MEWAR UNIVERSITY CHITTORGARH (RAJASTHAN)

Faculty of Engineering and Technology

Scheme and Syllabus

of

Master of Technology (Part-time)
Environmental Science and Engineering

MEWAR UNIVERSITY CHITTORGARH (RAJASTHAN)
Faculty of Engineering and Technology

Three – Year (Part-time) M Tech: Environmental Science and Engineering

Eligibility for Admission: The Master of Technology (Environmental Science and Engineering) is an inter-disciplinary post-graduate programme. A candidate for being eligible for admission to the Master of Technology in Environmental Science and Engineering in the faculty of engineering and technology should have passed B.Sc. (Engg.)/ B.Tech/ B.E. or any other equivalent engineering degree in the relevant discipline / branch or M.Sc. degree (Chemistry / Biochemistry / Biotechnology / Physics / Agriculture / Forestry / Mining / Geography) from any recognized Indian or foreign University.

A candidate should have at least 55% marks or equivalent CGPA in the qualifying examination (50% marks or equivalent CGPA for Scheduled Caste/Scheduled Tribes Candidates) on the basis of which the admission is being sought.

Overview of the Programme: The normal duration of programme shall be Six Semesters for part-time students. A part time candidate shall mean a person employed in any government/ semi-government/ private organisation. The duration of the programme is extendable upto five years. However, in exceptional circumstances one-year extension may be granted with approval of the Vice-Chancellor of the University.

The complete programme comprises of 13 theory courses (09 Core and 04 elective) and 02 Lab courses followed by the dissertation in two phases. Student has to obtain at least 40 % marks to pass the examination (both internal and external examination separately) for all the courses specified in the scheme of the programme. The degree will be awarded on the basis of cumulative marks obtained in all the six semesters and the division obtained will be as under:

MEWAR UNIVERSITY CHITTORGARH (RAJASTHAN)
Scheme of Three – Year (Part-time) M Tech: Environmental Science and Engineering

First Semester

Course Code	Course Title	Contact Hours per week		Credit Hours	Internal Assessment/Evaluation		External Examination /Viva-voce	Total Marks
		L	P		Assignments /Lab Record	Teacher's Evaluation		
ESE – 611	Environmental Chemistry and Microbiology	4	-	4	30	10	60	100
ESE – 613	Water Treatment Processes	4	-	4	30	10	60	100
ESE – 711/713/715	Elective – I	3	-	3	20	10	45	75
ESE – 617	Environmental Engg. Lab-I	-	2	2	15	10	25	50
Total Semester Credits = 13					**Total Semester Marks = 325**			

Second Semester

Course Code	Course Title	Contact Hours per week		Credit Hours	Internal Assessment/Evaluation		External Examination /Viva-voce	Total Marks
		L	P		Assignments /Lab Record	Teacher's Evaluation		
ESE – 612	Air and Noise Pollution	4	-	4	30	10	60	100
ESE – 614	Wastewater Treatment Processes	4	-	4	30	10	60	100
ESE – 712/714/716	Elective – II	3	-	3	20	10	45	75
ESE – 618	Environmental Engg. Lab-II	-	2	2	15	10	25	50
Total Semester Credits = 13					**Total Semester Marks = 325**			

Third Semester

Course Code	Course Title	Contact Hours per week		Credit Hours	Internal Assessment/Evaluation		External Examination /Viva-voce	Total Marks
		L	P		Assignments	Teacher's Evaluation		
ESE – 615	Ecology	4	-	4	30	10	60	100
ESE – 621	Industrial Waste Management	4	-	4	30	10	60	100
ESE – 721/723/725	Elective – III	3	-	3	20	10	45	75
Total Semester Credits = 11					**Total Semester Marks = 275**			

Fourth Semester

Course Code	Course Title	Contact Hours per week		Credit Hours	Internal Assessment/Evaluation		External Examination /Viva-voce	Total Marks
		L	P		Assignments	Teacher's Evaluation		
ESE – 616	Solid and Hazardous Waste Management	4	-	4	30	10	60	100
ESE – 624	Environmental Impact Assessment	4	-	4	30	10	60	100
ESE – 722/724/726	Elective – IV	3	-	3	20	10	45	75
Total Semester Credits = 11					**Total Semester Marks = 275**			

Fifth Semester

Course Code	Course Title	Contact Hours per week		Credit Hours	Internal Assessment/Evaluation		External Examination /Viva-voce	Total Marks
		L	P		Assignments / Report	Teacher/ Committee Evaluation		
ESE – 627	Research Methodology	2	-	2	30	20	-	50
ESE – 629	Dissertation (Phase-I)	-	4	4	50	50	-	100
Total Semester Credits = 06					**Total Semester Marks = 150**			

Sixth Semester

Course Code	Course Title	Contact Hours per week		Credit Hours	Internal Assessment/Evaluation		External Examination /Viva-voce	Total Marks
		L	P		Report	Teacher(s) Evaluation		
ESE – 630	Dissertation (Phase-II)	-	12	12	50	-	250	300
Total Semester Credits = 12					**Total Semester Marks = 300**			

LIST OF ELECTIVES

ELECTIVE – I

1.	ESE – 711	Advance Water Supply and Wastewater Management
2.	ESE – 713	Bioremediation: Principles and Applications
3.	ESE – 715	Water Quality Management

ELECTIVE – III

1.	ESE – 721	Environmental Issues, Protection and Laws
2.	ESE – 723	Air Quality Modelling
3.	ESE – 725	Surface Water Quality Modeling and Control

ELECTIVE – II

1.	ESE – 712	Environmental Planning and Management
2.	ESE – 714	Life Cycle Analysis and Design for Environment
3.	ESE – 716	Advanced Computational Methods and Optimization

ELECTIVE – IV

1.	ESE – 722	Renewable Energy Sources
2.	ESE – 724	Environmental Risk Assessment
3.	ESE – 726	Geographic Information System (GIS) in Environmental Engineering

Internal Assessment/Examination: The internal evaluation for all theory courses (40% of the total marks) will be based on the evaluation of **three assignments** provided during the semester and assessment of the teacher concerned. Similarly, the internal evaluation for all Lab courses (50% of the total marks) will be based on the evaluation of lab record and assessment of the teacher concerned.

