MASTER OF TECHNOLOGY

ENVIRONMENTAL ENGINEERING

CURRICULAM

(EFFECTIVE FROM 2018 - 19 ONWARDS)

DEPARTMENT OF CIVIL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
TIRUCHIRAPPALLI – 620 015

Master of Technology
(Environmental Engineering)

CURRICULUM

(Effective from 2018 – 19 Onwards)

DEPARTMENT OF CIVIL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
TIRUCHIRAPPALLI - 620 015, INDIA.

VISION OF THE INSTITUTE

- To provide valuable resources for industry and society through excellence in technical education and research.

MISSION OF THE INSTITUTE

- To offer state-of-the-art undergraduate, postgraduate and doctoral programmes.
- To generate new knowledge by engaging in cutting-edge research.
- To undertake collaborative projects with academia and industries.
- To develop human intellectual capability to its fullest potential.

VISION OF THE DEPARTMENT

Shaping infrastructure development with societal focus

MISSION OF THE DEPARTMENT

Achieve International Recognition by:

Developing Professional Civil Engineers
Offering Continuing Education
Interacting with Industry with emphasis on R&D

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO 1	Graduates of the programme will become effectively as environmental engineers in government, industry, or other organizations; designing, improving, and implementing efficient environmental engineering practices that is sustainable.
PEO 2	Graduates of the programme will provide solutions to environmental engineering problems that account for economical, societal, ethical, as well as with standards both as individuals and in team environments, by applying acquired engineering knowledge.
PEO 3	Graduates of the programme will continue their lifelong learning to remain effective professionals to maintain and enhance technical and professional growth.

PROGRAMME OUTCOMES (POs)

Graduates of the Environmental Engineering Programme will be able:

a. To acquire in-depth knowledge of environmental engineering, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.
b. To analyze complex environmental engineering problems critically, apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.
c. To think laterally and originally, conceptualize and solve environmental engineering problems, evaluate a wide range of potential solutions for those problems and arrive at technically feasible and economically viable solutions after considering health and safety, cultural, societal and environmental factors in the core areas of expertise.
d. To extract information pertinent to environmental engineering problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually / in group(s) to the development of scientific / technological knowledge in one or more domains of environmental engineering.
e. To create, select, learn and apply appropriate techniques, resources, and advanced environmental modelling tools, including modelling and prediction, to complex environmental engineering activities with an understanding of the limitations.
f. To possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-

making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

g. To demonstrate knowledge and understanding of environmental engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently after consideration of economical and financial factors.
h. To communicate with the engineering community, and with society at large, regarding complex environmental engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.
i. To recognize the need for, and have the preparation and ability to engage in life-long learning, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.
j. To acquire professional and intellectual integrity, professional ethics and code of conduct, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the society for sustainable development.
k. To observe and examine critically the outcomes of one's actions in addressing Environmental Engineering problems and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

GRADUATE ATTRIBUTES (GA)

1. Scholarship of Knowledge
2. Critical Thinking
3. Problem Solving
4. Research Skill
5. Usage of modern tools
6. Collaborative and Multidisciplinary work
7. Project Management and Finance
8. Communication
9. Life-long Learning
10. Ethical Practices and Social Responsibility
11. Independent and Reflective Learning

GA AND PO MAPPING

The Programme Outcomes have been derived from the Graduate Attributes. Hence, they are aligned to each other one to one as indicated below:

Graduate Attributes	Programme Outcomes										
	a	b	c	d	e	f	g	h	i	j	k
1	√										
2		√									
3			√								
4				√							
5					√						
6						√					
7							√				
8								√			
9									√		
10										√	
11											√

CORRELATION BETWEEN THE POs AND THE PEOs

Three levels of correlation have been identified between the Pos and the PEOs, viz, High, Medium and Low. The correlation matrix is given below:

PEOs		Programme Outcomes (POs)										
		a	b	c	d	e	f	g	h	i	j	K
Programme Educational Objectives	1	H	H	H	M	M	H	M	M	M	H	H
	2	M	M	H	L	L	M	H	H	M	H	M
	3	M	M	M	L	L	H	L	H	H	M	M

Note: H - High; M - Medium; L - Low

SEMESTER I

Code	Course of Study	Credit
MA601	Numerical Methods and Applied Statistics	3
CE701	Environmental Process Chemistry and Microbiology	3
CE703	Physico-chemical Process for Water and Wastewater Treatment	4
	Elective I	3
	Elective II	3
	Elective III	3
CE709	Environmental Quality Measurements Laboratory	2
		21

SEMESTER II

Code	Course of Study	Credit
CE702	Biological Process Design for Wastewater Treatment	4
CE704	Solid and Hazardous Waste Management	3
CE706	Air Pollution and Control Engineering	3
	Elective IV	3
	Elective V	3
	Elective VI	3
CE710	Environmental Engineering Processes Laboratory	2
		21

SUMMER TERM

Code	Course of Study	Credit
	Practical Training (4 Weeks)	-

SEMESTER III

Code	Course of Study	Credit
CE747	Project Work	12

SEMESTER IV

Code	Course of Study	Credit
CE748	Project Work	12

PROGRAMME ELECTIVES

Sl. No.	Code	Course of Study	Credit
1.	CE711	Transport of Water and Wastewater	3
2.	CE712	Membrane Technologies for Water and Wastewater Treatment	3
3.	CE713	Industrial Wastewater Management	3
4.	CE714	Modeling of Natural Systems	3
5.	CE715	Groundwater Flow and Contaminant Transport Through Porous Media	3
6.	CE716	Analytical Methods for Environmental Monitoring	3
7.	CE717	Environmental Impact Assessment	3
8.	CE718	Cleaner Production and Environmental Sustainable Management	3
9.	CE719	Ecological and Ecosystems Engineering	3
10.	CE720	Indoor Air Quality	3
11.	CE721	Environmental Biotechnology	3
12.	CE722	Geoenvironmental Engineering	3
13.	CE723	Advanced Geoenvironmental Characterization Techniques	3
14.	CE724	Remote sensing and GIS for Environmental applications	3
15.	CE725	Environmental Systems Analysis	3

OPEN ELECTIVES

Sl. No.	Code	Course of Study	Credit
1.	CE716	Analytical Methods for Environmental Monitoring	3
2.	CE724	Remote sensing and GIS for Environmental applications	3

COURSE OUTCOME AND PO MAPPING

PROGRAMME CORE

Course Outcomes: On successful completion of the course, students will be able to:

Course Code	Course Name	CO	Course outcomes At the end of the course student will be able	a	b	c	d	e	f	g	h	i	j	K
MA601	Numerical methods and applied statistics	CO1	To distinguish the concepts of linear and nonlinear systems	H	H	M	L					M		
		CO2	To solve the problems through linear programming approaches	M	H	H	M					L		
		CO3	To correlate any results using statistical methods		H	M	H		L			H		M
		CO4	To develop statistical models between variables		M			H				M		M
CE701	Environmental Process chemistry and microbiology	CO1	to infer the chemical processes involved in the treatment of water and wastewater	M	M		H		M			M		M
		CO2	to apply the concepts of solubility equilibria and redox chemistry for treatment of industrial wastewater	M	H							M	H	L
		CO3	to quantify the dosage of chemicals requirement based on chemical reactions in water treatment	H	L		M		M			L		
		CO4	to differentiate between different microbial species and their growth kinetics	M			H	L	M			L		
CE703	Physico chemical process for water and wastewater treatment	CO1	To evaluate various physical and chemical treatment options for treatment of water and wastewater	H	H				H			L		M

		CO2	To explain the mechanism behind the treatment processes and their advantages and disadvantages	H	M	M	M		M			H		
		CO3	To design various physico- chemical units for the treatment of water and wastewater	H	H	H	M		H			M		L
		CO4	To use the modeling concepts in the real field applications		M	H	M	L	L	L		M	M	M
CE709	Environmental Quality Measurements Laboratory	CO1	to apply different analysis techniques for the measurement of physical and chemical parameters of water and wastewater	H	M		H	L	M			L		M
		CO2	to explain the operation and mechanism of different analytical equipments and their advantages and limitations	H			M		M			L		
		CO3	to relate the theoretical knowledge of sampling and analysis into lab practice	H	H	L	H		L			L		
		CO4	to estimate the concentration of various parameters in water, wastewater, and ambient air	H	M		H	H						
CE702	Biological process design for wastewater treatment	CO1	To describe the range of conventional and advanced biological treatment processes for the treatment of bulk organics, nutrients and micro pollutants	H	L	L	M	L			M	L		
		CO2	To design the biological reactors based on biokinetics	H	H	M	M		M					M
		CO3	To select appropriate processes for specific applications, and have some knowledge of practical design considerations	M	H	M	H	H	H	M			L	L

