

## DEPARTMENT OF CIVIL ENGINEERING

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**PERIYAR  
MANIAMMAI**  
INSTITUTE OF SCIENCE & TECHNOLOGY  
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# Board of Studies in Civil Engineering

## CURRICULUM & SYLLABUS

*(For the candidates admitted from 2018-19 onwards  
Based on Outcome Based Education)*

*FOR*

**M.Tech (Environmental Engineering)  
DEGREE PROGRAMME**

## **STRUCTURE OF M.Tech ENVIRONMENTAL ENGINEERING PROGRAMME**

<b>S.No.</b>	<b>Topic</b>	<b>Credits</b>
<b>1.</b>	Core courses	<b>12</b>
<b>2.</b>	Core Lab	<b>8</b>
<b>3.</b>	Programme Electives	<b>15</b>
<b>4.</b>	Open Electives	<b>3</b>
<b>5.</b>	Audit Courses	<b>0</b>
<b>6.</b>	Mandatory Course	<b>2</b>
<b>7.</b>	Core (Mini Project)	<b>2</b>
<b>8.</b>	Dissertation	<b>26</b>
	<b>Total</b>	<b>68</b>

## SEMESTER-WISE STRUCTURE OF CURRICULUM

### REGULATIONS – 2018

(Applicable to the students admitted from the Academic year 2018-19)

#### SEMESTER I

Sub. Code	Category	Name of the Course	Hours per week			C
			L	T	P	
YEN101	Core I	Chemistry and Microbiology for Environmental Engineers	3	0	0	3
YEN102	Core II	Unit Operation and Processes in Environmental Systems	3	0	0	3
YEN103	Programme Elective	Elective - I	3	0	0	3
YEN104	Programme Elective	Elective – II	3	0	0	3
YEN105	Core Lab I	Environmental Quality Measurements Laboratory - I (Water & Wastewater)	0	0	2	2
YEN106	Core Lab II	Microbiology Laboratory	0	0	2	2
YRM107	MLC	Research Methodology and IPR	2	0	0	2
	Audit I	Audit Course- 1	2	0	0	0
		<b>TOTAL</b>	<b>16</b>	<b>0</b>	<b>4</b>	<b>18</b>

#### SEMESTER II

Sub. Code	Category	Name of the Course	Hours per week			C
			L	T	P	
YEN201	Core III	Transport of Water and Wastewater	3	0	0	3
YEN202	Core IV	Biological Treatment of Wastewater	3	0	0	3
YEN203	Programme Elective	Elective - III	3	0	0	3
YEN204	Programme Elective	Elective – IV	3	0	0	3
YEN205	Core Lab III	Environmental Quality Measurements Laboratory - II (Air, Noise and Solidwaste)	0	0	2	2
YEN206	Core Lab IV	Unit Operation Laboratory	0	0	2	2
YEN207	Core	Mini Project	0	0	4	2
	Audit 2	Audit Course - 2	2	0	0	0
		<b>TOTAL</b>	<b>14</b>	<b>0</b>	<b>8</b>	<b>18</b>

### SEMESTER III

Sub. Code	Category	Name of the Course	Hours per week			C
			L	T	P	
YEN301	Programme Elective	Elective – V	3	0	0	3
	Open Elective	Open Elective	3	0	0	3
YEN303	Dissertation	Dissertation Phase - I	0	0	20	10
	<b>TOTAL</b>		<b>6</b>	<b>0</b>	<b>20</b>	<b>16</b>

### SEMESTER IV

Sub. Code	Category	Name of the Course	Hours per week			C
			L	T	P	
YEN401	Dissertation	Dissertation Phase - II	0	0	32	16
	<b>TOTAL</b>		<b>--</b>	<b>--</b>	<b>--</b>	<b>16</b>

**TOTAL CREDITS - 68**

**Note:**

1. HOD concerned has to provide options for selecting the relevant MOOC courses or any elective paper which are offered.
2. The credit distribution is followed as per the guidelines given by AICTE/UGC.

## PROFESSIONAL ELECTIVE COURSES

### Elective I

Sub. Code	Name of the Course	Hours per week			C
		L	T	P	
YEN103A	Energy and Environment	3	0	0	3
YEN103B	Environmental Economics	3	0	0	3
YEN103C	Air Pollution and Control	3	0	0	3

### Elective II

Sub. Code	Name of the Course	Hours per week			C
		L	T	P	
YEN104A	Instrumental Methods and Analysis of Environmental Pollutants	3	0	0	3
YEN104B	Theory and Practice of Industrial Wastewater Treatment	3	0	0	3
YEN104C	Environmental Policies and Legislation	3	0	0	3

### Elective III

Sub. Code	Name of the Course	Hours per week			C
		L	T	P	
YEN203A	Environmental Biotechnology	3	0	0	3
YEN203B	Sustainable Urban development Concepts and Strategies	3	0	0	3
YEN203C	Solid and Hazardous Waste Management	3	0	0	3

### Elective IV

Sub. Code	Name of the Course	Hours per week			C
		L	T	P	
YEN204A	Remote sensing and GIS	3	0	0	3
YEN204B	Environmental Geotechnology	3	0	0	3
YEN204C	Simulation and Modeling in Environmental Systems	3	0	0	3

**Elective V**

Sub. Code	Name of the Course	Hours per week			C
		L	T	P	
YEN301A	Ground Water Contamination and Transport Modeling	3	0	0	3
YEN301B	Environmental Impact Assessment	3	0	0	3
YEN301C	Membrane Separation for Water and Wastewater	3	0	0	3

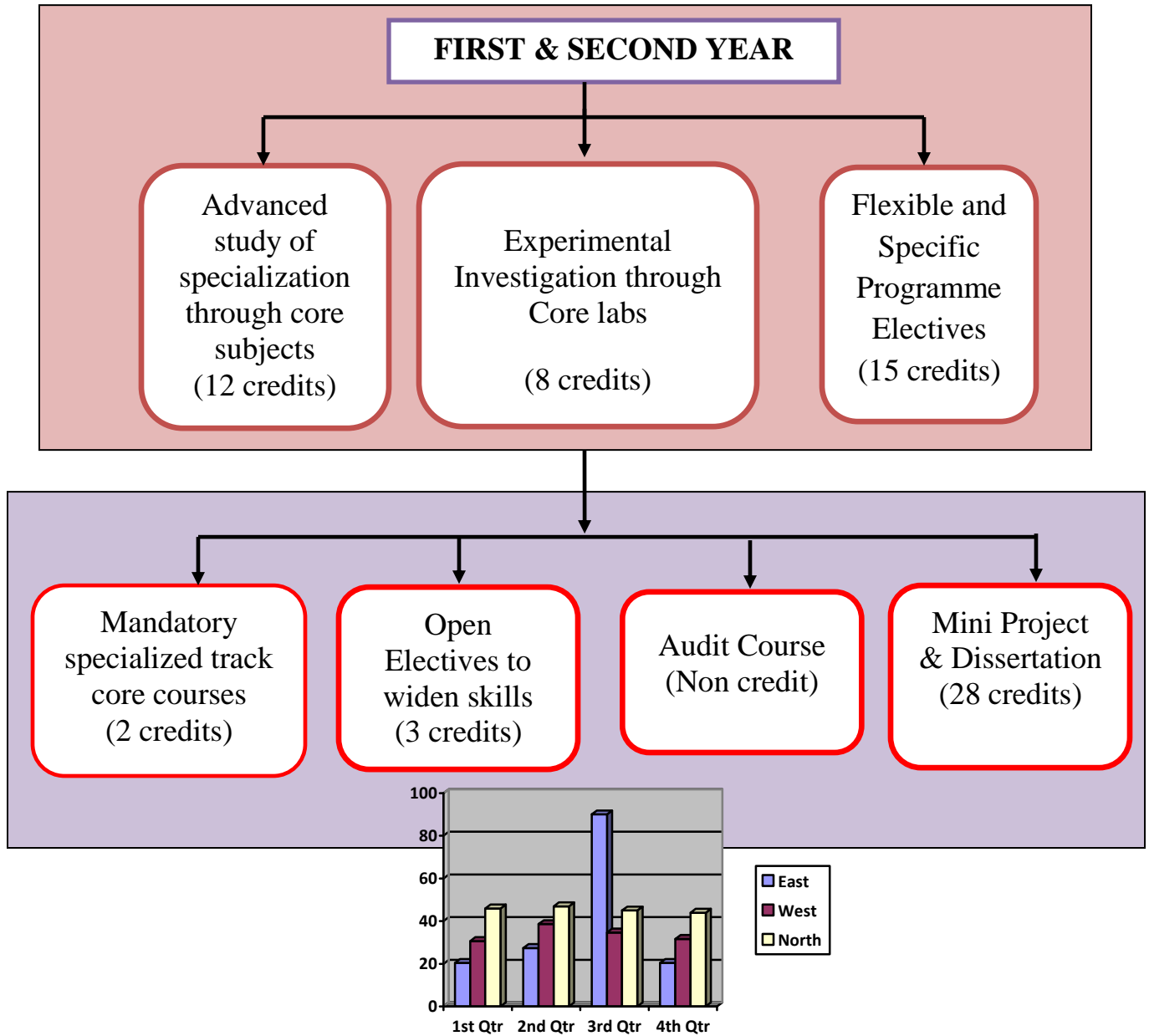
**AUDIT COURSES**

Sub. Code	Name of the Course	Hours per week			C
		L	T	P	
YEGOE1	English for Research Paper Writing	2	0	0	0
YPSOE1	Constitution of India	2	0	0	0

