4 credits	0-0-12
	Elective (PE)	4 credits	3-0-0
	Elective (PE)	4 credits	3-0-0
	Elective (PE)	4 credits	3-0-0
	Elective (OE/PE)	4 credits	3-0-0
	Total credits	**18/20 credits**	

PROGRAM ELECTIVE COURSES

Stream A			
PHL653	Semiconductor Electronics	4 credits	3-0-0
PHL654	Experimental Methods	4 credits	3-0-0
PHL702	Science & Techn. of Thin Films	4 credits	3-0-0
PHL723	Vacuum Science & Cryogenics	4 credits	3-0-0
PHL725	Physics of Amorphous Materials	4 credits	3-0-0
PHL726	Nanostructured Materials	4 credits	3-0-0
Stream B			
PHL655	Laser Physics	4 credits	3-0-0
PHL755	Statistical & Quantum Optics	4 credits	3-0-0
PHL758	Theory & Applic. of Holography	4 credits	3-0-0
PHL790	Integrated Optics	4 credits	3-0-0
PHL791	Fiber Optics	4 credits	3-0-0
PHL792	Optical Electronics	4 credits	3-0-0
Stream C			
PHL656	Microwaves	4 credits	3-0-0
PHL657	Plasma Physics	4 credits	3-0-0
PHD658	Mini Project	4 credits	0-0-6
PHL741	Quantum Electrodyna mics & Particle Physics	4 credits	3-0-0
PHL742	General Relativity & Introductory Astrophysics	4 credits	3-0-0
PHL743	Group Theory & its Applications	4 credits	3-0-0
PHL744	Advanced Topics in Quant Mech.	4 credits	3-0-0

NOTE: Students are required to take at least one course from each of the streams. Students are NOT allowed to take M.Tech. SSM, AO, OE courses as Open Electives.

PHL661	Selected Topics #	4 credits	3-0-0
PHL662	Special Topics #	4 credits	3-0-0
PHS663	Independent Study #	4 credits	3-0-0

Independent Study and Selected 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.

PHL 551 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.

PHL 552 Electrodynamics:

4 credits (3-1-0)

Review of electrostatics and magnetostatics, 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, appli-cations to communication and radar.

PHL 553 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.

PHL 554 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.

PHL 555 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.

PHL 556 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.

PHL 557 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.

PHL 558 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.

PHP 561 Laboratory I:
6 credits (0-0-12)
Experiments from the areas of Optics, Electrodynamics and Electronics will form the practical contents of this course.

PHP 562 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.

PHP 563 Advanced Laboratory II:
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.

PHL 565 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.

PHL 567 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.

PHL 569 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 a-decay, Fermi's theory of b-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).

PHD 651 Project I:
3 credits (0-0-6)

PHD 652 Project II:
6 credits (0-0-12)

PHL 653 Semiconductor Electronics:
3 credits (3-0-0)
Semiconductors junction review; charge storage and transient behavior, equivalent circuit of diode, p-n hetro-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; Hetro-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.

PHL 654 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.

PHL 655 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 the 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. Physic 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.

PHL 656 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.

PHL 657 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.

PHD 658 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.

PHL 661 Selected Topics:
3 credits (3-0-0)

PHL 662 Special Topics:
3 credits (3-0-0)

PHL 741 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.

PHL 742 General Relativity and Introductory Astrophysics:
3 credits (3-0-0)
Tensors, definition algebraic properties, orientation tensor, symmetrisation and antisymmerti-sation. 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.

PHL 743 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.

PHL 744 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.

DEPARTMENT OF MANAGEMENT STUDIES

M.B.A. Programme

The Department of Management Studies offers two MBA programmes. The full-time MBA programme is focused on “Management Systems” and "Telecommunication Systems Management" and is designed to be completed in two years. The part-time MBA programme* is focused on “Technology Management” and is designed to be completed in three years. The programme provides a wide range of choices to the student resulting in attractive employment opportunities at the completion of the programme by incorporating a combination of various technical skills and value focused decision making along with the regular teaching. All this is imparted in a course work offered in a flexible mode.