External Examination/Viva -voce: For all the theory courses, there will be **08 (Eight)** questions to be set by the external paper setter (nominated /approved by the competent authority) out of which the candidate will have to attempt **05 (Five)** questions all carrying equal marks. Duration of each external examination will be three hours. Similarly, the external evaluation for all Lab courses (50% of the total marks) will be based on the evaluation/viva-voce conducted by an external examiner (from the relevant field) nominated/approved by the competent authority.

Submission and Evaluation of Dissertation:

a) A dissertation supervisor (s) having at least post- graduate qualification, from industry/research organization shall be assigned to the student approved by the competent authority. *In no case, the candidate can have more than two dissertation supervisors.*

b) Dissertation work (Phase-I) in 5^{th} semester shall comprise of literature survey, problem formulation, finalization of goals to be achieved, outlines of the methodology to be used for achieving the targeted goals and final decision about S/W, H/W tools to be used for dissertation work in 6^{th} semester. The entire work will be documented in the form of report.

c) Internal assessment of dissertation (Phase-I) in 5^{th} semester will be made by the committee evaluating the report (50% weightage), oral presentation and response of the student in the discussion / presentation (50% weightage). The dissertation supervisor (s) shall be the member (s) of the committee.

d) The submission of dissertation (Phase-II) in 6^{th} semester shall be allowed only after ensuring that the research work carried out by the candidate has attained the level of satisfaction of the 'Dissertation Supervisor (s)' and proof of communication/acceptance of the research paper (if any, and certified in the report) in the relevant refereed journal/ conference.

e) The final dissertation external examination in 6^{th} semester shall be taken by a panel of examiners comprising of concerned Supervisor (s), one external examiner (from the relevant field) nominated/approved by the competent authority. Hard copies of dissertation, one for each supervisor (s), examiner and the university/ department, are required to be submitted by the student before the final dissertation external examination. The candidate shall appear before the examining committee for oral examination and presentation on the scheduled date.

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 611 ENVIRONMENTAL CHEMISTRY AND MICROBIOLOGY

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Environmental Chemistry:

Introduction and basic concepts of environmental chemistry.

Environmental composition, stratospheric chemistry (ozone), tropospheric chemistry (smog, precipitation), atmospheric aerosols, chemistry of global climate (greenhouse gases). Environmental issues related to aqueous organic matter, water pollution and wastewater treatment chemistry. Chemistry of solid wastes. Organic biocides.

Microbiology:

Basic concepts of cell structure and function. Biochemistry of carbohydrates, fats and lipids, and proteins. Enzymes and co-factors.

Bacteria, algae, fungi, protozoa and virus – characteristics, morphology/structure, classification, spore formation, economic importance (beneficial and harmful aspects), role in bio-concentration and species of importance. Control of microbes.

Role of microorganisms in sewage treatment. Bio-remediation, bio-leaching and metal extraction, biosensors to detect environmental pollution, and biological fuel generation.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- "Environmental Chemistry" by G.W. vanLoon and S.J. Duffy, Oxford University Press.
- "Chemistry for Environmental Engineering" by Clair N. Sawyer, Perry McCarty and Gene F. Parkin, McGraw Hill Inc. New York.
- "Introduction to Biotechnology" by A. Deswal and S. Deswal, Dhanpat Rai & Co. (P) Ltd. N. Delhi.
- "Microbiology" by M.J. Pelczar and R.D. Reid, Tata McGraw Hill Inc.
- "Environmental Engineering" by H.S. Peavy, D.R. Rowe & G.Tchobanoglous, McGraw Hill Inc. New York.

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 612 AIR AND NOISE POLLUTION

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Air Pollution:

Introduction: definition, atmospheric composition, origin of air pollution, sources, classification and effects of air pollutants.

Meteorological aspects of air pollution: dispersion of air pollutants, plume behaviours, air diffusion models, design of stacks, effects of air pollution on meteorological conditions.

Air pollution sampling: ambient and stack sampling, ambient air quality monitoring, air quality standards.

Engineered methods of air pollution control: atmospheric cleansing processes, approaches to contaminant control, control devices for particulate contaminants and gaseous contaminants.

Noise Pollution:

Definition, unit of measurement, loudness, hearing mechanism, measurement of noise and weighting networks, sources of noise, psychological & pathological effects of noise, strategies for noise pollution control, noise monitoring and standards.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- "Environmental Engineering" by H.S. Peavy, D.R. Rowe & G.Tchobanoglous, McGraw Hill Inc. New York.
- "Air Pollution" by H.C. Perkins, McGraw Hill Publishers, New York.
- "Air Pollution" by Rao and Rao, Tata McGraw Hill Publishers, New Delhi.
- "A Basic Course in Environmental Studies" by S. Deswal and A. Deswal, Dhanpat Rai & Co. (P) Ltd. N. Delhi.
- "Environmental Engineering" by A.P. Sincero and G.A. Sincero, PHI, N. Delhi.

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 613 WATER TREATMENT PROCESSES

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Water Quality: wholesomeness of water, definitions, water-quality parameters and their examination and significance, water-quality requirements and standards.

Water Purification Processes in Natural Systems: physical, chemical and bio-chemical processes. Response of streams to bio-degradable organic waste, application of natural processes in engineered systems.