**OPEN ELECTIVES**

Sub. Code	Name of the Course	Hours per week			C
		L	T	P	
YCOOE1	Business Analytics	3	0	0	3
YMEOE1	Industrial Safety	3	0	0	3
YMAOE1	Operations Research	3	0	0	3
YCOOE2	Cost Management of Engineering Projects	3	0	0	3

**FLOW CHART FOR THE ENTIRE PROGRAMME**



Semester	Course Code	Course Name	L	T	P	C
I	YEN101	Chemistry and Microbiology for Environmental Engineers	3	0	0	3

## COURSE CONTENT

<b>UNIT I</b>	<b>FUNDAMENTALS ON ANALYTICAL CHEMISTRY</b>	<b>12</b>
	oxidation and reduction reactions, balancing equation by electron method -Colloids – Redox potentials – partition co-efficient – Beer – Lambert’s Law – Limitations – Electrode potential – Applications of potentiometry – pH measurements, glass electrodes, ion selective electrodes – Instrumentations- Atomic spectroscopy – Flame photometry – Atomic Adsorption Spectrophotometry – principle- UV– visible spectrophotometer -Application in determination of mercury, lead and cadmium in water samples. Chromatography – Gas chromatography – simple instrumentation – Application in measuring SO <sub>2</sub> , NO <sub>2</sub> & H <sub>2</sub> S by spectrophotometry.	
<b>UNIT II</b>	<b>DEGRADATION OF CHEMICALS</b>	<b>6</b>
	Transport and transformation of chemicals – DO, BOD and COD – Photo catalysis - Degradation of foodstuffs, detergents, pesticides and hydrocarbons	
<b>UNIT III</b>	<b>SOIL CHEMISTRY</b>	<b>9</b>
	Soil properties, clay minerals - acid-base and ion-exchange reactions in soil - salt affected soil and its remediation	
<b>UNIT IV</b>	<b>MICROORGANISMS AND NUTRITIONAL REQUIREMENTS</b>	<b>9</b>
	Basic principles of microbiology- structure and function of microbial cell-pure and mixed cultures-metabolism-Aerobic and Anaerobic pathways- Microbial growth and growth kinetics-Classification and morphological aspects of Bacteria, Fungi, Protozoa and algae. Microbial Nutrition –Growth of micro-organism in different media, growth curve, methods of enumeration of micro-organisms, sterilization and disinfection.	
<b>UNIT V</b>	<b>MICROBIOLOGY IN WASTE WATER</b>	<b>9</b>
	Biological methods to treat waste water- Microbiology in air pollution control (biofilter and bio scrubber), biodegradation of toxic pollutant. Practical: culture, identify and explain microorganisms in environmental cultures	



## **TEXT BOOKS**

1. Sawyer,C.N., MacCarty, P.L. and Parkin, G.F., Chemistry for Environmental Engineering and Science, Tata McGraw – Hill, Fifth edition, New Delhi 2003.
2. Colin Baird ‘Environmental Chemistry’, Freeman and company, New York, 2011.
3. Pelczar, Jr, M.J., E.C.S., Krieg, R.Noel., and Pelczar Merna Foss. "Microbiology 5th edition., Tata McGraw Hill Publishing Company Limited, New Delhi-2001
4. Maeir, R.M., I.L.Pepper and C.P. Gerba, “ Environmental Microbiology”, Academic Press, New York, 2008

## **REFERENCES**

1. Des W. Connell, “Basic Concepts of Environmental Chemistry”, CRC Press, 2nd Edition, 2005
2. Gary W VanLoon, Stephen J Duffy,” Environmental Chemistry: A Global Perspective”, Oxford University Press, 2010

Semester	Course Code	Course Name	L	T	P	C
I	YEN102	Unit Operation and Processes in Environmental systems	3	0	0	3

COURSE CONTENT						Hours
<b>UNIT I</b>	<b>PRIMARY TREATMENT METHODS</b>					<b>9</b>
		Screening-Solid Separation-Floatation – Equalization – measurement – Mixing – Coagulation and flocculation				
<b>UNIT II</b>	<b>SEDIMENTATION AND FILTRATION</b>					<b>9</b>
		Principles – Types of settling – Thickening – Dick’s theory , Talmadge theory, principle of filtration – Carman – Kozeny equation – Types of filters				
<b>UNIT III</b>	<b>AERATION</b>					<b>9</b>
		Two film theory – Mass transfer – Fixed and floating aerators – Designing of aerator – Air stripping – packed columns and trays				
<b>UNIT IV</b>	<b>ADSORPTION</b>					<b>9</b>
		Theory of adsorption – Isotherms – fixed and fluidized beds – break through curves – Leaching – Definition and types, ion exchange studies, Determinations of adsorption kinetics				
<b>UNIT V</b>	<b>MEMBRANE PROCESSES</b>					<b>9</b>
		Reverse Osmosis and Electro dialysis - Species Transformation Processes - Chemical Oxidation / Reduction Processes, Disinfection using Chlorine and UV, Advanced Oxidation Process.				

### TEXT BOOKS

1. Metcalf Eddy ,Inc. George Tchobanoglous, Franklin Burton H, David Stensel,” Wastewater Engineering”, Tata McGraw-Hill Education ,2002
2. Hendricks,” Water Treatment Unit Processes: Physical and Chemical,” CRC, 2006.
3. Pelczar Jr. Michael,” Microbiology”, Tata McGraw-Hill Education,2001

### REFERENCES

1. Tushar p,” Adsorption: Surface Chemistry,” Rajat Publications, 2004.
2. Ajey Kumar Patel, Achanta Ramakrishna Rao,” Aeration Systems for Wastewater Treatment”, Lap Lambert Academic PublishinG,-2011
3. James Cappucciono, Natalic Sherman,” Microbiology: A Laboratory Manual,” Pearson, 2007.

Semester	Course name	Course Code	L	T	P	C
I	YEN105	Environmental Quality Measurements Laboratory-I (Water and Wastewater)	0	0	2	2

#### List of Experiments:

1. Determination of pH, Turbidity and Electrical conductivity
2. Determination of Alkalinity
3. Determination of Acidity
4. Determination of Hardness
5. Determination of Sulphates
6. Determination of Fluorides
7. Determination of Nitrates
8. Residual chlorine analysis
9. Test on Dissolved Oxygen and BOD
10. Test on COD

#### TEXT BOOKS

1. Standard Methods for the Examination of Water and Wastewater, 20th Edition.
2. Manual on water supply and Treatment, CPHEEO, Ministry of Urban Development, GOI, New Delhi, 2000.

Semester	Course Code	Course Name	L	T	P	C
I	YEN106	Microbiology Laboratory	0	0	2	2

### List of Experiments

1. Preparation of culture media
2. Isolation, culturing and Identification of Microorganisms
3. Microorganisms from polluted habitats (soil, water and air)
4. Measurement of growth of microorganisms
5. Biodegradation of organic matter in waste water Analysis of air borne microorganisms
6. Staining of bacteria.
7. Effect of pH, temperature on microbial growth
8. Pollutant removal using microbes from industrial effluent.
9. Bacteriological analysis of wastewater (Coliforms, *E.coli*, *Streptococcus*) – MPN
10. Bacteriological analysis of wastewater (Coliforms, *Streptococcus*) - MF techniques

### TEXT BOOKS

1. Benfield, L.D.; Weand, B.L.; Judkins, J.F. (1982) Process chemistry for water and wastewater. Prentice Hall Inc Englewood Cliffs New Jersey.
2. Weber Jr., W.J. (1972) Physico-chemical Process for Water Quality Control. Wiley Inc. Newyork.
3. Peavy, H.S., Rowe, D.R., Tchobanoglous, G. Environmental Engineering, McGraw Hills, New York, 1985.