OVERALL STRUCTURE

		Minimum	Maximum
Duration	Full-time	2 years	3 years
	Part-time*	3 years	5 years
Total Credits		72	
Compulsory Audit		(6 courses)	

Modules

1. Core Module	General Management 9 courses (27 credits) + 6 compulsory Audit Courses
2. Focus Module	Focus of the Programme (additional core in Focus Area) 4 courses (12 credits)
3. Elective Module-I	Open Electives 5 courses (15 credits)
4. Elective Module-II	Specialization Stream 4 courses (12 credits) (Strategic Management, Organisation Management, Manufacturing Management, Information Technology Management, Marketing, Finance, Public Sector Management)
5. Project Module	6 credits (Industry-based)
6. Industrial Training/ Seminar	8 weeks Industrial Placement after first year for Full-Time students. In case of part time students a Seminar Series of of equivalent learning time weightage will be designed.

LIST OF COURSES

CORE MODULE

Core Courses

SML 710	Creative Problem Solving	3 credits	(2-0-2)
SML 720	Business Environment and Corporate Strategy	3 credits	(2-0-2)
SML 730	Organisation Management	3 credits	(3-0-0)
SML 731	Human Resources Management	3 credits	(3-0-0)
SML 740	Quantitative Methods in Management	3 credits	(2-0-2)
SML 745	Operations Management	3 credits	(3-0-0)
SML 760	Marketing Management	3 credits	(2-0-2)
SML 770	Managerial Accounting and Financial Management	3 credits	(2-0-2)
SML 780	Managerial Economics	3 credits	(2-0-2)

Compulsory Audit Courses

SMP 791	Computer Laboratory	1 credit	(0-0-2)
SMV 793	Statistics for Management	1 credit	(1-0-0)
SMV 794	Communication Skills	1.5 credits	(1-0-1)
SMV 795	Systems Thinking	1 credit	(1-0-0)
SMV 895	Management Research Methodology	1 credit	(1-0-0)
SMV 896	Human Values in Management	1 credit	(1-0-0)

* Part-time MBA programme has been held in abeyance.

SML 710 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.

SML 720 Business Environment and Corporate Strategy:

3 credits (2-0-2)

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

FOCUS MODULE- TECHNOLOGY MANAGEMENT

Core Courses

SML 700	Fundamentals of Management of Technology	3 credits	(3-0-0)
SML 701	Strategic Technology Management	3 credits	(2-0-2)
SML 702	Management of Innovation and R&D	3 credits	(2-0-2)
SML 703	Management of Technology Transfer and Absorption	3 credits	(2-0-2)

Technology Management -Electives
(To be opted under Elective Module I)

SML 704	Science and Technology Policy Systems	3 credits	(3-0-0)
SML 801	Technology Forecasting and Assessment	3 credits	(2-0-2)
SML 802	Management of Intellectual Property Rights	3 credits	(3-0-0)
SML 804	Technical Entrepreneurship	3 credits	(3-0-0)

FOCUS MODULE - MANAGEMENT SYSTEMS

Core Courses

SML 713	Information Systems Management	3 credits	(2-0-2)
SML 715	Quality and Environment Management Systems	3 credits	(2-0-2)
SML 716	Fundamentals of Management Systems	3 credits	(3-0-0)
SML 717	Business Systems Analysis and Design	3 credits	(2-0-2)

Management Systems- Electives
(To be opted under Elective Module I)

SML 714	Organisational Dynamics and Environment	3 credits	(3-0-0)
SML 811	Management Control Systems	3 credits	(3-0-0)
SML 812	Flexible Systems Management	3 credits	(2-0-2)
SML 813	Systems Methodology for Management	3 credits	(2-0-2)
SML 815	Decision Support and Expert Systems	3 credits	(2-0-2)
SML 819	Business Process Reengineering	3 credits	(2-0-2)

FOCUS MODULE - TELECOM SYSTEMS MANAGEMENT

SML 723	Telecommunication Systems Management	3 credits	(3-0-0)
SML 726	Telecom Systems Analysis, Planning and Design	3 credits	(3-0-0)
SML 728	International Telecommunication Management	3 credits	(3-0-0)
EEL 767	Telecommunication Systems	3 credits	(3-0-0)