		CO4	To execute and asses the performance of bioreactors in laboratory scale		H	M	M	H	L			L		H
CE704	Solid and Hazardous Waste Management	CO1	To explain the various functional elements involved in waste management system	H	L		M				L		L	
		CO2	To quantify and categorize solid wastes for any region	H	L		M	M		H	L	M	H	H
		CO3	To prepare concept design for the common functional elements of the waste management systems	H	M	L	L	L					M	M
		CO4	To select suitable waste processing technologies and disposal methods	M	H	H	L	M	L	M		L	H	H
CE706	Air pollution and control engineering	CO1	To classify the types and sources of air pollutants and to understand their effects on human health and the broader environment	H			M		H				H	
		CO2	To differentiate and design various air pollution control technologies for particulates and gaseous pollutants	H	H		M		L			M		
		CO3	To choose appropriate technologies for removal of selective pollutants	M	H	M	M	M						
		CO4	To establish and implement air quality management components	M	L	L			L	L		H	H	M
CE710	Environmental Engineering processes laboratory	CO1	Perform common environmental experiments relating to water and wastewater quality, and know which tests are appropriate for given environmental problems.	L	L	M	H	M				L		L
		CO2	To demonstrate and analyze basic reactor types and kinetics.	L	M		H	M						M
		CO3	To demonstrate and analyze basic environmental engineering	L		M	M	L		L		L		M

			processes (physical/chemical) for treatment of contaminants, including gas transfer, adsorption and advanced oxidation processes.											
		CO4	To give students theoretical understanding of and hands on experience with basic methods of environmental analysis.	M		M	M	L					L	M

PROGRAMME ELECTIVES

Course Code	Course Name	CO	Course outcomes	a	b	c	d	e	f	g	h	i	J	k
CE711	Transport of Water and Wastewater	CO1	To select various pipe design for water, supply main, distribution network	H	L									
		CO2	To design sewer network and water supply distribution network for various field conditions.	M	H	H		H	L			M		L
		CO3	To troubleshoot water and sewage transmission		H	M	M					H		
		CO4	To use various computer software for the design of water and sewage network		H	H	M	H						M
CE712	Membrane technologies for water and wastewater treatment	CO1	To differentiate various membrane processes, principles, separation mechanisms and its applications	H	H	M	H	H	L			L		
		CO2	To explain the selection criteria for different membrane processes	H	H	L	H	L	L			M		
		CO3	To design membrane bioreactors	H	M	M	H	H	M			M		M
		CO4	To develop synthetic membranes by various preparation techniques	M	H	L	H	M	L	L		M	L	M

		CO4	To recommend the pollution control methods for specific industries	M	M	L	L		H	M	L	L	H	M
CE713	Industrial wastewater management	CO1	to recognize various environmental problems due to improper management of industrial wastewater	M	H		M		M	L			H	
		CO2	to explain various technologies for removal of pollutants from industrial wastewater	H	M	L	M					L	M	M
		CO3	to design waste treatment flow sheets for industries	H	M	M	M	M	L			L	H	M
		CO4	to recommend the pollution control methods for specific industries	M	M	L	L		H	M	L	L	H	M
CE714	Modeling of Natural Systems	CO1	To develop contaminant transport model for natural systems	H	H	L	M	H			L	L	L	M
		CO2	To predict the quality of water in river, lakes and estuaries using specific models	H	M	M	M	L	L			L		
		CO3	To solve the transport equation using numerical techniques	M	H		H	M				L		M
		CO4	To estimate the concentration of pollutant in ambient air using dispersion models	M	M	L	H	H	L			L		M
CE715	Groundwater flow and Contaminant Transport through porous media	CO1	To develop flow and transport model for contaminant in subsurface water	H	H	M	H	M	L			L		M
		CO2	To differentiate various numerical techniques for solving flow and transport equations	H	M	L	H	M	L			L	M	M

		CO3	To develop reactive transport model for reactive species	M	M	L	H	H				M		L
		CO4	To apply the software packages to develop contaminant transport model for field condition	M	M	M	H	H	L	M	L	L	H	H
CE716	Analytical methods for environmental monitoring	CO1	To analyse the principles of volumetric and instrumental analytical methods in environmental monitoring	H	M	L	H	M	L			H		
		CO2	To use statistical methods for evaluating and interpreting data of environmental interest	M	M	M	H	M	M	L		M		M
		CO3	To discriminate various electrochemical methods	M	H	L	M	L	L			M	L	
		CO4	To summarize various material characterization techniques and its principles	H	L	L	H	L	L			L		
CE717	Environmental impact assessment	CO4	To analyse the environmental impacts of the proposed projects	H	H	M	L	M	M	L	M	L	H	M
		CO2	To predict the magnitude of an impact using mathematical tools	M	L	L	L	H				L		M
		CO3	To propose proper mitigation measures to avoid environmental impacts	M	H	M	L		L	M	H	M	H	H
		CO4	To summarize the EIA report with suitable environmental management plan	H	H		H		L	L	H		M	M
CE718	Cleaner production and environmental sustainable management	CO1	to modify schemes applied at different governance levels to achieve sustainable innovation.	H	H	L	L	L	H	L	L	M	H	L
		CO2	to prepare process flow diagram and material balance for various industrial processes	M	M		L	L			M		H	

		CO3	to summarize various techniques for cleaner production and to apply environmental sustainable management concepts in industries	M	M	L	H		M	L		L	H	
		CO4	to examine the toxicological and ecological aspects of ecotoxicology and to transfer knowledge of Eco toxicological theory to new environmental situations	M	H	H	M	L	M	H	M	M	H	H
CE719	Ecological and eco systems engineering	CO1	To classify, evaluate and design interface ecosystems	H	H	L	L	M	L	L	L	M	M	H
		CO2	To design sustainable loading of eco systems	M	H	M	M	H	M	L	L	M	H	M
		CO3	To develop model in different ecological scenarios and applications in real field	H	H	L	M	H	M	H	H	M	H	M
		CO4	To expertise on eco sanitation regarding different ecosystem	H	H	H	M	M	M	L		M	H	M
CE720	Indoor air quality	CO1	To point out the factors affecting Indoor Air Quality (IAQ)	H	H	M	M	L	M	L	M	L		M
		CO2	To predict the indoor air quality using mathematical model	M	L	M	M	H				M		M
		CO3	To suggest the control techniques for indoor air pollution	H	H	M	M	L	L	L		M	H	M
		CO4	To measure the pollutant concentration in indoor environment	M	M	H	H	H	L	L	L	L		M
CE721	Environmental biotechnology	CO1	To explain the mechanisms of detoxification and biodegradation of solid wastes	H	M	L	H	L	M			L		

		CO2	To list out the different methods for bioremediation of environment and to design biological system for the removal of nutrients	M	L	L	M	L	M	M		M	L	
		CO3	To evaluate the benefit of microorganisms in degrading organic contaminants and to choose suitable microorganism for biodegradation of selected compounds.	H	H	H	H	M	M	L		L	M	M
		CO4	To select suitable assessment methods for bioremediation	H	H	M	H	M	M	M	M	L	H	M
CE 722	Geoenvironmental Engineering	CO1	To identify the origin, nature, and extent of contamination in field.	H	M	L	H	L	L			M		M
		CO2	To predict the retention and flow properties of contaminants.	H	M		M		M	L		M	H	
		CO3	To adopt suitable sampling techniques for geoenvironmental characterization	M	L		M		M		L	M		
		CO4	To suggest the remediation techniques for decontamination	H	M	M	H	M	L	L		M	M	M
CE723	Advanced geoenvironmental characterization techniques	CO1	To judge the suitability of conventional test protocols for material characterization.	H	M	L	H	M	L			H		
		CO2	To adopt need-based laboratory testing for encountering geoenvironmental issues.	M	M	M	H	M	M	L		M		M
		CO3	To analyze and interpret the data generated from various characterization techniques.	M	H	L	M	L	L			M	L	
		CO4	To comprehend the knowledge of non-destructive testing techniques for tackling geoenvironmental issues	H	L	L	H	L	L			L		