Semester	Course Code	Course Name	L	T	P	C
I		Research Methodology and IPR	2	0	0	2

<b>UNIT I</b>	<b>9</b>
Meaning of research problem, Sources of research problem, Criteria-Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations	
<b>UNIT II</b>	<b>9</b>
Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.	
<b>UNIT III</b>	<b>9</b>
Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.	
<b>UNIT IV</b>	<b>9</b>
Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.	
<b>UNIT V</b>	<b>9</b>
New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.	
	<b>LECTURE</b>
	<b>TUTORIAL</b>
	<b>TOTAL</b>
	<b>30</b>
	<b>0</b>
	<b>30</b>
<b>REFERENCES</b>	
<ol style="list-style-type: none"> <li>1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science &amp; engineering students"</li> <li>2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"</li> <li>3. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"</li> <li>4. Halbert, "Resisting Intellectual Property", Taylor &amp; Francis Ltd ,2007.</li> <li>5. Mayall, "Industrial Design", McGraw Hill, 1992.</li> <li>6. Niebel, "Product Design", McGraw Hill, 1974.</li> <li>7. Asimov, "Introduction to Design", Prentice Hall, 1962.</li> <li>8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.</li> <li>9. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008</li> </ol>	

Semester	Course Code	Course Name	L	T	P	C
II	YEN201	Transport of Water and Wastewater	3	0	0	3
<b>COURSE CONTENT</b>						<b>HRS.</b>
<b>UNIT I</b>	<b>TRANSPORT OF WATER</b>					<b>9</b>
	Water Storage and Transmission, Storage- requirements, impounding reservoirs- intakes, pressure conduits, hydraulics - pumps and pumping units, capacity - selection of water pumps -economic design of pumps and economic design of gravity and pumping mains- Analysis of physical and Chemical characteristics of Water.					
<b>UNIT II</b>	<b>MATERIALS FOR PIPES</b>					<b>9</b>
	Specification for pipes, merits and demerits, pipe appurtenances, types of loads and stresses, water hammer, causes and prevention, control devices, laying, jointing and Testing of pipes.					
<b>UNIT III</b>	<b>DISTRIBUTION SYSTEM</b>					<b>9</b>
	Principles of design, analysis of distribution networks, Hardy Cross, equivalent pipe and Newton Raphson methods, computer applications in distributions network analysis, optimal design of networks, maintenance of distribution systems, methods of control and prevention of corrosion, storage, distribution and balancing reservoirs – EPANET- LOOP					
<b>UNIT IV</b>	<b>SANITARY SEWERAGE</b>					<b>9</b>
	Storm Drainage: Basic philosophy in storm drainage - drainage layouts - storm runoff estimation - Rainfall data analysis - hydraulics of flow in storm water drains - storm water drain materials and sections - design of storm drains - storm water inlets - Sanitation technology selection - sanitary sewage flow estimation - sewer materials - hydraulics of flow in sanitary sewers - partial flows - sewer design - sewer layouts. - Analysis of physical and Chemical characteristics of Waste water.					
<b>UNIT V</b>	<b>OPERATION &amp; MAINTENANCE</b>					<b>9</b>
	Maintenance requirements of sanitary sewerage - storm drainage systems - manpower requirement - Equipment requirement - preventive maintenance - monitoring safety requirements- corrosion in sewers - prevention and control - Specific problems related to waste water pumping - pumping - pump selection - wastewater pumping networks					

## **TEXT BOOKS**

1. G.S.Bridie & J.S. Bridie, Water Supply and Sanitary Engineering, DhanpatRai and Sons, New Delhi, 2010.
2. Hammer, M.J. Water & Waste water Technology, John Wiley & Sons, New York, 7<sup>TH</sup> edition, 2012.
3. Garg, S.K., “Environmental Engineering I & II”, Khanna Publishers, New Delhi 2007
4. Manual on Water Supply and Treatment, CPHEEO, Government of India, New Delhi, 2000
5. Manual on Sewage and Sewerage system, CPHEEO, Government of India, New Delhi, 2000

## **REFERENCES**

1. 'Water supply and wastewater Removal' Vol.I. John Wiley and Sons Manual on Water Treatment, CPHEEO, Government of India, New Delhi, 2010
2. Hussain S.K. A Text book of water supply and sanitary Engineering, Oxford and IBH Publishing Co., New, 2010.
3. Larry W. Mays, Mays Larry, “Water Distribution System Handbook”, McGraw-Hill Professional Publishing, 1999.

Semester	Course Code	Course Name	L	T	P	C
II	YEN202	Biological Treatment of Wastewater	3	0	0	3

## COURSE CONTENT

<b>UNIT I</b>	<b>INTRODUCTION</b>	<b>9</b>
	Objectives of biological treatment – significance – Principles of aerobic and anaerobic treatment - kinetics of biological growth – Factors affecting growth – attached and suspended growth - Determination of Kinetic coefficients for organics removal – Biodegradability assessment –selection of process- reactors- batch-continuous type	
<b>UNIT II</b>	<b>AEROBIC TREATMENT OF WASTEWATER</b>	<b>9</b>
	Design of sewage treatment plant units –Activated Sludge process and variations, Sequencing Batch reactors, Membrane Biological Reactors-Trickling Filters-Bio Tower-RBC-Moving Bed Reactors-fluidized bed reactors, aerated lagoons, waste stabilization ponds – nutrient removal systems – natural treatment systems, constructed wet land – Disinfection – disposal options – reclamation and reuse – Flow charts, layout, PID, hydraulic profile, recent trends	
<b>UNIT III</b>	<b>ANAEROBIC TREATMENT OF WASTEWATER</b>	<b>9</b>
	Attached and suspended growth, Design of units – UASB, up flow filters, Fluidized beds MBR, septic tank and disposal – Nutrient removal systems – Flow chart, Layout and Hydraulic profile – Recent trends.	
<b>UNIT IV</b>	<b>SLUDGE TREATMENT AND DISPOSAL</b>	<b>9</b>
	Design of sludge management facilities, sludge thickening, sludge digestion, biogas generation, sludge dewatering(mechanical and gravity) Layout, PID, hydraulics profile – upgrading existing plants – ultimate residue disposal – recent advances.	
<b>UNIT V</b>	<b>OPERATION AND MAINTENANCE</b>	<b>9</b>
	Construction and Operational Maintenance problems – Trouble shooting – Planning, Organizing and Controlling of plant operations – capacity building - Retrofitting Case studies – sewage treatment plants – sludge management facilities.	



## **TEXT BOOKS**

1. Arceivala, S.J., “Wastewater Treatment for Pollution Control”, Tata Mcgraw Hill, New Delhi, III Edition, 2006.
2. David Hendricks, “Fundamentals of Water Treatment Unit Process”, CRC Press, New York, 2010
3. F.R. Spellman, “Hand Book of Water and Wastewater Treatment Plant operations”, CRC Press, New York, III, Edition, 2013.

## **REFERENCES**

1. Manual on “Sewerage and Sewage Treatment” CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 1999.
2. Metcalf & Eddy, INC, “Wastewater Engineering – Treatment and Reuse”, Fourth Edition, Tata Mc Graw-Hill Publishing Company Limited, New Delhi, 2003.
3. Qasim, S.R. “Wastewater Treatment Plant, Planning, Design & Operation”, Technomic Publications, New York, II Edition, 1998.

Semester	Course Code	Course Name	L	T	P	C
II	YEN205	Environmental Quality Measurements Laboratory-II (Air,Noise and Solidwaste)	0	0	2	2

### List of Experiments

1. Determination of Ambient Air Quality Parameters- SPM, CO, NO<sub>x</sub> and SO<sub>x</sub>
2. Soil Analysis – pH and Conductivity,
3. Cation Exchange Capacity
4. Determination of Noise
5. Composition of Municipal Solidwaste
6. Proximate and Ultimate Analysis
7. Total Solids, Suspended Solids, Volatile Solids, Non Volatile Solids

### TEXT BOOKS

1. Standard Methods for the Examination of Water and Wastewater, 20th Edition.
2. Manual on water supply and Treatment, CPHEEO, Ministry of Urban Development, GOI, New Delhi, 2000.

<b>Semester</b>	<b>Course Code</b>	<b>Course Name</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>II</b>	<b>YEN206</b>	<b>Unit Operation Laboratory</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>2</b>

### **List of Experiments**

1. Coagulation and Flocculation
2. Studies on Filtration- Characteristics of Filter media
3. Disinfection for Drinking water (Chlorination)
4. Water Softening - Lime and Caustic Soda Process
5. Sludge volume Index
6. Sedimentation - Settling Column Analysis of Flocculating Particles
7. Adsorption - Colour Removal by Adsorption
8. Heavy Metal Precipitation
9. Kinetics of Activated Sludge Process

### **TEXT BOOKS**

1. Standard Methods for the Examination of Water and Wastewater, 20th Edition.
2. Manual on water supply and Treatment, CPHEEO, Ministry of Urban Development, GOI, New Delhi, 2000.