SPECIALIZATION-STRATEGIC MANAGEMENT

SML 820	Global Business Environment	3 credits	(3-0-0)
SML 821	Strategic Management	3 credits	(2-0-2)
SML 822	International Business	3 credits	(2-0-2)
SML 823	Strategic Change and Flexibility	3 credits	(2-0-2)
SML 824	Policy Dynamics and Learning Organization	3 credits	(2-0-2)
SML 825	Strategies in Functional Management	3 credits	(3-0-0)
SML 826	Business Ethics	3 credits	(3-0-0)
SML 827	International Competitiveness	3 credits	(3-0-0)
SML 829	Current and Emerging Issues in Strategic Management	3 credits	(3-0-0)*

SPECIALIZATION-ORGANISATION MANAGEMENT

SML 830	Organisational Structure and Processes	3 credits	(3-0-0)
SML 831	Management of Change	3 credits	(2-0-2)
SML 832	Managing Innovation for Organisational Effectiveness	3 credits	(3-0-0)
SML 833	Organisation Development	3 credits	(3-0-0)
SML 835	Labour Legislation and Industrial Relations	3 credits	(2-0-2)

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 730 Organisation Management :

3 credits (3-0-0)

Module I: Scope and the focus of enquiry. Multidisciplinary framework for organizational analysis. Organisation Management: Theory, practice and major schools of thought, application potentials and possibility.

Module II: Systems perspective on organizations. Contingency approach to organizational theory and practice. The socio-technical systems approach. Theory of organizational structures. Nature and consequences of structure.

Module III: Organisational change. Design and development of organisations. Impact of environmental and cultural variables on organization structure and style. Strategic thinking. Automation and organizational structure. Organizational interdependence and organizational evaluation.

SML 731N Human Resources Manage-ment:

3 credits (3-0-0)

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.

SML 839	Current and Emerging Issues in Organisation Management	3 credits	(3-0-0)*
HUL 710	Personality Structure and Dynamics	3 credits	(2-1-0)

SPECIALIZATION-MANUFACTURING MANAGEMENT

SML 840	Manufacturing Strategy	3 credits	(3-0-0)
SML 843	Supply Chain Logistics Management	3 credits	(3-0-0)
SML 844	Systems Reliability, Safety and Maintenance Management	3 credits	(3-0-0)
SML 845	Total Project Systems Management	3 credits	(2-0-2)
SML 846	Total Productivity Management	3 credits	(3-0-0)
SML 849	Current and Emerging Issues in Manufacturing Management	3 credits	(3-0-0)*
MEL 661	Materials Management	3 credits	(2-0-2)
MEL 783	Automation in Manufacturing	4 credits	(3-0-2)
MEL 852	Computer Integrated Manufacturing Systems	3 credits	(2-0-2)

SPECIALIZATION-INFORMATION TECHNOLOGY MANAGEMENT

SML 815	Decision Support and Expert Systems	3 credits	(2-0-2)
SML 850	Management of Information Technology	3 credits	(3-0-0)
SML 851	Database Design and Data Management	3 credits	(2-0-2)
SML 852	Network Systems: Application & Management	3 credits	(3-0-0)
SML 855	Electronic Commerse	3 credits	(2-0-2)
SML 857	Database Management Information System	3 credits	(3-0-0)
SML 859	Current and Emerging Issues in Information Technology Management	3 credits	(3-0-0)*

SPECIALIZATION-MARKETING

SML 861	Market Research	3 credits	(2-0-2)
SML 862	Product Management	3 credits	(3-0-0)
SML 863	Advertising and Sales Promotion Management	3 credits	(3-0-0)
SML 865	Sales Management	3 credits	(2-0-2)
SML 866	International Marketing	3 credits	(3-0-0)
SML 867	Industrial Marketing Management	3 credits	(3-0-0)
SML 869	Current and Emerging Issues in Marketing	3 credits	(3-0-0)*