CE724	Remote sensing and GIS for environmental applications	CO1	To summarize the basic spectral mechanism behind remote sensing and GIS techniques	H	M	L	H	H	M		L	M		
		CO2	To explain different software for data creation, analysis and modelling	H	M	L	H	H	M	M		M		L
		CO3	To understand geo database development and geo-spatial analysis for environmental applications	H			M	H	M		L	M		
		CO4	To apply the image processing techniques for various environmental problems	H	L		M		H		L	H		
CE725	Environmental systems analysis	CO1	To analyse the system performance using simulation models	H	M	M	M	M				L		L
		CO2	To optimize environmental engineering systems using optimization models	H	H	M	M	M	L			L		L
		CO3	To employ model-based environmental analysis	M	H	L	M	M	L			L		M
		CO4	To choose a suitable environmental system analysis method and tool for a given decision situation	M	M	M	H	L				M	M	L

MODES OF DELIVERY OF COURSES HELP IN ATTAINMENT OF THE POS

The teaching learning process comprises of different combinations of the modes of delivery of courses listed below;

- MD1: Lectures with interactions
- MD2: Tutorial
- MD3: Assignment
- MD4: Seminar / Term paper
- MD5: Presentations
- MD6: Group discussions
- MD7: Demonstrations / hands on training (Models, Laboratory) / mini project
- MD8: Case studies / field visit

METHOD		Justification	Attainment of POs	Sample Courses
MD1	**LECTURE WITH INTERACTIONS** Formal discourse in which the instructor presents a series of events, facts, or principles, explores a problem or explains relationships	1. To orient students towards the content of the subject 2. To introduce a subject, to present basic material and to give directions on procedures. 3. To introduce a demonstration, discussion, or performance. 4. To illustrate principles or concepts and to review, clarify, emphasize or summarize.	PO a, b, c, e, f, h, i	Numerical Methods and Applied Statistics, Environmental process chemistry and microbiology, Modeling of Natural Systems, Groundwater flow and contaminant transport through porous media, Geoenvironmental Engineering Solid and Hazardous Waste Management, Industrial Wastewater Management, Environmental Impact Assessment
MD2	**TUTORIAL**	1. A detailed presentation of view, which shows and	PO a, e, f, h, i	Physico-chemical Process for Water and Wastewater Treatment, Biological Process

	A method of instruction in which an instructor works directly with an individual student.	explains the user interface to the user. 2. Demonstration of the process with the help of examples to exhibit how a process or workflow is achieved. 3. Method of review, which tests or reinforces the understanding of particular content in related section or module. 4. Transition to additional sections or modules, which are built on previously provided instructions.		Design for Wastewater Treatment
MD3	**ASSIGNMENT** A method in which the instructor assigns reading to books, periodicals, project or research papers or exercises for the practice.	1. To orient students to a topic prior to classroom or Laboratory work. 2. To set the stage for a lecture demonstration or discussion. 3. To provide for or capitalize on individual differences in ability, background, or experience through differentiated assignments. 4. To provide for the review of material covered in class or to give practice.	PO a, b, c, d, e, f, g, h, i, j, k, l	Numerical Methods and Applied Statistics, Environmental process chemistry and microbiology, Modeling of Natural Systems, Groundwater flow and contaminant transport through porous media, Geoenvironmental Engineering Solid and Hazardous Waste Management, Industrial Wastewater Management, Environmental Impact Assessment
MD4	**SEMINAR / TERM PAPER** An arrangement	1. To provide general guidance for a group working on an advanced study or research	PO a, h	Physico-chemical Process for Water and Wastewater Treatment, Biological Process Design for Wastewater Treatment,

	involving the instructor and groups, rather than instructor and individual.	project. 2. To exchange information on techniques and approaches being explored by members of a study or research group. 3. To develop new and imaginative solutions to problems under study by the group. 4. To stimulate active participation.		Industrial Wastewater Management, Transport of Water and Wastewater
MD5	**PRESENTATIONS** A method in which group discussion techniques are used to reach instructional objectives.	1. To develop imaginative solutions to problems and to stimulate thinking and interest and to secure student participation. 2. To emphasize main teaching points and to supplement lectures, reading, or laboratory exercises. 3. To determine how well student understands concepts and principles and to prepare students for application of theory of procedure. 4. To increase students acceptance and commitments and utilizes student knowledge and experience.	PO a, e, h	Physico-chemical Process for Water and Wastewater Treatment, Biological Process Design for Wastewater Treatment, Industrial Wastewater Management, Transport of Water and Wastewater, Solid and Hazardous Waste Management, Environmental Impact Assessment
MD6	**GROUP DISCUSSION**	1. Whole group discussions provide for greater interaction between teacher and students.	PO a, b, c, f, h	Environmental Impact Assessment

		2. Teachers can check on what students are retaining through questions posed. 3. Students have a tendency to stay focused on the lesson because they might be called on to answer questions 4. Students may feel more comfortable asking questions during whole group discussions.		
MD7	**DEMONSTRATION** A method of instruction where the instructor by actually performing an operation or doing a job shows the students what to do, how to do it, and through explanations brings out why, where, and when it is done.	1. To teach manipulative operations or procedures. 2. To teach troubleshooting and to illustrate principles. 3. To teach operation or functioning of equipment and to set standards of workmanship. 4. To teach teamwork and to teach safety procedures.	PO a, b, c, d, e, f, g, h, i, j, k	Air pollution and Control Engineering, Indoor Air Quality
MD8	**Case Studies / field visit**	1. To allow students with real expertise and understanding, as well as judgement to excel. 2. To take risks, make judgements in uncertain situations 3. To propose and select from multiple possible options 4. to explore the topic and use critical thinking to come to a solution, decision, or action	PO a, b, d, f, h, i, j	Physico-chemical Process for Water and Wastewater Treatment, Biological Process Design for Wastewater Treatment, Industrial Wastewater Management, Transport of Water and Wastewater, Solid and Hazardous Waste Management.

The above seven methods of content delivery are further classified into simple elements for each course category as given in the table below;

S.No.	Course Category	Modes of Course delivery	Tools used for Course delivery
1.	Mathematics	▪ MD1: Lectures with interactions ▪ MD2: Tutorial ▪ MD3: Assignment	▪ Black board ▪ Multimedia Presentation
2.	Programme Core (Analytical)	▪ MD1: Lectures with interactions ▪ MD2: Tutorial ▪ MD3: Assignment ▪ MD4: Seminar / Term paper ▪ MD5: Presentations ▪ MD6: Group discussions ▪ MD7: Demonstrations / hands on training (Models, Laboratory) / mini project	▪ Black board ▪ Multimedia Presentation ▪ NPTEL materials http://nptel.iitm.ac.in ▪ Video Lectures ▪ MIT Open Courseware http://ocw.mit.edu /index.htm
3.	Programme Core (Laboratory)	▪ MD1: Lectures with interactions ▪ MD6: Group discussions ▪ MD7: Demonstrations / hands on training (Models, Laboratory) / mini project	▪ Black board ▪ Multimedia Presentation
4.	Programme Core (Design)	▪ MD1: Lectures with interactions ▪ MD2: Tutorial ▪ MD3: Assignment ▪ MD4: Seminar / Term paper ▪ MD5: Presentations ▪ MD6: Group discussions ▪ MD7: Demonstrations / hands on training (Models, Laboratory) / mini project ▪ MD8: Case studies / field visit	▪ Black board ▪ Multimedia Presentation ▪ NPTEL materials http://nptel.iitm.ac.in ▪ Video Lectures ▪ MIT Open Courseware http://ocw.mit.edu /index.htm
5.	Programme Electives	▪ MD1: Lectures with interactions ▪ MD2: Tutorial ▪ MD3: Assignment ▪ MD4: Seminar / Term paper ▪ MD5: Presentations ▪ MD6: Group discussions ▪ MD7: Demonstrations / hands on training (Models, Laboratory) / mini project ▪ MD8: Case studies / field visit	▪ Black board ▪ Multimedia Presentation ▪ NPTEL materials http://nptel.iitm.ac.in ▪ Video Lectures ▪ MIT Open Courseware http://ocw.mit.edu /index.htm