<b>Semester</b>	<b>Course Code</b>	<b>Course Name</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>III</b>	<b>YEN303</b>	<b>Dissertation Phase - I</b>	<b>0</b>	<b>0</b>	<b>20</b>	<b>10</b>

### **COURSE CONTENT**

The student individually works on a specific topic approved by faculty member who is familiar in this area of interest. The student can select any topic which is relevant to his/her specialization of the programme. The topic may be experimental or analytical or case studies. At the end of the semester, a detailed report on the work done should be submitted which contains clear definition of the identified problem, detailed literature review related to the area of work and methodology for carrying out the work. The students will be evaluated through a viva-voce examination by a panel of examiners including one external examiner.

<b>Semester</b>	<b>Course Code</b>	<b>Course Name</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>IV</b>	<b>YEN401</b>	<b>Dissertation Phase - II</b>	<b>0</b>	<b>0</b>	<b>32</b>	<b>16</b>

### **COURSE CONTENT**

The student should continue the phase I work on the selected topic as per the formulated methodology. At the end of the semester, after completing the work to the satisfaction of the supervisor and review committee, a detailed report should be prepared and submitted to the head of the department. The students will be evaluated based on the report and the viva-voce examination by a panel of examiners including one external.

## ELECTIVES

Semester	Course Code	Course Name	L	T	P	C
I	YEN103A	Energy and Environment	3	0	0	3

### COURSE CONTENT Hours

#### UNIT I GENERAL 9

Trends in waste generation-Processing Philosophy- Typical waste composition and its uses-Waste recovery methods-Waste recycling methods-Energy recovery methods

#### UNIT II RECOVERY OF WASTE MATERIAL 9

Recovery of waste materials-Plastic recovery –Energy recovery-Metal recovery-Glass recovery-Non ferrous metals recovery-Composting-Check list

#### UNIT III RECYCLING OF WASTE MATERIAL 9

Separation and recycling of waste – Principles - separation-Air classifier – Screening-Hammer mill-Products of recycling-Recycling applications-Case histories-House hold waste recycling –Scrap fragmentation Process

#### UNIT IV WASTE HANDLING SYSTEMS 9

Waste handling and storage-Supply and demand-Compacting and storage-Storage hoppers-Waste handling systems-Access and safety –Compactors

#### UNIT V DISPOSAL OF WASTE 9

Waste disposal-Management- Conveyance – Specific examples- Refractories-Development-Chimneys-Control and instrumentation-Operation and safety.

### TEXT BOOKS

1. Vaish Troloki, Energy, Environment and Ecology, Vayu Education of India, New Delhi, 2001
2. Salvato, “Environmental Sanitation”, John Wiley & Sons, New York, 1982
3. David Kut and Gerard Hare, ”Waste recycling for energy recovery”, Architectural Press, 1981.

### REFERENCES

1. Metcalf & Eddy, “Wastewater Engineering Treatment Disposal Reuse”, Tata McGraw-Hill, New York, 2003.
2. Arcievala S.J., Wastewater treatment and Disposal – Engineering and Ecology in pollution control, Marcel Dekker. Inc., New York, 1981.

3. Chandra and Adab, "Rubber and plastic Waste", Cbs, 2004.

Semester	Course Code	Course Name	L	T	P	C
I	YEN103B	Environmental Economics	3	0	0	3

## **COURSE CONTENT**

<b>UNIT I</b>	<b>THEORY AND CONCEPT</b>		<b>9</b>
	Nature and significance of environmental economics – definition and scope of environmental economics – basic theory – market system and the environment – welfare and environment – the economics of externalities.		
<b>UNIT II</b>	<b>ENVIRONMENT AND ECONOMICS</b>		<b>9</b>
	Environment – economy linkage – environment as a necessity and luxury – population and environment linkage – environmental use as an allocative problem – environment as a public good – valuation of environmental damages: land, water, air and forest.		
<b>UNIT III</b>	<b>ENVIRONMENTAL PROBLEMS</b>		<b>9</b>
	Economic development and environmental problems – air pollution – water pollution – sound pollution – energy use and environment problem – pollution and urbanization – global warming and green house effect – health, urbanization, transport and technology – environmental degradation.		
<b>UNIT IV</b>	<b>POLLUTION CONTROL</b>		<b>9</b>
	Prevention, control and abatement of pollution – choice of policy instruments in developing countries – environmental law – sustainable development – indicators of sustainable development – environmental planning – environmental accounting.		
<b>UNIT V</b>	<b>POLICY MEASURES</b>		<b>9</b>
	Basic approach – design of environmental policy – Indian environment policies and performance – pollution control boards and their function.		

### **TEXT BOOKS:**

1. M. Karpagam (1993), Environmental Economics, Sterling Publishers, New Delhi.
2. S. Sankaran (1994) Environmental Economics, Margham, Madras
3. N. Rajalakshmi and Dhulasi Birundha (1994), Environmental Economics, Economic analysis of Environment, Allied publishers, Ahmedabad.

4. S.Varadarajan and S. Elangovan(1992), Environmental economics, Speed, Chennai.

**REFERENCES:**

1. Singh G.N (Ed.) (1991) Environmental Economics, Mittal Publications, New Delhi.
2. Garge, M.R. (Ed.) (1996), Environmental Pollution and Protection, Deep and Deep Publications, New Delhi.
3. Lodha, S.L (Ed.) (1991), Economics of Environment, Publishers, New Delhi. 8. The Hindu survey of Environment: Annual Reports.



Semester	Course Code	Course Name	L	T	P	C
I	YEN103 C	Air Pollution and Control	3	0	0	3

## COURSE CONTENT

### UNIT I INTRODUCTION TO AIR POLLUTANTS 9

Air resource management system - Air quality management - Scales of air pollution problem - Sources and classification of pollutants and their effect on human health vegetation and property - Global implications of air pollution - Meteorology Fundamentals - Atmospheric stability – Micrometeorology - Atmospheric turbulence - mechanical and thermal turbulence - Wind profiles - Atmospheric Diffusion - Atmospheric diffusion theories - Steady-state atmospheric diffusion equation – Plume rise - Diffusion models - Ambient air quality and emission standards – Air pollution indices – Air Quality Sampling and Monitoring.

### UNIT II CONTROL OF PARTICULATE CONTAMINANTS 9

Settling chambers - Filters, gravitational, Centrifugal – multiple type cyclones, prediction of collection efficiency, pressure drop, wet collectors, Electrostatic Precipitation theory – ESP design – Operational Considerations – Process Control and Monitoring – Case Studies.

### UNIT III CONTROL OF GASEOUS CONTAMINANTS 9

Absorption – principles - description of equipment-packed and plate columns - design and performance equations – Adsorption - principal adsorbents - Equipment descriptions – Design and performance equations – Condensation - design and performance equation – Incineration - Equipment description - design and performance equations - Biological Air Pollution Control Technologies – Bio-Scrubbers, Biofilters – Operational Considerations – Process Control and Monitoring – Case Studies.

### UNIT IV EMERGING TRENDS 9

Process Modification – Automobile Air Pollution and its control – Fuel Modification - Mechanical Particulate Collectors – Entrainment Separation – Internal Combustion Engines – Membrane Process – Ultraviolet Photolysis – High Efficiency Particulate Air Filters – Technical & Economic Feasibility of selected emerging technologies for Air pollution control

### UNIT V INDOOR AIR QUALITY 9

Sources and Causes of Indoor Air Quality Problems- Risk due to Indoor Air pollutants- sources of indoor Air pollutants- Indoor Air Quality Regulations- Indoor Air Quality Models- Indoor Air Quality Control- Case Studies

## **TEXT BOOKS**

1. Noel de Nevers, Air Pollution Control Engineering, Mc Graw Hill, New York, 2010.
2. Lawrence K. Wang, Norman C. Parelra, Yung Tse Hung, Air Pollution Control Engineering, Tokyo, 2004.
3. Anjaneyulu. Y, 'Air Pollution and Control Technologies', Allied Publishers (P) Ltd., India, 2002

## **REFERENCES**

1. David H.F. Liu, Bela G. Liptak 'Air Pollution', Lewis Publishers, 2000.
2. Arthur C.Stern, ' Air Pollution (Vol.I – Vol.VIII)', Academic Press, 2006.
3. Wayne T.Davis, 'Air Pollution Engineering Manual', John Wiley & Sons, Inc., 2000

<b>I</b>	<b>YEN104A</b>	<b>Instrumental methods and analysis of environmental pollutants</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
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## **COURSE CONTENT**