SPECIALIZATION-FINANCE

SML 811	Management Control Systems	3 credits	(3-0-0)
SML 870	Advanced Financial Management	3 credits	(2-0-2)
SML 871	Accounting for Decision Making	3 credits	(2-0-2)
SML 872	Working Capital Management	3 credits	(3-0-0)
SML 873	Security Analysis and Portfolio Management	3 credits	(3-0-0)
SML 874	Indian Financial System	3 credits	(3-0-0)
SML 875	International Financial Management	3 credits	(3-0-0)
SML 879	Current and Emerging Issues in Finance	3 credits	(3-0-0)*

SPECIALIZATION-PUBLIC SECTOR MANAGEMENT

SML 881	Management of Public Sector Enterprises in India	3 credits	(3-0-0)
SML 889	Current and Emerging Issues in Public Sector Management	3 credits	(3-0-0)

SPECIAL IZATION-CONSULANCY MANAGEMENT

SML 822	International Business	3 credits	(2-0-2)
SML 833	Organisation Development	3 credits	(3-0-0)
SML 845	Total Project Systems Management	3 credits	(2-0-2)
SML 897	Consultancy Process and Skill	3 credits	(3-0-0)
SML 898	Consultancy and Professional Practices	3 credits	(3-0-0)
SML 899	Current and Energing Issues in Cohnsultancy Management	3 credits	(3-0-0)*

SML 740 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.

SML 745 Operations Management:

3 credits (3-0-0)

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, Job evaluation and payment systems. Total quality control. Maintenance management and equipment replacement policies. Network planning and control. Line of Balance, World Class Manufacturing and factories of the future. Case Studies.

OPENELECTIVES

SML 734	Management of Small Scale Industrial Enterprises	3 credits	(3-0-0)
SMP 783	Management Laboratory	3 credits	(0-0-6)
SML 816	Total Quality Management	3 credits	(2-0-2)
SML 817	Management of System Waste	3 credits	(2-0-2)
SML 818	Industrial Waste Management	3 credits	(2-0-2)
SML 880	Selected Topics in Management (Open Slot to float any new course)	3 credits	(2-0-2)
SML 887	Business Law	3 credits	(2-0-2)
HUL 762	Industrial Economics	3 credits	(3-0-0)
HUL 738	International Economics	3 credits	(3-0-0)
CSL 672	Computer Network	4 credits	(3-0-2)
CSL 740	Software Engineering	4 credits	(3-0-2)

Electives from Focus Modules and Specialisation Streams.

(Minimum one elective is to be opted from the Focus Area of the programme or from the other Focus Area).

PROJECT

SMD 792*	Minor project	3 credits (0-0-6)
SMD 890*	Project	6 credits (0-0-12)

*(only for those students registered at DMS)

INDUSTRIAL TRAINING/SEMINAR
(Non-credit requirements)

SMT 893	Industrial Training
SMC 894	Seminar

Note:

1. All credit courses are of three credits each. The details of non SM Courses are available under the respective Department/Centre. In addition to above some more courses may be available, details of which may be had from the Department of Management Studies.

2. The students of focus module "Telecommunication Systems Management" should contact the Dept. of Management Studies before taking the courses.

SML 760 Marketing Management:

3 credits (2-0-2)

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- Economic Environment, Market: market segmentation. Consumer-buyer behaviour models. 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 production. 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.

SML 770 Managerial Accounting and Financial Management:

3 credits (2-0-2)

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. Statement of changes in Financial Position: cash, working capital, all resources basis. 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.

SML 780 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, their interrelationships. Inflation analysis; (Indian) Monetary System and Banking Structure. Monetary policy analysis and its implications to industry. Issues of economic 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, Exchange Rate. Analysis of Economic Survey and Government Budget.

SMP 791 Computer Laboratory:

1 credits (0-0-2)

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).

SMV 793 Statistics for Management:
1 credit (1-0-0)
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.

SMV 794 Communication Skills:
1.5 credits (1-0-1)
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.