6.	Open Electives	▪ MD1: Lectures with interactions ▪ MD2: Tutorial ▪ MD3: Assignment ▪ MD4: Seminar / Term paper ▪ MD5: Presentations ▪ MD6: Group discussions ▪ MD7: Demonstrations / hands on training (Models, Laboratory) / mini project	▪ Black board ▪ Multimedia Presentation ▪ NPTEL materials http://nptel.iitm.ac.in ▪ Video Lectures ▪ MIT Open Courseware http://ocw.mit.edu /index.htm

The modes of delivery methods are chosen to meet the Program Outcomes. The mapping of modes of Course delivery to the Program Outcomes is shown in the Table

Modes of Delivery	**Programme Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
MD1	√	√	√		√	√		√	√		
MD2	√				√	√		√	√		
MD3	√	√	√	√	√	√	√	√	√	√	√
MD4	√							√			
MD5	√				√			√			
MD6	√	√	√			√		√			
MD7	√	√	√	√	√	√	√	√	√	√	√
MD8	√	√		√		√		√	√	√	

Course Code	**:**	MA601
Title of the Course		**NUMERICAL METHODS AND APPLIED STATISTICS**
Designation as a required or elective	**:**	Core
Prerequisites	**:**	Basic knowledge in Mathematics
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. To gain an understanding of statistical methods relevant to upper division interdisciplinary courses
2. To study the concepts of both discrete and continuous probability distribution
3. To calculate the confidence intervals for various population parameters
4. To analyze the problems using Linear programming approach

Course Content

Linear System - Gaussian Elimination and Gauss - Jordan Methods - Matrix Inversion - Gauss Seidel Method - Nonlinear Equations - Regula Falsi and Newton - Raphson Methods - Interpolation - Newton's and Lagrange's Interpolation - Linear Programming - Graphical and Simplex methods - Big-M method - Two phase method - Dual simplex method - Dual theory - Sensitivity analysis - Integer programming –applications - Random Variable - Two Dimensional Random Variables - Standard Probability Distributions - Binomial Poisson and Normal Distributions - Moment Generating Function - Sampling Distributions - Confidence Interval Estimation of Population Parameters - Testing of Hypotheses - Large Sample Tests for Mean and Proportion – t - Test, F-Test and Chi-Square Test - Curve Fitting - Method of Least Squares - Regression and Correlation - Rank Correlation - Multiple and Partial Correlation - Analysis of Variance - One Way and Two Way Classifications -Experimental Design - Latin Square Design - Time Series Analysis.

References

1. *Bowker and Liberman, Engineering Statistics, Prentice-Hall, 1972.*
2. *Venkatraman, M. K., Numerical Methods in Science and Engineering, National Publisher Company, 5th Edition, 1999.*
3. *M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for scientific and engineering computation, 6th edition, New Age International (p) Limited, 2007*
4. *Operations Research: An introduction, Hamdy A. Taha, 10th edition Pearson Prentice Hall, 2007.*
5. *S. C. Gupta, Fundamentals of Statistics, Himalaya Publishing House, 7th Revised and Enlarged Edition, 2014.*
6. *S.C. Gupta and V. K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand and Sons, 2014.*

Course Outcomes

At the end of the course student will be able
1. to distinguish the concepts of linear and nonlinear systems
2. to solve the problems through linear programming approaches
3. to correlate any results using statistical methods
4. to develop statistical models between variables

Course Code	**:**	CE701
Title of the Course	**:**	**ENVIRONMENTAL PROCESS CHEMISTRY AND MICROBIOLOGY**
Designation as a required or elective	**:**	Core
Prerequisites	**:**	Basic knowledge in Chemistry and Microbiology
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. To study the basic concepts of environmental chemistry and acid base equilibria
2. To use the solubility equilibria approach for the removal of heavy metals from water and wastewater
3. To discuss the application of redox chemistry in water and wastewater treatment
4. To describe the characteristics and growth kinetics of microbial populations

Course Content

Environmental Chemistry - Chemical Equilibria and kinetics fundamentals – Chemical thermodynamics; Acid Base Equilibria - Equilibrium Diagrams - Alkalinity and Acidity, Carbonic Acid System, Buffer and buffer intensity; Gas Laws; Solubility Equilibria- Removal of Heavy Metals from Complex Water and Wastewater Systems; Oxidation Reduction Equlilibria - Stability Diagrams - Application of Redox Chemistry; Water Stabilization- Langelier Saturation Index - Caldwell Lawrence Diagrams - Water Softening and Neutralization - Chemical Precipitation; Microbiological concepts - classification of microorganisms - prokaryotic, eukaryotic, structure - Microbial metabolism - respiration and energy generation- microbial growth-enzyme kinetics – bio kinetics – Microbiology of wastewater Treatment.

References

1. *Benfield, L.D.; Weand, B.L.; Judkins, J.F., Process chemistry for water and wastewater. Prentice Hall Inc, Englewood Cliffs, New Jersey, 1982.*
2. *Weber Jr., W.J., Physico-chemical Process for Water Quality Control. Wiley Inc. Newyork,. 1972.*
3. *Tortora. G. J., B. R. Furke, and C. L. Case, Microbiology- An introduction (11th Ed.), Benjammin /Cummings publ. Co. ,Inc., California, 2013.*
4. *Pelczar, M. J., Chan E. C. S. and Krieg, N. R., Microbiology, 5th Edition, Tata McGraw Hill, New Delhi, 1993.*

Course Outcomes

At the end of the course student will be able

1. to infer the chemical processes involved in the treatment of water and wastewater
2. to apply the concepts of solubility equilibria and redox chemistry for treatment of industrial wastewater
3. to quantify the dosage of chemicals requirement based on chemical reactions in water treatment
4. to differentiate between different microbial species and their growth kinetics

Course Code	**:**	**CE703**
Title of the Course	**:**	**PHYSICO-CHEMICAL PROCESS FOR WATER AND WASTEWATER TREATMENT**
Designation as a required or elective	**:**	Core
Prerequisites	**:**	Basic knowledge in water and wastewater
Contact Hours, Type of Course	**:**	45
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. To learn the physical, chemical and biological characteristics of water and wastewater
2. To provide an understanding of various physicochemical methods for treatment of water and wastewater
3. To explain the limitations, advantages and disadvantages of each unit operations and processes
4. To study the principle and design of the physical and chemical treatment units used for the removal of undesirable constituents (contaminants) from water and wastewater

Course Content

Water Quality - Physical, Chemical and Biological Parameters of Water - Water Quality Requirement - Potable Water quality Standards, Wastewater Effluent Standards, Water Quality Indices; Water Purification in Natural Systems; Primary, Secondary and Tertiary Treatment - Unit Operations - Unit Processes; Particle Separation Processes - Coagulation and Flocculation Processes, Particle Surface Charge, Surface Potential and Stability of Colloidal Dispersions; Sedimentation and Flotation Processes, Gravity Thickeners, Clarifiers and Flotation Systems - Filtration and Ultrafiltration Processes, Modeling Approaches for Rapid Sand Filters - Solute Separation Processes - Gas Transfer Processes, Diffused and Surface Aeration and Air Stripping of Volatile Contaminants in Packed Tower - Adsorption and Ion Exchange Processes, Sorption Isotherm Models and Rates Considerations, Sorption in Completely Mixed and Packed Bed Reactors - Precipitation Processes - Reverse Osmosis and Electro dialysis - Species Transformation Processes - Chemical Oxidation / Reduction Processes, Disinfection using Chlorine and UV, Advanced Oxidation Process.