Water Treatment Processes: Theory, Design and Application – aeration, solids separation, settling operations, coagulation and flocculation, adsorption, filtration, chlorination and other disinfection processes, softening, taste and odour removal, corrosion phenomenon, and other water treatment processes like removal of fluoride, arsenic, iron and manganese.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- "Water Quality and Treatment" A Handbook of Public Water Supply by The American Water Works Association (AWWA), McGraw Hill Inc. New York.
- "Environmental Engineering" by H.S. Peavy, D.R. Rowe and G Tchobanoglous, McGraw-Hill Book Co. NY.
- "Physicochemical Processes for Water Quality Control" by W.J. Weber, Wiley Interscience, NY.
- "Environmental Engineering" by A.P. Sincero and G.A. Sincero, PHI, N. Delhi.
- "Water Quality" by American Water Works Association (AWWA).
- "Water Treatment" by American Water Works Association (AWWA).
- "Environmental Engineering (Vol. I)" by S.K. Garg, Khanna Publishers, N. Delhi.
- "Manual on Water Supply and Treatment" by CPHEEO, GOI, N. Delhi.

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 614 WASTEWATER TREATMENT PROCESSES

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Wastewater flow rates, wastewater composition. characteristics and examination, effluent standards.

Wastewater Treatment Processes: objectives, methods and implementation considerations. Theory, design and application of physical, chemical and biological wastewater treatment processes including biological contactors, UASB and anaerobic filters. Sludge handling, treatment and disposal.

Design of low cost systems like septic tanks, oxidation ponds, aerated lagoons, etc.

Advanced wastewater treatment (nutrient and solids removal).

Wastewater Disposal, Reclamation and Reuse.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- "Wastewater Engineering – Treatment, Disposal and Reuse" by Metcalf and Eddy, Tata McGraw Hill Publishing Co., New Delhi.
- "Environmental Engineering" by H.S. Peavy, D.R. Rowe and G Tchobanoglous, McGraw-Hill Book Co. NY.
- "Water and Wastewater Engineering (Vol. I & II)" by G.M. Fair, J.C. Geyer and D.A. Okun, John Wiley & Sons Inc New York NY.
- "Environmental Engineering" by A.P. Sincero and G.A. Sincero, PHI, N. Delhi.
- "Environmental Engineering (Vol. II)" by S.K. Garg, Khanna Publishers, N. Delhi.
- "Manual on Sewerage and Sewage Treatment" by CPHEEO, GOI, N. Delhi.

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 615 ECOLOGY

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Introduction: definitions, scope and importance.

Ecosystems: concept, structure & function and classification of ecosystems. Types, characteristic features, structure and function of major ecosystems.

Energy flow within the ecosystems: energy and material, energy flow, food chains & food webs, trophic level and ecological pyramids. Biogeochemical cycles and limiting factors.

Population ecology: population attributes, simple models of population growth, growth form, growth rates, interactions among organisms, survival and extinction. Human population growth.

Biodiversity: definition, levels, measurement and value/importance of biodiversity. Biogeographical classification of India. Biodiversity at global, national and local levels. Hotspots of biodiversity. Threats to biodiversity. Conservation of biodiversity. Biodiversity Treaty.

Ecosystem development and evolution: definition, models of succession, significance of ecological development. Evolution of the ecosystem. Ecosystem management.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- "Fundamentals of Ecology" by E.P. Odum, W.B. saunders Co. USA.
- "Ecology" by E.P. Odum, Oxford & IBH publishing, N. Delhi.
- "First Ecology" by A. Beeby and A.N. Brennan, Oxford University Press.
- "A Basic Course in Environmental Studies" by S. Deswal and A. Deswal, Dhanpat Rai & Co. (P) Ltd., N. Delhi.
- "Ecology and Environment" by P.D. Sharma, Ashish Publication.
- "The Biodiversity of India" by E. Bharucha, Mabin Publishing, Ahmedabad.

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 616 SOLID AND HAZARDOUS WASTE MANAGEMENT

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Introduction: definitions, generation of solid waste, sources, classification, quantity, composition and characteristics of solid waste. Solid waste collection, transportation, processing, recovery and disposal.

Disposal: recovery of material, selection of site, land disposal, disposal in water bodies, feeding to hogs.

Sanitary Land Filling: definition, methodology, leachate treatment, gas collection and recirculation.

Composting: aerobic and anaerobic composting, vermin-composting.

Incineration: 3Ts to control high temperature in incinerators, design approach, prevention of air pollution.

Pyrolysis: process, basic steps involved, end product, pyrolysis od specific solid waste.

Solid Waste Management: 3Rs of solid waste management, material and energy recovery operations.

Hazardous wastes: introduction, types, health effects, treatment methods, management and disposal.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- "Environmental Engineering" by H.S. Peavy, D.R. Rowe & G.Tchobanoglous, McGraw Hill Inc. New York.
- "Environmental Engineering" by A.P. Sincero and G.A. Sincero, PHI, N. Delhi.
- "Solid Waste: Engineering, Principles and Management Issues" by Tchobanoglous, Theisen and Eliassen, McGraw Hill, New York.
- "Waste Management: Planning, Evaluation and Technologies" by D.C. Wilson, Oxford Press, London.
- "Hazardous Waste Management" by Michael D. La Grega, Phillip L. Buckingham, Jeffery Evans.
- "Environmental Science and Engineering" by J.G. Henry & G.W. Heinke

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 617 ENVIRONMENTAL ENGINEERING LAB - I

Internal Assessment/Evaluation: 25 Marks
External Examination: 25 Marks
Duration of Examination: 03 Hours

List of Experiments:

1. To determine the pH of a given sample of water.
2. To determine the various forms of alkalinity and acidity in water sample.
3. To determine the chloride content in a given water sample.
4. To determine temporary and permanent hardness in a given sample of water.
5. To determine total, dissolved, suspended and volatile residues in water sample.
6. To determine the dose of coagulant required for optimum coagulation.
7. To determine the dissolved oxygen (DO) in a given sample of water.
8. To determine the sulphate concentration in a given sample of water.
9. To determine the coliform bacteria by total count method in a given sample of water.
10. To determine the most probable number of coliform bacteria in a given water sample by British technique.