SMV 795 Systems Thinking:
1 credit (1-0-0)
Systems thinking in evolution of Management thought. Hard and Soft Systems thinking, Open Systems thinking. Socio-technical systems, Flexible Systems thinking, Analytic and synthetic approaches. Basic systems concepts, principles, and metaphors. General system theory. Principles of cybernetics.

SMV 895 Management Research Methodology:
1 credit (1-0-0)
Problem conceptualization and definition. Hypothesis formulation. Selection of Research Methods, Flexible Systems Methodology for preparing research design, Scaling, sampling methods, 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.

SMV 896 Human Values in Management:
1 credit (1-0-0)
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.

SML 700 Fundamentals of Management of Technology:
3 credits (3-0-0)
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. Environment impact study. Factors promoting technology acquisition. Flexibility in Technology Management. Technology transfer and absorption, Modes of global technology transfer. Technological Entrepreneurship.

Module III: Managing productivity and quality in technology age. 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.

SML 701 Strategic Technology Management:
3 credits (2-0-2)
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.

SML 702 Management of Innovation and R&D:
3 credits (2-0-2)
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.

SML 703 Management of Technology Transfer and Absorption:
3 credits (2-0-2)
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.

SML 704 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.

SML 713 Information Systems Management:

3 credits (2-0-2)

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.

SML 714 Organisational Dynamics and Environment:

3 credits (3-0-0)

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.

SML 715 Quality and Environment Management Systems:

3 credits (2-0-2)

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, 1S0 9000, Quality Policy, Data, Records and Traceability. Documenting the Quality System: Quality Manual, Quality Audit, Design and Change Control, ISO 9000 Registration. Six Sigma.

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.

SML 716 Fundamentals of Management Systems:

3 credits (3-0-0)

Module I: The concept of a system, systems and cybernetics, Systems Approach to management. Emerging paradigm, customer centred management systems, Flexible Management Systems. Management Systems in various countries: Western Management Systems, Japanese Management Systems, 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 Management.

Module III: Methodology for developing Management System. Optimization and Learning Systems methodologies, Microworld, Continuous Improvement and Reengineering of Management Systems. Organizing to improve systems.

SML 717 Business Systems Analysis and Design:
3 credits (2-0-2)
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.

SML 723 Telecommunications System Management:
3 credits (3-0-0)
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.

SML 726 Telecom Systems Analysis, Planning, and Design:
3 credits (3-0-0)
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.

SML 728 International Telecommunication Management:
3 credits (3-0-0)
Module I : Rote of select International Institutions. Historical development and evolution of telecom, Patterns of Transaction iin international telecom management; managing the market growth.

Structure of the Telecommunications sector of developed and developing in select countries; trends in privatization; liberalization and deregulation.

Module II : Role of telecommunications in socio-economic development; new technologies and services for international telecommunications; business application of global networks. Regional prospectus on development of Telecom.

Module III : Current issues and implications for the industry, Indian markets, policy issues, skill formation for ITM, problems, challanges of growth.

SML 801 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.

SML 802 Management of Intellectual Property Rights:
3 credits (3-0-0)
Module I: Nature of Intellectual Property: Patents, Designs, Trademarks and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

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, 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.

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 or acquisition, Entrepreneurship, International Entrepreneurship.

SML 811 Management Control Systems:

3 credits (3-0-0)

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.

SML 812 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. 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.

Module III: Flexibility in functional systems, Information Systems flexibility, manufacturing flexibility, organisational flexibility, financial flexibility, and strategic flexibility. Linkage of flexibility with organisational performance.

SML 813 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.

SML 815 Decision Support and Expert Systems:

3 credits (2-0-2)

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.

SML 819 Business Process Reengineering:

3 credits (2-0-2)

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.

SML 820 Global Business Environment

3 credits (3-0-0)

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 contaxt 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.

SML 821 Strategic Management

3 credits (2-0-2)

Module I Strategic Management Process.

The Strategic Management Process, Flexible system view of Strategic Management, Strategic Situation Analysis, PEST 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.

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, life cycle analysis, value chain analysis, culture fit, screening strategic option, Analysing return risk and feasibility, selection of strategies.