<b>UNIT I</b>	<b>INTRODUCTION</b>	Instrumental Methods, Selection of method, Precision and Accuracy, Errors in measuring signals, Noise/signal ratio, base line drift, Indicator tubes.	<b>9</b>
<b>UNIT II</b>	<b>SPECTROSCOPIC METHODS</b>	Electromagnetic radiation, matter radiation interactions; Colorimetry and Spectrophotometry, Fluorimetry, Nephelometry and Turbidimetry, flame photometry Atomic Absorption Spectrometry (AAS), Atomic Emission Spectrometry (AES) – Inductively coupled plasma (ICP) and Direct Current Plasma (DCP) spectrometry. ICP – MS (Mass spectrometry).	<b>9</b>
<b>UNIT III</b>	<b>CHROMATOGRAPHIC METHODS</b>	Classical methods, Column, Paper and thin layer chromatography (TLC), Gas Chromatography (GC), GC-MS, High performance liquid chromatography (HPLC) and Ion Chromatography (IC).	<b>9</b>
<b>UNIT IV</b>	<b>ELECTRO AND RADIO ANALYTICAL METHODS</b>	Conductometry, Potentiometry, Coulometry, Amperometry Polarography, Neutron Activation Analysis (NAA), X-ray Fluorescence (XRF) and X-ray Diffraction (XRD) methods.	<b>9</b>
<b>UNIT V</b>	<b>CONTINUOUS MONITORING INSTRUMENTS</b>	Non – dispersive infra-red (NDIR) analyzer for CO, Chemiluminescent analyzer for NO <sub>x</sub> , Fluorescent analyzer for SO <sub>2</sub> , Auto analyzer for water quality using flow injection analysis; permeation devices.	<b>9</b>

## **TEXT BOOKS**

1. Willard. H., Merritt, L., Dean, D.A. and Settle. F.A. ‘Instrumental methods of analysis, 7<sup>th</sup> Edn. Words Worth, New York, 2004.
2. Eckman D.P. “Industrial Instrumentation”, Wiley Eastern Ltd., 1989.
3. Considine D M and Considine G D “Process Instruments Controls” Handbook 3rd Edition , McGraw – Hill Book Co., NY, 1990.
4. Scborg D E, Edgar T.F and Mellichamp D.A, “Process Dynamics and Control” John Wiley 1989

## **REFERENCES**

1. Fribance, “Industrial Instrumentation Fundamentals” ,Mc Graw Hill Co. Inc. New York 1985
2. Ewing ‘Instrumental Methods of Chemical Analysis, 5<sup>th</sup> Edn., McGraw-Hill, New York, 1995.
3. Ernest Doebelin, Measurement systems, McGraw – Hill Book, Co., NY, 1975.
4. Astrom K.J., Bjon wittenmark, Computer controlled systems, Prentice- Hall of India, New Delhi 1994.
5. Cartis Johnson, Process Control Instrumentation Technology, Prentice-Hall of India, New Delhi 1993.

Semester	Course Code	Course Name	L	T	P	C
I	YEN104B	Theory and practice of industrial waste water treatment	3	0	0	3

## COURSE CONTENT

<b>UNIT I</b>	<b>INTRODUCTION</b>	<b>9</b>
	Industrial scenario in India– Industrial activity and Environment - Uses of Water by industry – Sources and types of industrial wastewater – Nature and Origin of Pollutants - Industrial wastewater and environmental impacts – Regulatory requirements for treatment of industrial wastewater – Industrial waste survey – Industrial wastewater monitoring and sampling -generation rates, characterization and variables –Toxicity of industrial effluents and Bioassay tests – Major issues on water quality management.	
<b>UNIT II</b>	<b>INDUSTRIAL POLLUTION PREVENTION</b>	<b>9</b>
	Prevention and Control of Industrial Pollution – Benefits and Barriers – Waste management Hierarchy - Source reduction techniques – Pollution Prevention of Assessment - Material balance - Evaluation of Pollution prevention options –Cost benefit analysis – payback period - Waste minimization Circles.	
<b>UNIT III</b>	<b>INDUSTRIAL WASTEWATER TREATMENT</b>	<b>9</b>
	Equalization - Neutralization – Oil separation – Flotation – Precipitation – Heavy metal Removal– Aerobic and anaerobic biological treatment – Sequencing batch reactors – High Rate reactors - Chemical oxidation – Ozonation – carbon adsorption - Photocatalysis – Wet Air Oxidation – Evaporation – Ion Exchange – Membrane Technologies – Nutrient removal.- Treatability studies.	
<b>UNIT IV</b>	<b>WASTEWATER REUSE AND RESIDUAL MANAGEMENT</b>	<b>9</b>
	Individual and Common Effluent Treatment Plants – Joint treatment of industrial and domestic wastewater - Zero effluent discharge systems - Quality requirements for Wastewater reuse – Industrial reuse , Present status and issues - Disposal on water and land – Residuals of industrial wastewater treatment – Quantification and characteristics of Sludge – Thickening, digestion, conditioning, dewatering and disposal of sludge – Management of RO rejects	

## **UNIT V CASE STUDIES**

**9**

Industrial manufacturing process description, wastewater characteristics, source reduction options and waste treatment flow sheet for Textiles – Tanneries – Pulp and paper – metal finishing – Oil Refining – Pharmaceuticals – Sugar and Distilleries.

### **TEXT BOOKS**

1. Eckenfelder, W.W., ‘Industrial Water Pollution Control’, Mc-Graw Hill, 2000.
2. Nelson Leonard Nemerow, “Industrial waste treatment – contemporary practice and vision for the future”, Elsevier, Singapore, 2007
3. Paul L. Bishop, ‘Pollution Prevention: - Fundamentals and Practice’, Mc-Graw Hill International, Boston, 2000.

### **REFERENCES**

1. Nemerow, N.I, Butterworth-Heinemann, “Theories of practice of Industrial Waste Treatment”, 2006.
2. Gurnham, C.F., “Principles of Industrial Waste Treatment “CRC Press, 1999.
3. Frank Woodard, ‘Industrial waste treatment Handbook’, Butterworth Heinemann, New Delhi, 2001

Semester	Course Code	Course Name	L	T	P	C
I	YEN104C	Environmental Policies and Legislation	3	0	0	3

## COURSE CONTENT

<b>UNIT I</b>	<b>INTRODUCTION</b>					<b>8</b>
	Basics of jurisprudence – Environmental law relation with other disciplines - Criminal law – Common Law – Relevant sections of the Code of Civil Procedure, Criminal Procedure Code – Indian Penal Code.					
<b>UNIT II</b>	<b>INDIAN CONSTITUTION AND ENVIRONMENT</b>					<b>10</b>
	Introduction – Fundamental Rights – Directive Principles of State Policy – Article 48 (A) and 51-A(g) Judicial enforceability – Constitution and Resources management and pollution control – Indian Forest Policy (1990) – Indian Environmental Policy (1992).					
<b>UNIT III</b>	<b>ADMINISTRATIVE REGIME &amp; LEGAL REGIME</b>					<b>9</b>
	Administrative regulations – constitution of Pollution Control Boards Powers, functions, Accounts, Audit etc. – Formal Justice Delivery mechanism Higher and Lower of judiciary – Constitutional remedies writ jurisdiction Article 32, 226 136 special reference to Mandamus and Certiorari for pollution abatement – Equitable remedies for pollution control					
<b>UNIT IV</b>	<b>POLLUTION CONTROL LAWS</b>					<b>9</b>
	Administrative regulation under recent legislations in water pollution control. Water (prevention & control of pollution) Act 1974 as amended by Amendment Act 1988. Water (prevention and control of pollution) Rules 1975 Water (prevention & control or Pollution) cess Act. 1977 as amended by Amendment Act 1987 and relevant notifications.					
<b>UNIT V</b>	<b>ENVIRONMENTAL (PROTECTION) ACT 1986</b>					<b>9</b>
	Relevant notifications in connection with Hazardous Wastes (management and handling) Biomedical wastes (management and handling), Noise pollution, Eco-labeling, and E.I.A.					

## **TEXT BOOKS**

1. Constitution of India Eastern Book Company Lucknow 12<sup>th</sup> Edn. 1997.
2. Constitutional Law of India – J.N. Pandey 1997 (31<sup>st</sup> Edn.) Central Law Agency Allahabad.
3. Administrative Law U.P.D. Kesari 1998. Universal Book Trade Delhi.
4. Environmental Law H.N. Tiwari, Allahabad Law. Agency 1997.

## **REFERENCES**

1. Environmental, A., Divan and Noble M. Environmental Law and Policy in India (cases, Materials and Statutes) 1991 Tripathi Bombay.
2. Environmental Policy. Forest Policy. Bare Acts – Government Gazette Notification.