Recommended Books and Codes:

- "Standard Methods for the Examination of Water and Wastewater" APHA Washington DC.
- "Chemistry for Environmental Engineering" by C.N. Sawyer and P.L. McCarty, McGraw-Hill Book Agency.
- IS: 3025 "Methods of Sampling and Test (Physical and Chemical) for Water and Wastewater.
- IS: 2720 "Method of Test for Soils"

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 618 ENVIRONMENTAL ENGINEERING LAB - II

Internal Assessment/Evaluation: 25 Marks
External Examination: 25 Marks
Duration of Examination: 03 Hours

List of Experiments:

1. To determine the pH of a given sample of sewage / soil.
2. To determine the various forms of alkalinity and acidity in sewage sample.
3. To determine total, dissolved, suspended and volatile residues in sewage sample.
4. To determine the chemical oxygen demand (COD) of a given sewage sample.
5. To determine the biochemical oxygen demand (BOD) of a given sewage sample.
6. To determine the sulphate concentration in a given sample of soil.
7. Determination of concentration of suspended particulate matter in air.
8. Measurement of nitrogen oxide (as NO_2) / sulphur dioxide / carbon monoxide concentration in air.
9. Determination of gaseous pollutants from vehicles fitted with internal combustion engines.
10. Measurement of noise in residential, industrial and traffic areas.

Recommended Books and Codes:

- "Standard Methods for the Examination of Water and Wastewater" APHA Washington DC.
- "Chemistry for Environmental Engineering" by C.N. Sawyer and P.L. McCarty, McGraw-Hill Book Agency.
- IS: 3025 "Methods of Sampling and Test (Physical and Chemical) for Water and Wastewater.
- IS: 2720 "Method of Test for Soils"
- IS 5182 "Methods for Measurement of Air Pollution"
- IS 14600 "Automotive Vehicles-Exhaust Emissions-Gasous Pollutants from Vehicles Equipped with ICE"
- IS 9989 "Assessment of Noise with respect to Community Response".

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 621 INDUSTRIAL WASTE MANAGEMENT

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Industrial wastes: characteristics and composition of different industrial effluents, effects of disposal of industrial effluents, prevention versus control of industrial pollution, linkage between technology and pollution prevention, standards for disposal of industrial effluents.

Strategies of industrial waste management: good house keeping, equalization, neutralization, chemical precipitation, etc. Water and energy use in industry.

Treatment strategies for industrial effluents: Mixing different effluent streams partially or fully, treatment of combined effluent. Treatment of specific characteristics of industrial effluents.

Process flow chart, effluent generation, composition and treatment of effluents from following industries – sugar, pulp and paper, distilleries, electroplating, dairy, oil refineries, steel, etc.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- "Industrial Wastewater Treatment" by M.N. Rao and A.K. Dutta, Oxford and IBH publishing company, New Delhi
- Water Recycling & Pollution Control Handbook, A.V. Bridge water, C.J. Mumford, Van Nostrand Reinhold Company New York.
- Pollution Control in Process Industries, S.P. Mahajan, Tata McGraw Hill Publishing Co. Ltd, New Delhi.
- Industrial Wastewater Management Handbook, Hardom Singh Azad, McGraw Hill Book Co., New York.
- Principle of Industrial Waste Treatment, C. Fred Gurnham, John Wiley & Sons Inc, New York.
- Industrial Pollution Control Handbook, Herbert F. Lund, McGraw

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 624 ENVIRONMENTAL IMPACT ASSESSMENT

Internal Assessment/Evaluation: 40 Marks
External Examination: 60 Marks
Duration of Examination: 03 Hours

Environmental Impact Assessment: concept, rationale/purpose, benefits, stages of environmental impact analysis.

Measurement of environmental impacts: physical environmental, social, economic and other variables. Environmental indices and impact assessment methods.

Identification, assessment, impact assessment methodologies and mitigation of fundamental impacts like – air, noise, water, soil & geological, biotic, socio-economic and aesthetic environmental impacts.

Economic approaches to environmental impact assessment: economic activities and environment, social benefit cost approach, input-output approach, econometric approach and programming approaches.

Case Studies: EIA of various development activities, projects like hydro or river valley, thermal, oil refineries, highway, etc.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- "Environmental Impact Assessment" by L.W. Canter, McGraw Hill Inc. New York.
- "Environmental Impact Analysis" by Jain, Urban and Stacey, Van Nostrand and Reinhold Co. NY.
- "Environmental Impact Assessment" by R.R. Barthwal, New Age Int., N. Delhi.
- "Environmental Impact Analysis Handbook" by Rau and Wooten, McGraw Hill Inc. New York.

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 627 RESEARCH METHODOLOGY

Internal Assessment/Evaluation: 50 Marks

Introduction to Educational Research: Concept; types – basic; applied and action; Need for educational research; Reviewing Literature; Need; Sources – Primary and Secondary; Purposes of Review; Scope of Review; steps in conducting review.

Identifying and defining research problem: Locating; analyzing stating and evaluating problem. Generating different types of hypotheses and evaluating them.

Methods of Research: Descriptive research design - survey; case study; content analysis; Ex-post Facto Research; Co relational and Experimental Research; Design and development of measuring instruments; Tests; questionnaires; checklists; observation schedules; evaluating research instruments; selecting a standardized test.

Data Collection: Procedure of data collection; Aspects of data collection; coding data for analysis; Statistical Methods of Analysis.

Descriptive statistics: Meaning; Graphical representations; mean; Range and standard deviation; characteristics and uses of normal curve; Inferential statistics: t-test; Chi-square tests; correlation (rank difference and product moment); ANOVA (one way); Selecting appropriate methods.

Procedure for writing a research proposal: Purpose; types and components of research proposal; Procedure for writing a research report; Audiences and types of research reports; Format of research report and journal articles.

Strategies for evaluating; Research disseminating and utilizing research – An Overview

Practice Tasks:

- Define a research problem in engineering education/industry after studying problem situation and literature
- Given the purpose, objectives of research, write hypotheses
- Select research designs for the given research objectives
- Identify the measuring instruments for the given research objectives/hypotheses
- Identify the appropriate statistical methods of analysis for the given research proposal.
- Critically analyse the given research reports on various aspects such as hypothesis, design, measuring tools, statistical analysis, interpretation etc. to identify the gaps or weaknesses in the study.