Module III Strategy Implementation.

Implementing strategy: Core competencies, Budgets, Policies, Best practices, Support Systems, Rewards. Culture and Leadership, Functional strategies.

SML 822 International Business:
3 credit (2-0-2)
Module I Key Issues in International Business.

Socio-cultural, economic and political forces facing business. Exchange rate determination, hedging: international sourcing. Understanding the determinants of competitive advantage in international business at the national, industry and firm level, global forces transforming international business. International Strategic Management. 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. Competing to shape the future, Embedding the Core competence perspective, coalition formation. Implications for functional strategies: marketing, HR, planning, organisational structure, production, Global Information Systems, Strategy Alternatives for Global Market entry and expansion, International negotiations.

SML 823 Strategic Change and Flexibility
3 credit (2-0-2)
Module I Managing 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 top Down Restructuring:

Corporate restructuring, Alliances, joint ventures, acquisitions and merges. Recorganising the firm, Financial and strategic analysis for restructuring. The merger process, statges of merger and acquisition, the impact of mergers and acquisitions on organizational performance.

Module III Implementation:

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.

SML 824 Policy Dynamics and Learning Organization
3 credit (2-0-2)
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 Methyodology 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 systes 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.

SML 825 Strategies in Functional Management
3 credit (3-0-0)
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.

SML 826 Business Ethics
3 credit (3-0-0)
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, practicabioity, 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.

SML 827 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.

SML 829 Current and Emerging Issues in Strategic Manage-ment:

3 credits (3-0-0)

(Relevant current and Emerging Issues)

SML 830 Organisational Structure and Processes:

3 credits (3-0-0)

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 of Talcott Parsons; Allport and Event-Structure theory. Organizational Governance- organizations as a subject of political enquiry, Models of organizational governance. Making and breaking patterns.

SML 831 Management of Change:

3 credits (2-0-2)

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.

SML 832 Managing Innovation for Organisational Effectiveness:

3 credits (3-0-0)

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.

SML 833 Organisation Development:

3 credits (3-0-0)

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.

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 cause. 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 of change.

SML 835 Labour Legislation and Industrial Relations:

3 credits (2-0-2)

Module I: Introduction of industrial relation and a systematic view of personnel. Labour Relation. Introduction to Indian Trade Unionism. Industrial relation and conflict in industries. Introduction of Labour Regulation Act, Factory 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 relation and economic development.

SML 839 Current and Emerging Issues in Organisation Management:

3 credits (3-0-0)

(Relevant current and Emerging Issues)

SML 840 Manufacturing Strategy:

3 credits (3-0-0)

Module I: Manufacturing strategy-relevance and concepts. Strategic issues in manufacturing, 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.

SML 843 Supply Chain Logistics Management

3 credits (3-0-0)

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, Postonement, 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, locationa dnd allocation, Automated Warehousing, Materials Handling and Packaging. Simulation aided planning of conveyor and warehousing systems.

Module III: Supply Chain Logistics Mix Management.

Logistical Connnectiveity: Transporation 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.

SML 844 Systems Reliability, Safety and Maintenance Management:

3 credit (3-0-0)

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 maintainabilty. Risk assessemtn and management for reliability and safety.

Module II: Maintenance Planning and Conctrol.

Maintancne 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.

SML 845 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, 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.

SML 846 Total Productivity Management:

3 credits (3-0-0)

Module I: Total Productivity overview; meaning, relevance and scope for productivity and effectiveness. Productivity conceptua-lisation. 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.

SML 849 Current and Emerging Issues in Manufacturing Management:

3 credits (3-0-0)

(Relevant current and Emerging Issues)

SML 859 Current and Emerging Issues in Information Technology Management:

3 credits (3-0-0)

(Relevant current and Emerging Issues)

SML 850 Management of Information Technology:

3 credits (3-0-2)

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.

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.

SML 851 Database Design and Data Management:

3 credit (2-0-2)

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.

SML 852 Network System: Applications and Management:

3 credits (3-0-0)

Module I: Networking fundamentals.

Communication fundamentals (transmission and transmission media; communication techniaues; 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, Remate 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.