References

1. *Weber, W. J. Physicochemical processes for water quality control, John Wiley and sons, Newyork, 2003.*
2. *Peavy, H. S., Rowe, D. R., Tchobanoglous, G. Environmental Engineering, McGraw Hills, New York, 2013.*
3. *Metcalf & Eddy, Inc. Wastewater Engineering, Treatment and Reuse, 5th Edition, Tata McGraw-Hill, New Delhi, 2013.*

Course Outcomes

At the end of the course student will be able

1. to evaluate various physical and chemical treatment options for treatment of water and wastewater
2. to explain the mechanism behind the treatment processes and their advantages and disadvantages
3. to design various physico- chemical units for the treatment of water and wastewater
4. to use the modeling concepts in the real field applications

Course Code	**:**	CE709
Title of the Course	**:**	**ENVIRONMENTAL QUALITY MEASUREMENTS LABORATORY**
Designation as a required or elective	**:**	Laboratory
Prerequisites	**:**	Basic knowledge in water and wastewater analysis
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. To analyse the physical and chemical characteristics of water and wastewater
2. To familiarize the methods to estimate the organic strength of wastewater
3. To study the various techniques for the examination of microorganisms
4. To measure the particulate and gaseous pollutant concentration in ambient air

Physical and Chemical Characteristics of Water - pH, Electrical Conductivity, Turbidity, Alkalinity, Acidity, Hardness, Sulphates, Fluorides, Nitrates - Analysis of Solids Content of Water - Total Solids, Suspended Solids, Volatile Solids, Non Volatile Solids - Residual Chlorine Analysis - Test on Dissolved Oxygen, BOD and COD - Metal Analysis; Microscopic Examination of Microorganisms - Preparation of Bacterial Smear - Staining - Basic Pure Culture Techniques - Bacteriological examination of water - Standard Plate Count Test, MPN Tests and MFT Tests; Ambient Air Quality Analysis - Determination of SPM, PM10, PM 2.5, CO, NO_X and SO_X -stack emission monitoring; Soil Analysis - pH, Conductivity, Cation Exchange Capacity, Sodium Adsorption Ratio.

References

1. *Standard Methods for the Examination of Water and Wastewater, 23rd Edition, 2017*
2. *Manual on water supply and Treatment, CPHEEO, Ministry of Urban Development, GOI, New Delhi, 2000.*

Course outcomes

At the end of the course student will be able

1. to apply different analysis techniques for the measurement of physical and chemical parameters of water and wastewater
2. to explain the operation and mechanism of different analytical equipments and their advantages and limitations
3. to relate the theoretical knowledge of sampling and analysis into lab practice
4. to estimate the concentration of various parameters in water, wastewater, and ambient air

Course Code	**:**	CE702
Title of the Course	**:**	**BIOLOGICAL PROCESS DESIGN FOR WASTEWATER TREATMENT**
Designation as a required or elective	**:**	Core
Prerequisites	**:**	Basic knowledge in wastewater and its treatment
Contact Hours, Type of Course	**:**	45
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. To learn the fundamentals of process kinetics and bioreactors
2. To study about various biological treatment processes and its operations for the wastewater treatment
3. To provide the knowledge about the kinetics of biological growth and its application in the design of biological reactors
4. To explain the design principles and operational problems involved in various biological treatment processes

Course Content

Constituents of Wastewaters - Sources - Significant Parameter - Fundamentals of Process Kinetics, Zero Order, First Order, Second Order Reactions, Enzyme Reactions - Bio Reactors - Types, Classification, Design Principles - Design of Wastewater Treatment Systems -Primary, Secondary and Tertiary Treatments - Evaluation of Biokinetic Parameters - Activated Sludge and its Process - Modifications, Biological Nitrification and Denitrification - Attached Growth Biological Treatment Systems -Trickling Filters - Rotating Biological Contactors - Waste Stabilization Ponds and Lagoons - Aerobic Pond, Facultative Pond, Anaerobic Ponds- Polishing Ponds, Aerated Lagoons - Anaerobic

Processes - Process Fundamentals - Standard, High Rate and Hybrid Reactors, Anaerobic Filters-Expanded / Fluidized Bed Reactors - Upflow Anaerobic Sludge Blanket Reactors - Expanded Granular Bed Reactors - Two Stage/Phase Anaerobic Reactors - Sludge Digestion, Sludge Disposal.

References

1. *Benefield, L.D. and Randall C.W. Biological Processes Design for wastewaters, Prentice-Hall, Inc. Eaglewood Cliffs, 1989.*
2. *Grady Jr. C.P.L and Lin H.C. Biological wastewater treatment: Theory and Applications, Marcel Dekker, Inc New York, 1980.*
3. *Metcalf & Eddy, Inc. Wastewater Engineering, Treatment and Reuse. 3rd Edition, Tata McGraw-Hill, New Delhi, 2003.*
4. *Arceivala, S. J. and Asolekar, S. R., Wastewater Treatment for Pollution Control, 3rd Edition, McGraw-Hill Education (India) Pvt. Ltd., New Delhi, 2006.*

Course Outcomes

At the end of the course student will be able
1. to describe the range of conventional and advanced biological treatment processes for the treatment of bulk organics, nutrients and micro pollutants
2. to design the biological reactors based on biokinetics
3. to select appropriate processes for specific applications, and have some knowledge of practical design considerations
4. to execute and asses the performance of bioreactors in laboratory scale

Course Code	**:**	CE704
Title of the Course	**:**	**SOLID AND HAZARDOUS WASTE MANAGEMENT**
Designation as a required or elective	**:**	Core
Prerequisites	**:**	Fundamental knowledge in Waste management
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. To understand the nature of the various functional elements in regional waste management systems and the relationships among them
2. To provide a knowledge about generation, characteristics and composition of urban solid waste, hazardous waste and biomedical waste
3. To enumerate and describe different disposal and treatment methods for municipal solid waste, hazardous waste and biomedical waste
4. To discuss the various elements of integrated waste management system

Course Content

Types and Sources of Solid and Hazardous Wastes - Need for Solid and Hazardous Waste Management Waste Generation Rates - Composition - Hazardous Characteristics -

TCLP Tests - Waste Sampling - Source Reduction of Wastes - Recycling and Reuse - 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 - Labelling and Handling of Hazardous Wastes. Waste Processing - Processing Technologies - Biological and Chemical Conversion Technologies - Composting - Thermal Conversion Technologies - Energy Recovery - Incineration - Solidification and Stabilization of Hazardous Wastes - Treatment of Biomedical Wastes - Disposal in Landfills - Site Selection - Design and Operation of Sanitary Landfills - Secure Landfills and Landfill Bioreactors - Leachate and Landfill Gas Management - Landfill Closure and Environmental Monitoring - Closure of Landfills - Landfill Remediation - Legislations on Management and Handling of Municipal Solid Wastes, Hazardous Wastes, and Biomedical Wastes - Elements of Integrated Waste Management.

References

1. *George Tchobanoglous, Hilary Theisen and Samuel A, Vigil, Integrated Solid Waste Management, McGraw- Hill, New York, 1993.*
2. *John Pichtel, Waste Management Practices : Municipal, Hazardous, And Industrial, CRC press, 2014*
3. *CPHEEO, Manual on Municipal Solid waste management, Central Public Health and Environmental Engineering Organization, Government of India, New Delhi, 2016.*

Course Outcomes

At the end of the course student will be able
1. to explain the various functional elements involved in waste management system
2. to quantify and categorize solid wastes for any region
3. to prepare concept design for the common functional elements of the waste management systems
4. to select suitable waste processing technologies and disposal methods

Course Code	**:**	CE706
Title of the Course	**:**	**AIR POLLUTION AND CONTROL ENGINEERING**
Designation as a required or elective	**:**	Core
Prerequisites	**:**	Basic knowledge in Air pollution
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. To provide general understanding of air quality and its impact on the environment and human health
2. To study the fate and transport of air pollutants and its measurement techniques
3. To discuss the different control methods and design principles for gaseous and particulate pollutant
4. To explain the principles of biological air pollution control technologies and its limitations

Course Content

Air pollutants - Sources - classification of pollutants - effect on human health vegetation and property - Reactions of pollutants and their effects - Smoke, smog and ozone layer disturbance - Greenhouse effect - Ambient and stack sampling - pollution measurement methods - Criteria pollutants - Ambient air quality and emission standards - Air pollution indices - Air Act - Industrial sources of air pollution - Behaviour of pollutants in atmosphere - Emission factors - regulations - control strategies and policies - Choosing appropriate air pollution control technology - Particulate Pollutant Control - Settling chambers - Filtration - Electrostatic precipitation - Cyclone separation - Wet collectors - Design of various particle control devices - Gaseous Pollutant Control - Gas absorption in tray and packed towers - Absorption with/without chemical reaction - Adsorption in fixed beds - Breakthrough - Wet scrubbers - Design of various pollutant control devices - Control technologies for removal of SO_2, NO_x, VOC - Control technologies for motor vehicles - Biological air pollution control technologies - bioscrubers - biofilters - Integrated air pollution control systems.