Recommended Books:

- Borg; W and Gall; M. Educational Research: An Introduction; New York; Longman.2003
- Cohen; L. Educational Research in Classrooms and Schools! A Manual of Materials and Methods NY: Harper and Row

Publishers.2000
- CPSC: Developing Skills in Technician Education Research Modules 1 to 11 Singapore; Colombo Plan Staff College for Technician Education
- Garrett; HE and Woodworth; RS. Statistics in Psychology and Education; Educational Research; Bombay: Vakils Fetter and Simons Ltd. 2003
- Gay; LR; Educational Research; Ohio: Charles E. Merril Publishing Company2000
- Wiersma William Research Methods in Education – An Introduction London; Allyn and Bacon; Inc.2000

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 629 DISSERTATION (PHASE-I)

Internal Assessment/Evaluation: 100 Marks

The primary objective of this course is to enhance the student ability to analyze and carry out independent investigations etc. Each student will carry out independent work which should involve creativity; innovation and ingenuity. A dissertation supervisor (s) having at least post- graduate qualification; from industry/research organization shall be assigned to the student approved by the competent authority. *In no case; the candidate can have more than two dissertation supervisors.* Industry oriented projects may be encouraged for the purpose.

The whole Dissertation work will be carried out and reported in two phases in 5^{th} semester and 6^{th} semester. Dissertation work (Phase-I) in 5^{th} semester shall comprise of literature survey; problem formulation; finalization of goals to be achieved; outlines of the methodology to be used for achieving the targeted goals and final decision about S/W; H/W tools to be used for dissertation work in 6^{th} semester. The entire work will be documented in the form of report.

Internal assessment of dissertation (Phase-I) in 5^{th} semester will be made by the committee evaluating the report (50% weightage); oral presentation and response of the student in the discussion / presentation (50% weightage). The dissertation supervisor (s) shall be the member (s) of the committee.

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 630 DISSERTATION (PHASE-II)

Internal Assessment/Evaluation: 50 Marks
External Examination: 250 Marks

The complete dissertation work shall comprise of literature survey; problem formulation; methodology used; S/W; H/W tools used; Results and discussion followed by the conclusions & further scope of work in that area. The submission of dissertation in 6th semester shall be allowed only after ensuring that the research work carried out by the candidate has attained the level of satisfaction of the 'Dissertation Supervisor (s)' and proof of communication/acceptance of the research paper (if any; and certified in the report) in the relevant refereed journal/ conference.

The final dissertation external examination in 6th semester shall be taken by a panel of examiners comprising of concerned Supervisor (s); one external examiner (from the relevant field) nominated/approved by the competent authority. Hard copies of dissertation; one for each supervisor (s); examiner and the university/ department; are required to be submitted by the student before the final dissertation external examination. The candidate shall appear before the examining committee for oral examination and presentation on the scheduled date.

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 711 ADVANCE WATER SUPPLY AND WASTEWATER MANAGEMENT

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Planning of Water Supply Projects: objective, basic design considerations, components of water supply scheme, water demands and estimation of design capacity, population forecast. Preparation of project report. Water sources and their characteristics, assessment of the yield and development of the sources, transmission of water, hydraulic analysis of distribution network and its optimization, design of distribution system, leakage analysis and control.

Planning of Wastewater Management Projects: urban hydrology and estimation of municipal sewage and storm runoff, design of sewerage systems, selection of pumps and design of pumping station, sewer appurtenances, construction and maintenance of sewerage system.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- "Manual on Water Supply and Treatment" by CPHEEO, GOI, N. Delhi.
- "Environmental Engineering" by H.S. Peavy, D.R. Rowe and G Tchobanoglous, McGraw-Hill Book Co. NY.
- "Manual on Sewerage and Sewage Treatment" by CPHEEO, GOI, N. Delhi.
- "Wastewater Engineering – Treatment, Disposal and Reuse" by Metcalf and Eddy, Tata McGraw Hill Publishing Co., New Delhi.
- "Elements of Water Supply and Wastewater Disposal" by G.M. Fair, J.C. Geyer and D.A. Okun, John Wiley & Sons Inc New York NY.
- "Environmental Engineering" by A.P. Sincero and G.A. Sincero, PHI, N. Delhi.
- "Environmental Engineering (Vol. I & II)" by S.K. Garg, Khanna Publishers, N. Delhi.

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 712 ENVIRONMENTAL PLANNING AND MANAGEMENT

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Introduction: environmental and sustainable development, concept of carrying capacity, relation among quality of life, carrying capacity and resource utilization.

Engineering Methodology in Planning and its Limitations: carrying capacity based short and long term regional planning.

Environmental Protection: economic development and social welfare consideration in socio-economic developmental policies and planning. Total cost of development and environmental protection cost. Case studies on regional carrying capacity planning.

Engineering Economics: value engineering, time value of money, cash flows, budgeting and accounting.

Cleaner Technologies: introduction and their role in environmental protection.

Environmental Quality Management: total quality management (TQM) and ISO 14000 Series of Standards. Introduction and importance of environmental audit in environmental management.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- "Planning and Design of Engineering Systems" by Danoy and Warner, Unwin Hyman Publications.
- "ISO 14000 Environmental Management" by Goetsch and Staley, Prentice Hall NJ.
- "Environmental Protection" by Chanlett, McGraw Hill Publication, USA.
- "Environmental Quality Management" by B.N. Lohani, South Asian Publications.
- "Environmental Health and Safety Auditing Handbook" by Lee Harrison, McGraw Hill Inc., USA.

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 713 BIOREMEDIATION: PRINCIPLES AND APPLICATIONS

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Introduction: bioremediation, current bioremediation practices and applications.

Microbial Systems of Bioremediation: factors influencing bioremediation (environmental, physical and chemical factors), genetic responses of microorganisms to the presence of pollutants.

Application of genetically engineered microorganisms for hazardous waste management, microbial transformation reactions (aerobic and anaerobic bio-transformations), microbial detoxification of specialty chemicals (insecticides, herbicides, fungicides, polychlorinated biphenyls, heavy metals).