Semester	Course Code	Course Name	L	T	P	C
II	YEN203A	Environmental Biotechnology	3	0	0	3

## COURSE CONTENT

<b>UNIT I</b>	<b>INTRODUCTION</b>	<b>5</b>
	Principles and concepts of environmental biotechnology—usefulness to mankind, current status.	
<b>UNIT II</b>	<b>DETOXIFICATION OF ENVIRONMENTAL POLLUTANTS</b>	<b>8</b>
	Degradation of high concentrated toxic pollutants—halogenated, non-halogenated, petroleum hydrocarbons, metals. Mechanisms of detoxification—oxidation, dehalogenation, biotransformation of metals, biodegradation of solid wastes.	
<b>UNIT III</b>	<b>MICROBIAL TECHNOLOGY FOR WASTE TREATMENT</b>	<b>12</b>
	Biotechnological remedies for environmental pollution—decontamination of groundwater systems, subsurface environment—reclamation concepts—bioremediation. Production of proteins – biofertilizers. Physical, chemical and microbiological factors of composting – health risk – pathogens – odour management – Microbial cell/enzyme technology – adapted microorganisms – biological removal of nutrients – algal biotechnology and applications in agriculture – role of extracellular polymers. Biogas technology – case studies.	
<b>UNIT IV</b>	<b>RECOMBINANT DNA TECHNOLOGY AND GENETIC APPLICATION</b>	<b>10</b>
	Concept of rDNA technology – expression vectors – cloning of DNA – mutation – construction of microbial strains, radioactive probes, protoplast fusion technology – applications.	
<b>UNIT V</b>	<b>ETHICAL AND REGULATORY ISSUES</b>	<b>10</b>
	Environmental effects and ethics of microbial technology – safety of genetically engineered organisms – microbial containment – Risk assessment	

## **TEXT BOOKS**

1. Chaudhury, G.R. 'Biological degradation and Bioremediation of toxic chemicals', Dioscorides Press, Oregon, 1994.
2. Martin.A.M, 'Biological degradation of wastes', Elsevier Applied Science, London, 1991.
3. Sayler, Gray S. Robert Fox and James W. Blackburn Environmental Biotechnology for Waste Treatment, Plenum Press, New York, 1991.
4. Blaine Metting.F (Jr.,) Soil Microbiology Ecology, Marcel Dekker Inc., 1993.

## **REFERENCES**

1. Wainwright, M, An Introduction to Environmental Biotechnology, 1999.
2. Old, R.W., and Primrose, S.B., Principles of Gene Manipulation 3<sup>rd</sup> Ed. Blackwell Sci. Publ., Cambridge, 1985.
3. Bruce E. Rittmann, Eric Seagren, Brian A.Wrenn and Albert J. Valocchi, Chittaranjan Ray, Lutgarde Raskin, Insitu Bioremediation (2nd Edition) Naves Publication, U.S.A, 1991

Semester	Course Code	Course Name	L	T	P	C
II	YEN203B	Sustainable Urban development Concepts and Strategies	3	0	0	3

## COURSE CONTENT

<b>UNIT I</b>	<b>Introduction</b>					<b>9</b>
	Introduction to sustainable development –Energy Resources-Renewable Non – conventional energy sources-Energy needs-Conserving natural resources					
<b>UNIT II</b>	<b>Environmental Protection</b>					<b>9</b>
	Environmental protection in urban areas-Co ordination and enforcement – Legislative aspects-Population control-Technological aspects-Application of EIA-Methodology to urban development programme					
<b>UNIT III</b>	<b>Urban Landscape</b>					<b>9</b>
	Principles of urban landscape- Landscape design for front areas and other functional areas in urban development –Develict areas-Reclamation of derlict areas					
<b>UNIT IV</b>	<b>Community Development</b>					<b>9</b>
	Community involvement in developing settlement – Developmental programs related to urban and rural society—Impact of programme on social development					
<b>UNIT V</b>	<b>Development Management</b>					<b>9</b>
	Socio economic factors in the development of urban and rural settlements-Legal administrative and financial frame works –Development management and control					

## TEXT BOOKS:

1. Neil S. Grigg., " Urban Water Infrastructure Planning - Management and Operations ", John Wiley and Sons, 1986.
2. Overtens D.E. and Meadows M.E., " Storm Water Modelling ", Academic Press, NewYork, 1976.

## REFERENCES:

1. Environmental, A., Divan and Noble M. Environmental Law and Policy in India(cases, Materials and Statutes) 1991 Tripathi Bombay.
2. Environmental Policy. Forest Policy. Bare Acts – Government Gazette Notification.

Semester	Course Code	Course Name	L	T	P	C
II	YEN203C	Solid and Hazardous Waste Management	3	0	0	3

## COURSE CONTENT

### UNIT I SOURCES, CLASSIFICATION AND REGULATORY FRAMEWORK 9

Types and Sources of solid and hazardous wastes - Need for solid and hazardous waste management – Elements of integrated waste management and roles of stakeholders - Salient features of Indian legislations on management and handling of municipal solid wastes, hazardous wastes, biomedical wastes, lead acid batteries, electronic wastes , plastics and fly ash – Financing waste management.

### UNIT II WASTE CHARACTERIZATION AND SOURCE REDUCTION 9

Waste generation rates and variation - Composition, physical, chemical and biological properties of solid wastes – Hazardous Characteristics – TCLP tests – waste sampling and characterization plan - Source reduction of wastes –Waste exchange - Extended producer responsibility - Recycling and reuse

### UNIT III STORAGE, COLLECTION AND TRANSPORT OF WASTES 9

Handling and segregation of wastes at source – storage and collection of municipal solid wastes – Analysis of Collection systems - Need for transfer and transport – Transfer stations Optimizing waste allocation– compatibility, storage, labeling and handling of hazardous wastes – hazardous waste manifests and transport

### UNIT IV WASTE PROCESSING TECHNOLOGIES 9

Objectives of waste processing – material separation and processing technologies – biological & chemical conversion technologies – methods and controls of Composting - thermal conversion technologies, energy recovery – incineration – solidification & stabilization of hazardous wastes- treatment of biomedical wastes

Waste disposal options – Disposal in landfills - Landfill Classification, types and methods – site selection - design and operation of sanitary landfills, secure landfills and landfill bioreactors – leachate and landfill gas management – landfill closure and environmental monitoring – Rehabilitation of open dumps – landfill remediation

**TEXT BOOKS**

1. George Tchobanoglous et al, "Integrated Solid Waste Management", McGraw - Hill, 2014.
2. Manual on Municipal Solid waste Management, CPHEEO, Ministry of Urban Development, Govt. Of. India, New Delhi, 2000.
3. Tchobanoglous Thiesen Ellasen; Solid Waste Engineering Principles and Management, McGraw - Hill 1997.

**REFERENCES:**

1. R.E.Landrefh and P.A.Rebers," Municipal Solid Wastes-Problems & Solutions" ,Lewis, 1997.
2. Blide A.D.& Sundaresan, B.B,"Solid Waste Management in Developing Countries", INSDOC, 1993.
3. Georges E. Ekosse, Rogers W'O Okut-Uma, Pollution control & Waste management in Developing Countries, Commonwealth Publishers, New Delhi, 2000.
4. B. B. Sundaresan, A. D. Bhide – Solid Waste Management, Collection, Processing and Disposal, Mudrashilpa Offset Printers, 2001.

Semester	Course Code	Course Name	L	T	P	C
II	YEN204A	Remote Sensing and GIS	3	0	0	3

### COURSE CONTENT

<b>UNIT I</b>	<b>FUNDAMENTALS OF REMOTE SENSING</b>	<b>9</b>
	Definition, Physics of Remote Sensing, Electromagnetic Radiation and its interactions with atmosphere, Spectral reflectance of earth materials and vegetation	
<b>UNIT II</b>	<b>PLATFORMS AND SENSORS</b>	<b>9</b>
	Aerial Photographs, Active and passive sensors, Data products, Various satellite in orbit and their sensors.	
<b>UNIT III</b>	<b>DATA PROCESSING</b>	<b>9</b>
	Data analysis - Visual Interpretation and Digital Image Processing – classification	
<b>UNIT IV</b>	<b>GIS</b>	<b>9</b>
	Introduction to GIS, concepts and Data base structure, various GIS software.	
<b>UNIT V</b>	<b>REMOTE SENSING AND GIS APPLICATIONS</b>	<b>9</b>
	Management and monitoring of land, air, water and pollution studies, conservation of resources, Identification of site for waste disposal – optimization of Route for collection of MSW	

### TEXT BOOKS

1. Anji Reddy.M,” Textbook of Remote Sensing and GIS”, BPB Publications,2006
2. T. M. Lillesand and R.W.Kiefer,” Remote Sensing and Image Interpretation “,Wiley,2011
3. E. T. Engman and R. J. Curney,” Remote Sensing in Hydrology,”Chapman&Hall,1990

### REFERENCES

1. Lillies and T.M. and Kiefer, R.W., “Remote Sensing and Image Interpretation ", John Wiley and Sons, 1994.
2. Burrough, P.A. and McDonnell, R.A., “Principles of Geographical Information Systems", Oxford University Press, 1998. 3. Lintz, J. and Simonet, " Remote Sensing of Environment ", Addison Wesley Publishing Company, 1994.
3. David Martin,” Geographic Information Systems”, Routledge,1995.