References

1. *Wark Kenneth and Warner C.F, Air pollution its origin and control. Harper and Row Publishers, New York, 1997.*
2. *Rao C.S., Environmental pollution control Engineering, New age international Ltd, New Delhi, 2007.*
3. *Peavy, H.S., Rowe, D.R., Tchobanoglous, G. Environmental Engineering, McGraw Hills, New York 1985.*
4. De Nevers, N., Air Pollution Control Engineering, McGraw Hill, New Delhi, 1995

Course Outcomes

At the end of the course student will be able

1. to classify the types and sources of air pollutants and to understand their effects on human health and the broader environment
2. to differentiate and design various air pollution control technologies for particulates and gaseous pollutants
3. to choose appropriate technologies for removal of selective pollutants
4. to establish and implement air quality management components

Course Code	**:**	CE710
Title of the Course	**:**	**ENVIRONMENTAL ENGINEERING PROCESSES LABORATORY**
Designation as a required or elective	**:**	Laboratory
Contact Hours, Type of Course	**:**	45
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. To brief the application of various physico-chemical processes in water and wastewater treatment
2. To quantify the requirement of chemicals for treatment of water
3. To familiarise the kinetics and isotherm models of various processes.
4. To measure the performance of various processes in water and wastewater treatment.

Water Softening - Lime and Caustic Soda Process - Coagulation and Flocculation of Water - Optimization of Dose, pH and Time of Flocculation - Sedimentation - Settling Column Analysis of Flocculating Particles - Filtration - Chlorination - Adsorption- Colour Removal by Adsorption - Heavy Metal Precipitation - Kinetics of Activated Sludge Process - anaerobic digestion - biogas potential- Specific methanogenic activity

Reference

1. *Benfield, L.D.; Weand, B.L.; Judkins, J.F., Process chemistry for water and wastewater. Prentice Hall Inc Englewood Cliffs New Jersey, 1982.*
2. *Weber Jr., W.J. , Physico-chemical Process for Water Quality Control. Wiley Inc. Newyork, 1972.*
3. *Peavy, H.S., Rowe, D.R., Tchobanoglous, G. Environmental Engineering, McGraw Hills, New York, 1985.*
4. *Benefield, L.D. and Randall C.W. Biological Processes Design for wastewaters, Prentice-Hall, Inc. Eaglewood Cliffs, 1989.*

Course Outcomes

At the end of the course student will be able

1. Perform common environmental experiments relating to water and wastewater quality, and know which tests are appropriate for given environmental problems.
2. To demonstrate and analyze basic reactor types and kinetics.
3. To demonstrate and analyze basic environmental engineering processes (physical/chemical) for treatment of contaminants, including gas transfer, adsorption and advanced oxidation processes.
4. To give students theoretical understanding of and hands on experience with basic methods of environmental analysis.

PROGRAMME ELECTIVES

Course Code	**:**	CE711
Title of the Course	**:**	**TRANSPORT OF WATER AND WASTEWATER**
Designation as a required or elective	**:**	Core
Prerequisites	**:**	Basic knowledge in transport of water and wastewater
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. to learn the water transmission mains
2. to study the various components of water distribution system
3. to design Sewer networks and Storm water drains
4. To utilize Computer applications in the design of water distribution and sewer networks

Course Content

Fluid properties - fluid flow - continuity principle, energy principle and momentum principle - frictional head loss in free and pressure flow, minor heads losses, Carrying Capacity - Flow measurement - Estimation of storage capacity - impounding reservoirs - intakes - gravity and pressure conduits - hydraulics of fluid flow - pumps and accessories - capacity of pumps - selection of pumps - maintenance - economic design of pumps and pumping mains , Jointing, laying and maintenance, water hammer analysis - water distribution pipe networks Design, analysis and optimization – appurtenances - corrosion prevention - minimization of water losses - leak detection - storage reservoirs- Strom water Drainage - Necessity- combined and separate system - Estimation of storm water runoff - Formulation of rainfall intensity duration and frequency relationships - Rational methods - Planning factors - Design of sanitary sewer - partial flow in sewers, economics of sewer design - Wastewater pumps and pumping stations- sewer appurtenances - material, construction, inspection and maintenance of sewers - Design of sewer outfalls - mixing conditions; transition flow critical depth in sewers - draw down curves and hydraulic jump - Use of computer software in water transmission, water distribution, sewer and storm water design – EPANET 2.0, SEWER, BRANCH and Canal ++.

References

1. *"Manual on water supply and Treatment", CPHEEO, Ministry of Urban Development, GoI, New Delhi, 2013.*
2. *Bajwa, G.S. "Practical Handbook on Public Health Engineering", Deep Publishers, Shimla, 2003*
3. *M.J.Hammer, "Water and Wastewater Technology", Prentice Hall, New Jercy, 2001*

Course Outcomes

At the end of the course student will be able

1. to select various pipe design for water supply main and distribution network
2. to design sewer network and water supply distribution network for various field conditions
3. to analyze and solve serious problems in water and sewage transmission
4. to use various computer software for the design of water and sewage network

Course Code	**:**	CE712
Title of the Course	**:**	**MEMBRANE TECHNOLOGIES FOR WATER AND WASTEWATER TREATMENT**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	Basic knowledge in water and wastewater treatment
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. To provide a general overview of membrane materials, modules, transport phenomena, and process engineering fundamentals
2. To focus on the most commonly employed membrane processes for water purification
3. To study the role of membrane bioreactors for the treatment of wastewater
4. To brief the membrane preparation methods and its applications

Course Content

Principles of Membrane Processes - Types and Classification - Theory of Membrane Separation - Types and Choice of Membranes - Liquid Membranes - Characterization of Membranes - Recent Development in Membranes - Modules and Washing Process - Electrodialysis - Principles, Electrodialysis Stack and its Various Components - Ion Exchange Capacity - Electrical Resistance of Ion Exchange Membrane - Donnon Dialysis - Reverse Osmosis - Theory and Principle - Membrane Materials - Design Considerations - Filtration- Theory - Nanofiltration - Ultrafiltration -Microfiltration - Membrane Module/Element Designs - Design of Membrane Systems - Membrane Bioreactors - Bio treatment Fundamentals - Biomass Separation - Principles - MBR Design Principles - Submerged Anaerobic Membrane Bioreactors - Fouling - Pretreatment Methods and Strategies - Langlier and Silt Indexes - Cleaning Methods - Foulants Analysis - Disposal of RO Concentrate - Rejects in Membranes - Synthetic Membranes - Preparation Methods - Composite Membranes - Preparation Methods and Applications - Immersion Precipitation Preparation Techniques - Phase Inversion Membranes - Introduction to Module and Process Design.

References

1. *R.D. Noble and S.A. Stern, Membrane Separations Technology: Principles and Applications, Elservier, 1995.*
2. *E.D. Schroeder, Water & Wastewater Treatment, McGraw Hill, 1977.*
3. *J.G. Crespo and K.W. Boddekes, Membrane Processes in Separation and Purification, Kluwer Academic Publications, 1994.*
4. *R. Rautanbach and R. Albrecht, Membrane Process, John Wiley & Sons, 1989.*

Course Outcomes

At the end of the course student will be able
1. to differentiate various membrane processes, principles, separation mechanisms and its applications
2. to explain the selection criteria for different membrane processes
3. to design membrane bioreactors
4. to develop synthetic membranes by various preparation techniques

Course Code	**:**	CE713
Title of the Course	**:**	**INDUSTRIAL WASTEWATER MANAGEMENT**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	Basic knowledge in water and wastewater treatment
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. To study the sources and characteristics of industrial wastewater
2. To learn various pollution prevention options
3. To familiarize the various industrial wastewater treatment methods
4. To give an idea about waste treatment flow sheet for different industries

Course Content

Industrial Wastewater - Sources - Types - Environmental Impacts - Regulatory Requirements - Generation Rates - Characterization -Toxicity and Bioassay Tests - Prevention vs Control of Industrial Pollution - Source Reduction Techniques - Waste Audit - Evaluation of Pollution Prevention Options - Waste Minimization - Equalization - Neutralization - Floatation - Precipitation - Adsorption - Aerobic and Anaerobic Biological Treatment - Sequencing Batch Reactors - High Rate Reactors - Chemical Oxidation - Ozonation - Photocatalysis - Wet Air Oxidation - Evaporation - Ion Exchange - Membrane Technologies - Individual and Common Effluent Treatment Plants - Zero Effluent Discharge Systems - Wastewater Reuse - Disposal of Effluent on Land - Residual Management - Industrial Manufacturing Process - Description, Wastewater Characteristics, Source Reduction Options and Waste Treatment Flow Sheet for Textiles

- Tanneries -Pulp and Paper - Metal Finishing - Petroleum Refining - Pharmaceuticals - Sugar and Distilleries - Food Processing - Fertilizers - Thermal Power Plants - Electroplating - Industrial Estates.