Bioremediation systems and processes (solid, liquid and slurry phase bioremediation), microbial cleaning of gases (bio-filtration and bio-scrubbing).

In-situ bioremediation, laboratory scale bio-treatability studies for bioremediation, management of bioremediation projects.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- "Bioremediation: Innovative Site Remediation Technology" by W.D. Anderson, American Academy of Environmental Engineers.
- "Bioremediation: Principles and Practice" by Sikdar and Irwin, Technomic Publications, Lancaster, PA, USA.

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 714 LIFE CYCLE ANALYSIS AND DESIGN FOR ENVIRONMENT

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Engineering Products and Processes- environmental health and safety, product life cycle stages, material toxicity, pollutio and degradation, environmentally conscious design and manufacturing approaches, sustainable development and industrial ecology. System life-cycles from cradle to re-incarnation, 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 assessment, design for recycling practices. Re-manufacturability assessments, design for re-manufacture / 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.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- "Environmental Health and Safety Auditing Handbook" by Lee Harrison, McGraw Hill Inc., USA.
- "ISO 14000 Environmental Management" by Goetsch and Staley, Prentice Hall NJ.
- "Environmental Engineering" by H.S. Peavy, D.R. Rowe & G.Tchobanoglous, McGraw Hill Inc. New York.

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 715 WATER QUALITY MANAGEMENT

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Introduction: quality parameters and classification of natural water, physico-chemical and biological water quality classification of aquatic systems, sources of pollution, characteristics of point and non-point sources of pollution.

Eutrophication in natural water bodies: causes, processes and control.

Toxic Wastes: sources, transport and management strategies.

Thermal Pollution: causes, model and control.

Acid Rains: occurrence, impacts and strategies to control.

Water Quality Monitoring: objectives, requirements, planning and various techniques.

Case Studies related to water quality monitoring under various river action plans including Ganga and Yamuna Action Plans.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- "Water Quality: Characteristics, Modeling and Modifications" by Tchobanoglous and Schroeder, Addison-Wesley Pub. Co. USA.
- "Principles of Surface Water Quality Modeling and Control" by Thomann and Mullar, Harper and Row Pub. NY.
- "Standard Methods for the Examination of Water and Wastewater" APHA Washington DC.
- "Engineering Approaches for Lake Management (Vol. I)" by Reckhow and Chapra, Butterworth Pob. Boston.
- "Applied Stream Sanitation" by C.J. Velz, Wiley Interscience NY.
- "Biology and Water Pollution Control" by C.E. Warren, Saunders Publications Philedephia.

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 716 ADVANCED COMPUTATIONAL METHODS AND OPTIMIZATION

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Numerical Methods: Newton Rapson method for solution of simultaneous equations, numerical solutions of partial differential equations, finite difference methods, finite element method and method of characteristics. Explicit and implicit methods to solve simple parabolic differential equations, convergence, boundary value problems and successive over relaxation methods. Numerical dispersion errors and their prevention, comparison of solutions by analytical and finite difference techniques for one dimensional instantaneous discharge, simple computer program based examples.

Optimization: definition and classification of optimization problems, importance in environmental studies, single and multivariable optimization without and with constraints.

Linear Programming: standard form of problems, pivotal reduction of equations, single and two phase simplex methods, piece wise linear approximation of non-linear optimization.

Numerical Search Methods for 1-D Non-linear Problems: Dichotomous, Fibonacci and Golden section methods, quadratic and cubic interpolation methods, solutions of linear programming problems using computer programming.

Statistics and Probability: frequency distribution, central tendency and dispersion, concepts of probability, Binomial, Poisson and normal distribution and their applications, method of least square and regression, multiple regression, Chi-squared test, F-test, t-test. Analysis of problems using computer programming.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- "Numerical Methods for Engineers" by Chapra and Canale, Tata McGraw Hill N. Delhi.
- "Introduction to Finite Element Method" by Desai and Abel, Affiliated East West Press N. Delhi.
- "The Finite Element Method" by O.C. Zienkiewiez, Tata McGraw Hill N. Delhi.
- "Handbook of Statistical Methods for Engineers and Scientists" by H.M. Wodsworth, McGraw Hill Inc. USA.

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 721 ENVIRONMENTAL ISSUES, PROTECTION AND LAWS

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Environmental Issues: climate change, global warming, stratospheric ozone depletion, acid rains, etc., scientific evidence for climate change, international response. International Protocols and Conventions pertaining to ozone layer, climate, bio-diversity, oceans, etc. Globalisation, sustainability and climate change. Environment Policy of Govt. of India.

Environmental Legislation and Laws in India: Laws and acts relating to water pollution, air pollution, industrial pollution, forest, solid waste disposal, etc. Enforcement machinery, environmental issues and judicial trend, corporate environmental liability.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- "Climate Change: From Science to Sustainability" by S. Peake and J. Smith, Oxford University Press.
- "Environmental Law" by D.S. Senegar, Prentice Hall of India N. Delhi.
- "Law and Environment" by Leela Krishan , P Eastern Book Co.
- "Environment Disasters and the Law" by Vinod Shankar Mishra, Ashish Publications.
- "A Basic Course in Environmental Studies" by S. Deswal and A. Deswal, Dhanpat Rai & Co. (P) Ltd., N. Delhi.

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 722 RENEWABLE ENERGY SOURCES

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Introduction: Fundamental concepts of energy, forms of energy, energy sources – conventional and non-conventional, renewable and non-renewable.

Renewable Energy Sources: Advantages, disadvantages, potential, utilization, application / usage, economics and environmental impacts of renewable energy sources (solar, wind, bio, hydro, tidal, wave, geothermal) with special emphasis on Indian scenario.

Integration of energy sources and promotions of renewables.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- "Renewable Energy: Power for a Sustainable Future" by G. Boyle, Oxford University Press.
- "Renewable Energy Sources and their Environmental Impact" by S.A. Abbasi and N. Abbasi, Prentice Hall of India N. Delhi.
- "A Basic Course in Environmental Studies" by S. Deswal and A. Deswal, Dhanpat Rai & Co. (P) Ltd., N. Delhi.