Semester	Course Code	Course Name	L	T	P	C
II	YEN204B	Environmental Geotechnology	3	0	0	3

## **COURSE CONTENT**

### **UNIT I SOIL PROFILE**

Soil as a multiphase system; Soil – environment interactions; Properties of water in relation to porous media; Water cycle with special reference to soil medium.

### **UNIT II SOIL MINERALOGY**

Soil mineralogy; significance of mineralogy in determining soil behavior; Mineralogical characterization

### **UNIT III MECHANISMS OF SOIL-WATER INTERACTIONS**

Diffuse double layer models; Force of attraction and repulsion; Soil- Water contaminant interaction; Theories of Ion exchange; Influence of organic and inorganic chemical interaction.

### **UNIT IV WASTE & ITS TRANSPORT IN SOIL**

Concepts of waste containment facilities; desirable properties of soil; contaminant transport and retention; contaminated site remediation

### **UNIT V REMEDIAL TECHNIQUES**

Introduction to advanced soil characterization techniques; volumetric water content; gas permeation in soil; electrical and thermal properties; pore –size distribution; contaminant analysis

## **TEXT BOOKS**

1. Geotechnical and Geoenvironmental Engineering Handbook, Rowe R. K, Kluwer Academic Publishers 2001
2. Fundamentals of Soil Behavior, Mitchell J.K and Soga K., John Wiley and Sons Inc. 2012
3. Introduction to Environmental Geotechnology, Fang, H.Y., CRC press 1997
4. Geotechnical Practice for Waste Disposal, Daniel D.E, Chapman and Hall 1993

## **REFERENCES**

1. Clay Barrier Systems for Waste Disposal Facilities, Rowe J.R., Quigley R.K., R.M. and Booker, Chapman and Hall 1995
2. Geoenvironmental Engineering: Principles and Applications, Reddi L.N. And Inyang H.F, Marcel Dekker Inc 2000
3. Waste Containment Systems, Waste Stabilization And Landfills: Design and Evaluation, Sharma H. D. And Lewis S.P, John Wiley & Sons Inc 1994

Semester	Course Code	Course Name	L	T	P	C
II	YEN204C	Simulation and Modeling in Environmental Systems	3	0	0	3

## COURSE CONTENT

<b>UNIT I</b>		<b>9</b>
	Scope of Environmental modeling – transport phenomena – advection - diffusion – sediment transport – lake dispersion calculation – simple transport models – equilibrium chemical model – equilibrium principles – numerical solution techniques – redox reactions in equilibrium models .	
<b>UNIT II</b>		<b>9</b>
	Eutrophication of lakes – conventional pollutants in rivers – toxic organic chemicals – modeling trace metals – mass balance and waste load allocation for rivers – study state model for metals in lakes – metals migration in soils .	
<b>UNIT III</b>		<b>9</b>
	Groundwater contamination – Darcy’s law – flow equations – contaminant solute transport equation – biotransformations - biofilms and bio availability – remediation – numerical methods.	
<b>UNIT IV</b>		<b>9</b>
	Atmospheric deposition and biogeochemistry – genesis of acid deposition – neutralizing capacities – biogeochemical models – ecological effects – critical loads – case studies –metal deposition.	
<b>UNIT V</b>		<b>9</b>
	Global change and Global cycles – Climate change and general circulation models – global carbon box model – nitrogen cycle – Global sulfur cycle – trace gases.	

## TEXT BOOKS

1. Environmental Modelling by Gerald .L. Schnoor, John Wiley and sons, Inc.
2. Process Dynamics in Environmental Systems by Walter .J. Weber,Jr and Francis ,John Wiley and sons, Inc.
3. Transport Modelling for Environmental Engineers and Scientists by Mark .M. Clark, John Wiley and Sons, Inc.



Semester	Course Code	Course Name	L	T	P	C
III	YEN301A	Ground Water Contamination and Transport Modeling	3	0	0	3

### COURSE CONTENT

#### UNIT I INTRODUCTION TO TRANSPORT PHENOMENA 9

Transport phenomenon, diffusion, dispersion, advection, adsorption, conservative and non-conservative pollutants, sources and sinks- point and nonpoint.

#### UNIT II FLOW AND TRANSPORT EQUATIONS 9

Governing Equations for flow and transport in surface and subsurface waters, chemical and biological process models, simplified models for lakes, streams, and estuaries.

#### UNIT III MODEL COMPLEXITY 9

Selection and development, model resolution, coupled and uncoupled models, Linear and nonlinear models, solution techniques, data requirements for calibration, application and evaluation of environmental control.

#### UNIT IV NUMERICAL MODELS 9

FDM, FEM and Finite volume techniques, explicit vs. implicit methods, numerical errors, and stability, High resolution techniques.

#### UNIT V SOFTWARE MODELLING 9

Stream quality modeling and Groundwater transport modeling using software.

### TEXT BOOKS

1. Alexander H.-d Cheng, Jacob Bear, "Modeling Groundwater Flow and Contaminant Transport", springer 02, 2011.
2. [PascualHoracio Benito](#), " Approaches to Modeling Contaminant Transport in Porous Media: Pore-Scale to Regional Scale Investigations,"Proquest, Umi Dissertation Publishing, 09-2011.
3. [Mark Goltz](#), [Junqi Huang](#), " Analytical Modeling of Solute Transport in Groundwater: Using Models to Understand the Effect of Natural Processes on Contaminant Fate and Transport I",John Wiley & Sons, Aug 2010.

## REFERENCES

1. [Rafael Antonio PrietoPiedrahita](#),” Treatment of Contaminated Sediments Using Reactive Cap Technology: Characterization and Modeling of Geotechnical, Hydraulic and Contaminant Transport”, Proquest, Umi Dissertation Publishing, Sep 2011.
2. [ChunmiaoZheng, Gordon D. Bennett](#),” Applied Contaminant Transport Modeling”, Wiley-Interscience, February 2002.
3. Shahr Shlomi,”Combining Geostatistical Analysis and Flow-And-Transport Models to Improve Groundwater Contaminant Plume Estimation, ”Proquest, Umi Dissertation Publishing,2011.

Semester	Course Code	Course Name	L	T	P	C
III	YEN301B	Environmental Impact Assessment	3	0	0	3

### COURSE CONTENT

<b>UNIT I</b>	<b>UNIT I-INTRODUCTION TO EIA</b>	<b>12</b>
	Environmental Impact Assessment (EIA)- Environmental Impact Statement - Environmental Risk assessment -Legal and Regulatory aspects in India - Types and limitations of EIA - Terms of reference in EIA - Issues in EIA - National - Cross sectoral - social and cultural.	
<b>UNIT II</b>	<b>METHODOLOGIES</b>	<b>12</b>
	Methods of EIA –Check lists – Matrices – Networks – Cost-benefit analysis – Analysis of alternatives – Case Studies.	
<b>UNIT III</b>	<b>PREDICTION AND ASSESSMENT</b>	<b>12</b>
	Assessment of Impact on land, water and air, noise, social, cultural flora and fauna; Mathematical models; public participation – Rapid EIA.	
<b>UNIT IV</b>	<b>ENVIRONMENTAL MANAGEMENT PLAN</b>	<b>12</b>
	Plan for mitigation of adverse impact on environment – options for mitigation of impact on water, air and land, flora and fauna; Addressing the issues related to the Project Affected People – ISO 14000	
<b>UNIT V</b>	<b>CASE STUDIES</b>	<b>12</b>
	EIA for infrastructure projects – Bridges – Stadium – Highways – Dams – Multi-storey Buildings – Water Supply and Drainage Projects	

### TEXT BOOKS

1. Canter, L.W., “Environmental Impact Assessment”, McGraw-Hill, New York. 2006.
2. Lawrence, D.P., “Environmental Impact Assessment - Practical solutions to recurrent problems”, Wiley-Interscience, New Jersey 2003.
3. Petts, J., “Handbook of Environmental Impact Assessment”, Vol., I and II, Conwell Science London. 2009.

## **REFERENCES**

1. Biswas, A.K. and Agarwala, S.B.C., “Environmental Impact Assessment for Developing Countries”, Butterworth Heinemann, London. 2004.
2. The World Bank Group, “Environmental Assessment Source Book Vol. I, II and III. The World Bank, Washington. 2001.