SML 855 Electronic Commerce:

3 credits (2-0-2)

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 tech nolo-gies, Virtual concepts, Government internet commerce.

SML 857 Database Management Information Systems:

3 credit (3-0-0)

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, AnSI/ SPARC model for DMMS, 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 Oracle database and application development tools. Database security Designer/2000 CASE, Developer/2000 (Forms, Reports Graphics), Discoverer/ 2000.

Module III: Emerging data management techniques

Distributed database ystems and object databases. Data warehousing and data mining; the SEMMA (Sample Explore, Modify, Model, Asses) process using SAS to build executive information systems and decision support systems.

SML 861 Market Research:

3 credits (2-0-2)

Module I: Research concepts; exploratory, descriptive and conclusive

research. The marketing decision-making process and the place 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, Motivational research, Advertising research, Statistical Analysis and reporting.

Module III: Marketing Information Systems, Structure and design, its role in planning and control; the place of marketing research.

SML 862 Product Management:
3 credit (3-0-0)
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 selecgion. Establishing techno-economic feasibility product testing and test marketing. Developing the strategy and the plan. Implementing the plan, coordination and control. Around identity, Image, Equity, Arround Plan and Management.

Module III

Organization for Product Management, Marketing manager-product manager-brand manager concept, approaches and organizational role product manager- functions and tasks product manager-his tools and techniques. Arround extensions, acquisitions, Arround value consumer in sight.

SML 863 Advertising and Sales Promotion Management:
3 credits (3-0-0)

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 and scheduling. Integrated programme and budget planning. Implementing the programme, coordination and control. Advertising Agencies in India, their services and terms, 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.

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.

SML 865 Sales Management:
3 credits (2-0-2)
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- His tasks and responsibilities, relations with Salesmen and relations with Top Management. Operating environment for Field Sales Managers. Sales forcasting.

Module II: Information and Planning, The qualities and role of a Field Sales Manager- Hierarchy of objectives and goals, concept of 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 of sales territories, procedure for designing sales territories. Determining sales manpower requirements to establish sales territories- Recruiting salesmen-Methods and the selection system. Distribution and chamel selection & main agancies.

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; the Managerial process of sales control.

SML 866 International Marketing:
3 credits (3-0-0)
Module I

Internatioal marketing-its scope and tasks- world economy prospects and Challenges; India's external trade. Analysis of export performance. Organization wet up for exports; Organizations engaged in export effort. Shipping terms and international trade terms. Information needs of exports.Costing and pricing in international trade.

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.

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.

SML 867 Industrial Marketing Management:
3 credits (3-0-0)
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, fact finding training); sales communications.

Module III: Marketing Research. Marketing control (variance analysis audit). Industrial purchase behaviour and processes, new product launch.

SML 869 Current and Emerging Issues in Marketing:
3 credits (3-0-0)
(Relevant current and Emerging Issues)

SML 870 Advanced Financial Management:
3 credits (2-0-2)
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. Break-even Lease Rental. Mergers Acquisition and corporate restructuring Cases and Problems.

SML 871 Accounting for Decision Making:
3 credits (2-0-2)
Module I: 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 orers. Case and Problems.

Module II: 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.

Module III: Restructuring Decisions:

Decisions relating to Investment in a New Project and New: Technology> Choice of Method of production. Restructuring and Expansion Decision. Mergers and Acquisition/Takeover. Cases and Problems.

SML 872 Working Capital Management:
3 credits (3-0-0)
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.

SML 873 Security Analysis and Portfolio Management:
3 credit (3-0-0)
Module I: Investment Environment.

Saving and Financial flows, Financial Intermediation, Investment in Corporate Securities and other Investment Outlets, New Issue market and Secondary Markets, Markets and Brokers. Sources of investment information. Tax incentives. Theoretical framework for investment Decision. Forecasting of future earnings, Concepts of Sustainable Earnings, Rating, Index. Interest Rate Structure and Yield to Maturity Curve. Regulatory Framework of Securities Markets in India. Practical Problems.

Module II: Valuation of Securities.