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 723 AIR QUALITY MODELLING

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Introduction to Air Quality Modelling – approaches to model formulation, model classification and criteria for model selection.

Air Pollution Meteorology – meteorological parameters, stability classification, plume rise, plume behaviour, dispersion parameters. Basic diffusion equation, deterministic, numerical and statistical modeling approach. Introduction to boundary layer, turbulance-physical modeling approach, stochastic modeling approach to air pollution dispersion. Theory of Gaussian plume model and its application.

Introduction to indoor air quality models. ISCST3, CALINE4, ROADAIR. Case studies.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- "Atmospheric Chemistry and Physics of Air Pollution" by John H. Seinfeld, John Wiley & Sons Inc. USA.
- "Air Pollution: Physical and Chemical Fundamentals" by John H. Seinfeld, McGraw Hill Inc. New York. .
- "Environmental Engineering" by H.S. Peavy, D.R. Rowe & G.Tchobanoglous, McGraw Hill Inc. New York.
- "Transport Modeling for Environmental Engineers and Scientists" by M.M. Clark, John Wiley & Sons Inc. USA.

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 724 ENVIRONMENTAL RISK ASSESSMENT

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Introduction: basic concepts of environmental risk and definitions, hazard identification procedures, environmental risk zonation.

Consequence analysis and modeling (discharge models, fire and explosion models, effect models, etc.)

Estimation of Incident Frequencies: estimation of incident frequencies from historical date, frequency modeling techniques like Fault Tree Analysis (FTA) and Event Tree Analysis (ETA).

Human Factors in Risk Analysis: calculation and presentation of risk (individual risk, societal risk). Risk management, rules, regulations and conventions. Case studies.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- "Introduction to Environmental Engineering and Science" by G.M. Masters, Prentice Hall, USA.
- "Environmental Organic Chemistry" by Schwarzenbach, Gschwend and Imboden, John Wiley & Sons, Inc. NY.

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 725 SURFACE WATER QUALITY MODELING AND CONTROL

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

River hydrology and derivation of the stream equation, derivation of 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 mechanism of eutrophication, lake phytoplankton models, river eutrophication analysis, finite segment models, elements of toxic substance.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- "Principles of Surface Water Quality Modeling and Control" by Thomann and Mueller, Harper and Row New York.
- "Water Quality: Characteristics, Modeling and Modifications" by Tchobanglons and Schroeder, Addison-Wesley Pub. Co. USA.
- "Modeling the Eutrophication Process" by E.J. Middlebrooks, Ann Arbor Science USA.
- "Environmental Modeling" by J.L. Schnoor, John Wiley & Sons USA.
- "Environmental Modeling: An Introduction" by J. Smith and P. Smith, Oxford University Press.

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 726 GEOGRAPHIC INFORMATION SYSTEM (GIS) IN ENVIRONMENTAL ENGINEERING

Internal Assessment/Evaluation: 30 Marks
External Examination: 45 Marks
Duration of Examination: 03 Hours

Introduction to GIS: hardware and software requirements for GIS, databases and database management systems, spatial databases, coordinate systems and geo-referencing, 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 environmental pollution, environmental impact assessment, natural resource management, etc.

Projects involving creation of small GIS modules related to environmental engineering problems and other generic areas.

Note: *The examiner is required to set EIGHT questions in all carrying equal marks covering the entire syllabus. The candidate is required to attempt FIVE questions.*

Recommended Books:

- "Concept and Techniques of Geographic Information Systems" by Lo and Young, Prentice Hall of India N. Delhi.
- "Getting Started with Geographic Information System, Upper Saddle River" by K. Clark, Prentice Hall N.J.
- "Introduction to Geographic Information Systems" by Kang-Tsung Chang, Tata McGraw Hill N. Delhi.

M TECH: ENVIRONMENTAL SCIENCE AND ENGINEERING

ESE – 611 ENVIRONMENTAL CHEMISTRY AND MICROBIOLOGY

Recommended Books:

- "Environmental Chemistry" by G.W. vanLoon and S.J. Duffy, Oxford University Press.
- "Chemistry for Environmental Engineering" by Clair N. Sawyer, Perry McCarty and Gene F. Parkin, McGraw Hill Inc. New York.
- "Introduction to Biotechnology" by A. Deswal and S. Deswal, Dhanpat Rai & Co. (P) Ltd. N. Delhi.

ESE – 612 AIR AND NOISE POLLUTION

Recommended Books:

- "Environmental Engineering" by H.S. Peavy, D.R. Rowe & G.Tchobanoglous, McGraw Hill Inc. New York.
- "A Basic Course in Environmental Studies" by S. Deswal and A. Deswal, Dhanpat Rai & Co. (P) Ltd. N. Delhi.

ESE – 613 WATER TREATMENT PROCESSES

Recommended Books:

- "Water Quality and Treatment" A Handbook of Public Water Supply by The American Water Works Association (AWWA), McGraw Hill Inc. New York.
- "Environmental Engineering" by H.S. Peavy, D.R. Rowe and G Tchobanoglous, McGraw-Hill Book Co. NY.
- "Environmental Engineering" by A.P. Sincero and G.A. Sincero, PHI, N. Delhi.
- "Manual on Water Supply and Treatment" by CPHEEO, GOI, N. Delhi.

ESE – 614 WASTEWATER TREATMENT PROCESSES

Recommended Books:

- "Wastewater Engineering – Treatment, Disposal and Reuse" by Metcalf and Eddy, Tata McGraw Hill Publishing Co., New Delhi.

- "Water and Wastewater Engineering (Vol. I & II)" by G.M. Fair, J.C. Geyer and D.A. Okun, John Wiley & Sons Inc New York NY.
- "Manual on Sewerage and Sewage Treatment" by CPHEEO, GOI, N. Delhi.