Semester	Course Code	Course Name	L	T	P	C
III	YEN301C	Membrane Separation for Water and Wastewater	3	0	0	3

## COURSE CONTENT

### UNIT I MEMBRANE FILTRATION PROCESSES 10

Solid Liquid separation systems- Theory of Membrane separation – mass Transport Characteristics - Cross Flow filtration - Membrane Filtration- Flux and Pressure drop -Types and choice of membranes, porous, non porous, symmetric and asymmetric – Plate and Frame, spiral wound and hollow fibre membranes – Liquid Membranes

### UNIT II MEMBRANE SYSTEMS 10

Microfiltration principles and applications – Ultra filtration principles and applications - Nano Filtration principles and applications – Reverse Osmosis: Theory and design of modules, assembly, plant process control and applications – Electro dialysis : Ion exchange membranes, process design- Pervaporation – Liquid membrane – Liquid Pertraction – Supported Liquid Membrane and Emulsion Liquid membrane - Membrane manufactures – Membrane Module/Element designs – Membrane System components – Design of Membrane systems - pump types and Pump selection – Plant operations – Economics of Membrane systems

### UNIT III MEMBRANE BIOREACTORS 9

Introduction and Historical Perspective of MBRs, Biotreatment Fundamentals, Biomass Separation MBR Principles, Fouling and Fouling Control, MBR Design Principles, Design Assignment, Alternative MBR Configurations, Commercial Technologies, Case Studies

### UNIT IV PRETREATMENT SYSTEMS 8

Membrane Fouling – Control of Fouling and Concentration Polarisation-Pretreatment methods and strategies – monitoring of Pretreatment – Langlier Index, Silt Density Index, Chemical cleaning , Biofoulant control

### UNIT V CASE STUDIES 8

Case studies on the design of membrane based water and wastewater treatment systems – zero Liquid effluent discharge Plants – Desalination of brackish water.

## **TEXT BOOKS**

1. Anthony Wachinski, Membrane Processes for water reuse, McGraw-Hill, USA, 2013
2. WEF, Membrane Bioreactors, WEF manual of Practice No.36, Water Environment Federation, USA.2012. Symon Jud, MBR Book – "Principles and application of MBR in water and wastewater treatment", Elsevier, 2006.
3. Yamamoto K. and Urase T, "Membrane Technology in Environmental management", special issue, Water Science and technology, Vol.41, IWA Publishing, 2000.

## **REFERENCES**

1. Jorgen Wagner, "Membrane Filtration handbook, Practical Tips and Hints, 2nd Edition, Revision2, Osmonics Inc., 2001.
2. Baker, R.W., "Membrane technology and applications", 2nd., John Wiley 2004 7 Noble, R.D. and Stern, S.A., "Membrane Separations Technology: Principles and Applications", Elsevier,Netherlands,1995.

## AUDIT COURSES

SUBCODE	SUB NAME	L	T	P	C
	<b>ENGLISH FOR RESEARCH PAPER WRITING</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>UNIT I</b>					<b>9</b>
Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and vagueness					
<b>UNIT II</b>					<b>9</b>
Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction					
<b>UNIT III</b>					<b>9</b>
Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.					
<b>UNIT IV</b>					<b>9</b>
key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature,					
<b>UNIT V</b>					<b>9</b>
skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions. useful phrases, how to ensure paper is as good as it could possibly be the first- time submission					
		<b>LECTURE</b>	<b>TUTORIAL</b>	<b>TOTAL</b>	
		<b>45</b>	<b>15</b>	<b>60</b>	
<b>REFERENCES</b>					
1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)					
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press					
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM.					
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011					

SUBCODE	SUB NAME	L	T	P	C
	<b>CONSTITUTION OF INDIA</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>UNIT I HISTORY AND PHILOSOPHY</b>					<b>9</b>
History of Making of the Indian Constitution: History-Drafting Committee, ( Composition& Working)Philosophy of the Indian Constitution: Preamble-Salient Features					
<b>UNIT IICONTOURS OF CONSTITUTIONAL RIGHTS &amp; DUTIES:</b>					<b>9</b>
Fundamental Rights -Right to Equality-Right to Freedom-Right against Exploitation-Right to Freedom of Religion-Cultural and Educational Rights-Right to Constitutional Remedies-Directive Principles of State Policy-Fundamental Duties.					
<b>UNIT IIIORGANS OF GOVERNANCE:</b>					<b>9</b>
Parliament-Composition-Qualifications and Disqualifications-Powers and Functions-Executive-President-Governor-Council of Ministers-Judiciary, Appointment and Transfer of Judges, Qualifications-Powers and Functions					
<b>UNIT IVLOCAL ADMINISTRATION</b>					<b>9</b>
District's Administration head: Role and Importance, -Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Pachayati raj: Introduction, PRI: ZilaPachayat. Elected officials and their roles, CEO ZilaPachayat: Position and role. Block level: Organizational Hierarchy (Different departments),Village level: Role of Elected and Appointed officials, Importance of grass root democracy					
<b>UNIT VELECTION COMMISSION:</b>					<b>9</b>
Election Commission: Role and Functioning. -Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.					
		<b>LECTURE</b>	<b>TUTORIAL</b>	<b>TOTAL</b>	
		<b>30</b>	<b>0</b>	<b>30</b>	
<b>REFERENCES</b>					
1. The Constitution of India, 1950 (Bare Act), Government Publication.					
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.					
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.					
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.					



## OPEN ELECTIVES

SUBCODE	SUB NAME	L	T	P	C
	<b>BUSINESS ANALYTICS</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>UNIT I</b>					<b>9</b>
<p>Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.</p> <p>Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.</p>					
<b>UNIT II</b>					<b>9</b>
<p>Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.</p> <p>Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology</p>					
<b>UNIT III</b>					<b>9</b>
<p>Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.</p> <p>Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.</p>					
<b>UNIT IV</b>					<b>9</b>
<p>Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.</p> <p>Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvend or Model, Overbooking Model, Cash Budget Model.</p>					
<b>UNIT V</b>					<b>9</b>
<p>Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making. Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.</p>					
		<b>LECTURE</b>	<b>TUTORIAL</b>	<b>TOTAL</b>	
		<b>45</b>	<b>0</b>	<b>45</b>	
<b>REFERENCES</b>					
<p>1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G.Schniederjans, Christopher M. Starkey, Pearson FT Press.</p> <p>2. Business Analytics by James Evans, persons Education.</p>					

<b>SUBCODE</b>	<b>SUB NAME</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	<b>INDUSTRIAL SAFETY</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

<b>UNIT I</b>	<b>9</b>		
Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.			
<b>UNIT II</b>	<b>9</b>		
Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.			
<b>UNIT III</b>	<b>9</b>		
Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.			
<b>UNIT IV</b>	<b>9</b>		
Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler,vi. Electrical motors, Types of faults in machine tools and their general causes.			
<b>UNIT V</b>	<b>9</b>		
Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance			
	<b>LECTURE</b>	<b>TUTORIAL</b>	<b>TOTAL</b>
	<b>45</b>	<b>15</b>	<b>60</b>
<b>REFERENCES</b>			
1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.			
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.			
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.			
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.			

<b>SUBCODE</b>	<b>SUB NAME</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	<b>OPERATIONS RESEARCH</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

<b>UNIT I</b>	<b>9</b>		
Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models			
<b>UNIT II</b>	<b>9</b>		
Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming			
<b>UNIT III</b>	<b>9</b>		
Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT			
<b>UNIT IV</b>	<b>9</b>		
Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.			
<b>UNIT V</b>	<b>9</b>		
Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation			
	<b>LECTURE</b>	<b>TUTORIAL</b>	<b>TOTAL</b>
	<b>45</b>	<b>15</b>	<b>60</b>
<b>REFERENCES</b>			
1. H.A. Taha, Operations Research, An Introduction, PHI, 2008 2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982. 3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008 4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009 5. Pannerselvam, Operations Research: Prentice Hall of India 2010 6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010			

SUBCODE	SUB NAME	L	T	P	C
	<b>COST MANAGEMENT OF ENGINEERING PROJECTS</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>UNIT I</b>					<b>9</b>
Introduction and Overview of the Strategic Cost Management Process Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.					
<b>UNIT II</b>					<b>9</b>
Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process					
<b>UNIT III</b>					<b>9</b>
Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector.					
<b>UNIT IV</b>					<b>9</b>
Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.					
<b>UNIT V</b>					<b>9</b>
Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.					
		<b>LECTURE</b>	<b>TUTORIAL</b>	<b>TOTAL</b>	
		<b>45</b>	<b>0</b>	<b>45</b>	
<b>REFERENCES</b>					
<ol style="list-style-type: none"> <li>1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi</li> <li>2. Charles T. Horngren and George Foster, Advanced Management Accounting</li> <li>3. Robert S Kaplan Anthony A. Alkinson, Management &amp; Cost Accounting</li> <li>4. Ashish K. Bhattacharya, Principles &amp; Practices of Cost Accounting A. H. Wheeler publisher</li> <li>5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.</li> </ol>					

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