Valuation of Variable Income Securities (Equity Shares): Theory of Valuation-Earnings and Dividend Model: Aggregate Economic Analysis, Industry Analysis, Fundamental Analysis, Technical Analysis, Growth Shares, Under and Overvalued Shares. Analysis of Fixed Income Securities like Preference Shares, Debentures/Bonds and other Financial Instruments Convertible Bonds: Warrants and Options, Practical Problems.

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. Practical Problems.

SML 874 Indian Financial System:
3 credits (3-0-0)
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.

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 Frame.

Module III: Mutual Funds and Banking Sector.

Investment Policy and performance appraisal of Unit Truest of India and other Mutual Funds. Management of Bank Funds. Development Banks-Operational and Allocation efficiency; New developments.

SML 875 International Financial Management:
3 credits (3-0-0)
Module I: Foreign Exchange Market and Risk Manage.nd Financial Institutions. Practical Problems.

Module III: Financial Management of MNCs.

Multinational Financial Management: Capital Budgeting Decisions for Multinational Corporation, Financing Decisions- Cost of Capital and Financial Structure, Working Capital Management and Control International Banking, International Transfer Pricing. Cases and Problems.

SML 879 Current and Emerging Issues in Finance:
3 credits (3-0-0)
(Relevant current and Emerging Issues)

SML 881 Management of Public Sector Enterprises in India:
3 credits (3-0-0)
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.

SML 889 Current and Emerging Issues in Public Sector Management:
3 credits (3-0-0)
(Relevant current and Emerging Issues)

SML 734 Management of Small Scale Industrial Enterprises:
3 credits (3-0-0)
Module I: Nature of entrepreneurial management, the new entrepreneur, his problems and prospects in the Indian environment. Practical aspects of setting up and running of industries including formulation of projects, 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 medium and large sector considerations. Informations network for new enterprises. Implication of WTO to SMEs. Globalisation & Competitiveness of SMEs.

SMP 783 Management Laboratory:
3 credits (0-0-6)
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.

SML 816 Total Quality Management:
3 credits (2-0-2)
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.

SML 817 Management of System Waste:
3 credits (2-0-2)
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.

SML 818 Industrial Waste Management:
3 credits (2-0-2)
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.

SMD 792 Minor Project:
3 credits (3-0-0)

SML 887 Business Law
3 credits (2-0-2)
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 contr Kinds of contact-Void and voidable contract. Uniforceable and illegal agreements. Offer and acceptal contract over the telephone.

Module II: Contract of Sale of Goods. Definition and essentials of a contract of sale Distinction between and agreement to sell, sale and hire purchase, sale distinguished from contract for work and labour. Kind goods, effect of perished goods. Document to the title of goods. Rules regarding transfer of proper Transfer of Title on sale. Rules regarding delivery of goods. Buyers rights against celler, and Right onpaid seller.

Module III: Negotiable Instrument-Definition and characteristic of Negotiable instrument. Liabilities of Partie Negotiable Instruments. Law of Arbitration-Definition of Arbitration, Effect of an arbitration. Arbitra without Intervention of Court. Power of Arbitration. Duties of Arbitrators, Brief exposure of Companies Consumer Production legislation and Environmental Legislation.

SML 897 Consultancy Process and Skills
3 credits (3-0-0)
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.

SML 898 Consultancy Professional Practice
3 credits (3-0-0)
Module I : Negotiation Skills, Professional Ethics and Code of Conduct. Managing a Consultancy firm-fundamentals of consulting firm management, consulting firms and IT in conslting firms, management of consulting assignments.

Module II : Consulting in variou areas of Management-Consulting in general and strategic manageent, 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.

SML 899 Current and Emerging Issues in Consultancy Management:
3 credits (3-0-0)

SLOT HOURS (General)

DAY	8 - 8:55	9 - 9:55	10 - 10:55	11 - 11:55	12 - 12:55	13 - 13:55	14 - 14:55	15 - 15:55	16 - 16:55	17 - 17:55	18 - 18:55		
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* For any Query, the concerned Department/Centre may be contacted.