ESE – 615 ECOLOGY

Recommended Books:

- "Ecology" by E.P. Odum, Oxford & IBH publishing, N. Delhi.
- "First Ecology" by A. Beeby and A.N. Brennan, Oxford University Press.

ESE – 616 SOLID AND HAZARDOUS WASTE MANAGEMENT

Recommended Books:

- "Solid Waste: Engineering, Principles and Management Issues" by Tchobanoglous, Theisen and Eliassen, McGraw Hill, New York.
- "Waste Management: Planning, Evaluation and Technologies" by D.C. Wilson, Oxford Press, London.

ESE – 617 ENVIRONMENTAL ENGINEERING LAB - I

Recommended Books and Codes:

- "Standard Methods for the Examination of Water and Wastewater" APHA Washington DC.
- "Chemistry for Environmental Engineering" by C.N. Sawyer and P.L. McCarty, McGraw-Hill Book Agency.

ESE – 621 INDUSTRIAL WASTE MANAGEMENT

Recommended Books:

- "Industrial Wastewater Treatment" by M.N. Rao and A.K. Dutta, Oxford and IBH publishing company, New Delhi

ESE – 624 ENVIRONMENTAL IMPACT ASSESSMENT

Recommended Books:

- "Environmental Impact Assessment" by L.W. Canter, McGraw Hill Inc. New York.
- "Environmental Impact Assessment" by R.R. Barthwal, New Age Int., N. Delhi.

ESE – 711 ADVANCE WATER SUPPLY AND WASTEWATER MANAGEMENT

Recommended Books:

- "Manual on Water Supply and Treatment" by CPHEEO, GOI, N. Delhi.
- "Wastewater Engineering – Treatment, Disposal and Reuse" by Metcalf and Eddy, Tata McGraw Hill Publishing Co., New Delhi.
- "Environmental Engineering (Vol. I & II)" by S.K. Garg, Khanna Publishers, N. Delhi.

ESE – 712 ENVIRONMENTAL PLANNING AND MANAGEMENT

Recommended Books:

- "Planning and Design of Engineering Systems" by Danoy and Warner, Unwin Hyman Publications.
- "ISO 14000 Environmental Management" by Goetsch and Staley, Prentice Hall NJ.
- "Environmental Quality Management" by B.N. Lohani, South Asian Publications.

ESE – 713 BIOREMEDIATION: PRINCIPLES AND APPLICATIONS

Recommended Books:

- "Bioremediation: Innovative Site Remediation Technology" by W.D. Anderson, American Academy of Environmental Engineers.
- "Bioremediation: Principles and Practice" by Sikdar and Irwin, Technomic Publications, Lancaster, PA, USA.

ESE – 714 LIFE CYCLE ANALYSIS AND DESIGN FOR ENVIRONMENT

Recommended Books:

- "Environmental Health and Safety Auditing Handbook" by Lee Harrison, McGraw Hill Inc., USA.
- "ISO 14000 Environmental Management" by Goetsch and Staley, Prentice Hall NJ.

ESE – 715 WATER QUALITY MANAGEMENT

Recommended Books:

- "Water Quality: Characteristics, Modeling and Modifications" by Tchobanoglous and Schroeder, Addison-Wesley Pub. Co. USA.
- "Principles of Surface Water Quality Modeling and Control" by Thomann and Mullar, Harper and Row Pub. NY.

ESE – 716 ADVANCED COMPUTATIONAL METHODS AND OPTIMIZATION

Recommended Books:

- "Numerical Methods for Engineers" by Chapra and Canale, Tata McGraw Hill N. Delhi.
- "The Finite Element Method" by O.C. Zienkiewiez, Tata McGraw Hill N. Delhi.
- "Handbook of Statistical Methods for Engineers and Scientists" by H.M. Wodsworth, McGraw Hill Inc. USA.

ESE – 721 ENVIRONMENTAL ISSUES, PROTECTION AND LAWS

Recommended Books:

- "Climate Change: From Science to Sustainability" by S. Peake and J. Smith, Oxford University Press.
- "Environmental Law" by D.S. Senegar, Prentice Hall of India N. Delhi.

ESE – 722 RENEWABLE ENERGY SOURCES

Recommended Books:

- "Renewable Energy: Power for a Sustainable Future" by G. Boyle, Oxford University Press.
- "Renewable Energy Sources and their Environmental Impact" by S.A. Abbasi and N. Abbasi, Prentice Hall of India N. Delhi.

ESE – 723 AIR QUALITY MODELLING

Recommended Books:

- "Atmospheric Chemistry and Physics of Air Pollution" by John H. Seinfeld, John Wiley & Sons Inc. USA.
- "Air Pollution: Physical and Chemical Fundamentals" by John H. Seinfeld, McGraw Hill Inc. New York. .
- "Transport Modeling for Environmental Engineers and Scientists" by M.M. Clark, John Wiley & Sons Inc. USA.

ESE – 724 ENVIRONMENTAL RISK ASSESSMENT

Recommended Books:

- "Introduction to Environmental Engineering and Science" by G.M. Masters, Prentice Hall, USA.

- "Environmental Organic Chemistry" by Schwarzenbach, Gschwend and Imboden, John Wiley & Sons, Inc. NY.

ESE – 725 SURFACE WATER QUALITY MODELING AND CONTROL

Recommended Books:

- "Principles of Surface Water Quality Modeling and Control" by Thomann and Mueller, Harper and Row New York.
- "Water Quality: Characteristics, Modeling and Modifications" by Tchobanglons and Schroeder, Addison-Wesley Pub. Co. USA.

ESE – 726 GEOGRAPHIC INFORMATION SYSTEM (GIS) IN ENVIRONMENTAL ENGINEERING

Recommended Books:

- "Concept and Techniques of Geographic Information Systems" by Lo and Young, Prentice Hall of India N. Delhi.
- "Getting Started with Geographic Information System, Upper Saddle River" by K. Clark, Prentice Hall N.J.
- "Introduction to Geographic Information Systems" by Kang-Tsung Chang, Tata McGraw Hill N. Delhi.