References

1. *Eckenfelder, W. W., Industrial Water Pollution Control, 3rd Edition, McGraw-Hill, 1999.*
2. *Arceivala, S.J., Wastewater Treatment for Pollution Control, 3rd Edition, McGraw-Hill, 2006.*
3. *Frank Woodard, Industrial waste treatment Handbook, Butterworth Heinemann, 2nd Edition, New Delhi, 2006*.

Course Outcomes

At the end of the course student will be able
1. to recognize various environmental problems due to improper management of industrial wastewater
2. to explain various technologies for removal of pollutants from industrial wastewater
3. to design waste treatment flow sheets for industries
4. to recommend the pollution control methods for specific industries

Course Code	**:**	CE714
Title of the Course	**:**	**MODELING OF NATURAL SYSTEMS**
Designation as a required or elective	**:**	Elective
Prerequisites	:	Basic Knowledge in water, wastewater and air quality parameters
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. To study the transport and fate of pollutant in natural systems such as lakes, rivers, estuaries and atmosphere
2. To provide an understanding of mathematical model development for natural systems
3. To brief the mass balance approach and some special models for prediction of air and water quality
4. To learn the numerical techniques for solving the system equations

Course Content

Definition - Classification - Examples of Models for Environmental Systems - Concepts of Scale in Natural Systems - Brief Review of Mass, Momentum and Energy Balance - Transport and fate of pollutant in aquatic systems - Lakes - Rivers - Dissolved oxygen model for streams - Estuaries - Finite Difference and Linear Algebraic Methods to Solve the System Equations - Some Special Models - Introduction to Air Quality Models -

Meteorology - Atmospheric Stability and Turbulence - Gaussian Plume Model and Modifications.

References

1. *Chapra, Steven C., Surface water quality modeling, McGraw Hill International Edition, 1997.*
2. *Davis, M.L., and Cornell, D.A. Introduction to Environmental Engineering, McGraw Hill International Editions, 1998.*
3. *Pevy, Rowe, and Techobanoglous, Environmental Engineering, McGraw Hill Publishing company, Newyork, 2007.*
4. *Gilbert M. Masters, Introduction to Environmental Engineering and Science, Prentice-Hall of India Pvt. Ltd., Newdelhi, 3rd Edition, 2007*
5. Martin, L.J. and McCucheon, S.C, *Hydrodynamics of transport for water quality modeling*, Lewis Publishers, Boca Raton, 1999.

Course Outcomes

At the end of the course student will be able
1. to develop contaminant transport model for natural systems
2. to predict the quality of water in river, lakes and estuaries using specific models
3. to solve the transport equation using numerical techniques
4. to estimate the concentration of pollutant in ambient air using dispersion models

Course Code	**:**	CE715
Title of the Course	**:**	**GROUNDWATER FLOW AND CONTAMINANT TRANSPORT THROUGH POROUS MEDIA**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	Basic knowledge in Modeling of natural systems
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. To provide an understanding of water movement in subsurface environment
2. To study the fate and transport of contaminants through porous media
3. To enumerate various model input parameters for transport of contaminants in subsurface water
4. To familiarize the groundwater modeling tools for model development and prediction

Course Content

Water Movement in the Subsurface - Groundwater Environment - Types of Aquifers - Sources of Contamination - Saturated Flow - Continuity Equation - Darcy's Law - Equation of Flow - Analytical Solutions and Numerical Modeling - Transport of Contaminants - Transport Equation - Dispersion and Diffusion in Porous Media -

Reaction Terms - Adsorption and Surface Complexation Models - Soil Chemical Kinetics - Modeling Groundwater Pollution - Coupling of Contaminant - Soil Interactions with Transport - Reaction and Transport of Trace Metals, Ligands and Non-polar Organic Solutes - Model Input Parameters - Initial and Boundary Conditions - Calibration - Sensitivity Analysis - Groundwater Transport Modelling Using VISUAL MODFLOW.

References

1. Zheng, C. and Bennett, G. D., Applied contaminant Transport Modeling, A John wiley& sons, inc, publication, Newyork, 2002.
2. *Freeze, R.A. and Cherry. J.A. Groundwater, Prentice Hall, 1979.*
3. *Sun, N. Z., Mathematical modelling of groundwater Pollution, Springer –Verlac Newyork Inc., and Geological publishing house, 1996.*
4. *Grathwohl, P., Diffusion in Natural Porous Media: Contaminant Transport, Sorption, desorption and Dissolution Kinetics, Kluwer Academic, Boston, 1998*

Course Outcomes

At the end of the course student will be able
1. to develop flow and transport model for contaminant in subsurface water
2. to differentiate various numerical techniques for solving flow and transport equations
3. to develop reactive transport model for reactive species
4. to apply the software packages to develop contaminant transport model for field condition

Course Code	**:**	CE716
Title of the Course	**:**	**ANALYTICAL METHODS FOR ENVIRONMENTAL MONITORING**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	-
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. To enumerate the various instrumental methods and its principles for environmental monitoring
2. To identify the ion selective electrodes for measurement of ions in water and wastewater
3. To study the principle of chromatography, spectrophotometry and their applications.
4. To provide the information about various material characterization techniques

Course Content

Classification of Instrumental Methods - Performance Characteristics of Instruments (Static And Dynamic) - Errors and Uncertainties in Performance Parameters - Noise Reduction - Sensitivity and Detection Limit - Errors -Types - Expression of Errors - Precision and Accuracy - Calibration of Instrumental Methods - Spectrophotometry - Electromagnetic Radiation - Atomic Absorption and Emission Spectrometry -Ultraviolet - Visible Spectrophotometry Principle and Instrumentation - Atomic Absorption Spectroscopy Principle and Instrumentation - Flame Photometer - Fluorimetry - Nephelometry and Turbidimetry - Principles, Chromatography - Principle and Classification - Column Efficiency and Resolution - Quantitative Determination - Column Chromatography - Thin Layer Chromatography - Principle and Application of Ion chromatography - Application Gas Chromatography (GC) - Principle and Application of High Precision Liquid Chromatography (HPLC) - Ion Chromatography Mass Spectroscopy - Gas Chromatography Mass Spectroscopy (GCMS) - Electro Chemical Methods - Electrochemical Cell - Reference Electrodes - Cyclic Votametry - Polarograph - Oscilloscopi Polarography - Ion Selective Electrodes - Conductometry - Electrolytic Conductivity - Specific Equivalent and Molar Conductance - Working Principles of pH, EC, TDS Meters - Material Characterization Techniques - SEM, TEM, XRD, FTIR, Thermal Analysis - Working Principles and Applications.

References

1. *D. A. Skoog, D.M. West and T.A. Nieman, Principles of Instrumental Analysis,. Thomson Asion (P) Ltd. Singapore, 2004.*
2. *H. H. Willard, L. L. Merit, J. A. Dean and F. A. Settle, Instrumental Methods of Analysis, CBP Publishers and Distributors, New Delhi, 1988.*

Course Outcome

At the end of the course student will be able

1. to analyse the principles of volumetric and instrumental analytical methods in environmental monitoring
2. to use statistical methods for evaluating and interpreting data of environmental interest
3. to discriminate various electrochemical methods
4. to summarize various material characterization techniques and its principles

Course Code	**:**	CE717
Title of the Course	**:**	**ENVIRONMENTAL IMPACT ASSESSMENT**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	Basic knowledge in Impact Assessment
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. To learn the importance of environmental impact assessment in various engineering projects
2. To brief the various methodologies involved in environmental impact assessment
3. To identify the prediction tools for the assessment of different environmental impacts
4. To describe the concepts of environmental management system

Course Content

Evolution of EIA - Concepts - Rapid and Comprehensive EIA - Legislative and Environmental Clearance Procedures in India Screening - Scoping - Base Line Studies - Methodologies - Check List - Matrices - Mitigation - Prediction Tools for EIA - Assessment of Impacts - Air - Water - Soil - Noise - Biological - Socio Cultural Environnent - Public Participation - Resettlement and Rehabilitation - Documentation of EIA - Environmental Management Plan - Post Project Monitoring - Environmental Audit - Life Cycle Assessment – Environmental Management Systems - Case Studies in EIA.

References

1. *Canter R. L., Environmental Impact Assessment, Mc Graw Hill International Edition, 1997.*
2. *John G. Rau and David C. Wooten (Ed), Environmental Impact Analysis Handbook, McGraw Hill Book Company, 1980.*

Course Outcomes

At the end of the course student will be able
1. to analyse the environmental impacts of proposed projects
2. to predict the magnitude of an impact using mathematical tools
3. to propose proper mitigation measures to avoid environmental impacts
4. to summarise the EIA report with suitable environmental management plan

Course Code	**:**	CE718
Title of the Course	**:**	**CLEANER PRODUCTION AND ENVIRONMENTAL SUSTAINABLE MANAGEMENT**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	Basic knowledge in Solid and Hazardous Waste Management
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. To provide the concept of sustainable development and to discuss the strategies and barriers of sustainability

2. To deliberate the principles and concepts of cleaner production and its importance
3. To discuss the green processes and green energy management in various industrial processes.
4. To learn the principles and methods of occupational safety and health, risk assessment and its management

Course Content

Concepts of Sustainable Development - Indicators of Sustainability - Sustainability Strategies, Barriers to Sustainability - Resource Degradation - Industrialization and Sustainable Development - Industrial Ecology - Socio Economic Policies for Sustainable Development - Clean Development Mechanism, - Principles and Concepts of Cleaner Production - Definition - Importance - Historical Evolution - Benefits - Promotion - Barriers - Regulatory versus Market Based Approaches - Environmental Management Hierarchy - Source Reduction Techniques - Process and Equipment Optimization, Reuse, Recovery, Recycle, Raw Material Substitution - Overview of CP Assessment Steps and Skills - Process Flow Diagram - Material Balance - CP Option Generation - Technical and Environmental Feasibility Analysis - Economic Valuation of Alternatives - Total Cost Analysis - Pollution Prevention and Cleaner Production Awareness Plan - Waste Audit - Environmental Statement - Green House Gases and Carbon Credit - Carbon Sequestration- Sustainable Development through Trade - Carbon Trading - Ecotoxicology - Hazards by Industry and its Environmental Effects - Relationship of Occupational Hygiene / Safety and Disease - Overview, Planning, Hazard Identification and Risk Assessment - Pesticides and Environment - Response to Toxic Exposures - Dose Response, Frequency Response and Cumulative Response - Lethal and Sub-Lethal Doses - Dose - Response Relationships between Chemical and Biological Reactions - Detoxification in Human Body - Detoxification Mechanisms, Organs of Detoxification - Green Energy and Green Process Management in Pharmaceutical, Construction, Textiles, Petroleum Refineries, Iron and Steel Industries.

References

1. *J. Kirkby, P. O'Keefe and Timberlake, Sustainable Development, Earthscan Publication, London, 1999.*
2. *P.L. Bishop, Pollution Prevention: Fundamentals and Practice, McGraw Hill International, 2004.*
3. *P. Modak, C. Visvanathan and M. Parasnis, Cleaner Production Audit, Environmental System Reviews, Asian Institute of Technology, Bangkok, 1995.*
4. *H. Koren, Handbook of Environmental Health and Safety -principle and practices, Lewis Publishers, 3rd Edition, 1995.*
5. *I. C. Shaw and J. Chadwick, Principles of Environmental Toxicology, Taylor & Francis ltd, 2000.*

Course Outcomes

At the end of the course student will be able

1. to modify schemes applied at different governance levels to achieve sustainable innovation.
2. to prepare process flow diagram and material balance for various industrial processes

3. to summarize various techniques for cleaner production and to apply environmental sustainable management concepts in industries
4. to examine the toxicological and ecological aspects of ecotoxicology and to transfer knowledge of Eco toxicological theory to new environmental situations

Course Code	**:**	CE719
Title of the Course	**:**	**ECOLOGICAL AND ECO SYSTEMS ENGINEERING**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	Fundamental knowledge in ecology
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. To familiarize the principles and concepts of ecosystem
2. To differentiate the structural and functional interactions of environmental systems
3. To provide the knowledge about modelling of ecological systems
4. To brief the sustainable loading of ecosystems

Course Content

Development and Evolution of Ecosystems - Principles and Concepts - Energy Flow and Material Cycling - Productivity - Classification of Ecotechnology - Ecological Engineering - Classification of Systems - Structural and Functional Interactions of Environmental Systems - Mechanisms of Steady State Maintenance in Open and Closed Systems - Modeling and Ecotechnology - Classification of Ecological Models - Applications - Ecological Economics - Self Organizing Design and Processes - Multi Seeded Microcosms - Interface Coupling in Ecological Systems - Concept of Energy - Determination of Sustainable Loading of Ecosystems - Ecosanitation - Soil Infiltration Systems - Wetlands and Ponds - Source Separation Systems - Aqua Cultural Systems - Agro Ecosystems - Detritus Based Treatment for Solid Wastes - Marine Systems - Case Studies.

References

1. *Kangas, P.C. and Kangas, P., Ecological Engineering: Principles and Practice, Lewis Publishers, New York, 2003.*
2. *Etnier, C. and Guterstam, B., Ecological Engineering for Wastewater Treatment, Lewis Publishers, New York, 1997.*

Course Outcomes

At the end of the course student will be able
1. to classify, evaluate and design interface ecosystems
2. to design sustainable loading of eco systems
3. to develop model in different ecological scenarios and applications in real field
4. to expertise on eco sanitation regarding different ecosystem

Course Code	**:**	CE720
Title of the Course	**:**	**INDOOR AIR QUALITY**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	Basic knowledge in Air pollution and control engineering
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. To assess the level of pollutants in indoor and outdoor air
2. To learn the modeling tools and concepts for indoor air quality assessment
3. To study the various outdoor sources contributing indoor air pollution
4. To elaborate various control technologies and strategies for indoor air pollution

Course Content

Indoor Activities of Inhabitants - Levels of Pollutants in Indoor and outdoor Air - Design and Operation of Buildings for Improvements of Public Health - IAQ Policy Issues - Sustainability - Air Pollutants in Indoor Environments - Private Residences, Offices, Schools, Public Buildings - Ventilation - Control of Several Pollutant Classes - Radon - Toxic Organic Gases - Combustion Byproducts - Microorganisms such as Molds and Infectious Bacteria - Concepts and Tools - Exposure - Material Balance Models - Statistical Models - Indoor Air Pollution from Outdoor Sources - Particulate Matter and Ozone - Combustion Byproducts - Radon and its Decay Products - Volatile Organic Compounds - Odors and Sick - Building Syndrome - Humidity - Bio Aerosols - Infectious Disease Transmission - Special Indoor Environments - A/C Units in Indoor - Measurement Methods - Control Technologies - Control Strategies.

References

1. *Thaddes Godish, Indoor air and Environmental Quality, CRC press, 2000.*
2. *Nazaroff* W.W. and *L. Alvarez-Cohen, Environmental Engineering Science, Wiley sons, Newyork, 2001*.
3. *Indoor Air Quality Handbook, John D. pengler, John F. McCarthy, and Jonathan M. Same, McGraw Hill, 2000.*

Course Outcomes

At the end of the course student will be able
1. to point out the factors affecting Indoor Air Quality (IAQ)
2. to predict the indoor air quality using mathematical model
3. to suggest the control techniques for indoor air pollution
4. to measure the pollutant concentration in indoor environment

Course Code	**:**	CE721
Title of the Course	**:**	**ENVIRONMENTAL BIOTECHNOLOGY**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	-
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. To study the principles and concepts of environmental biotechnology
2. To learn the applications of various biotechnological tools for the treatment and betterment of environment
3. To enumerate the various biotechnological remedies for environmental pollution
4. To brief the environmental effects and ethics of microbial technology

Course Content

Environmental Biotechnology - Principles and Concepts - Usefulness to Mankind - Degradation of High Concentrated Toxic Pollutants - Halogenated, Non Halogenated, Petroleum Hydrocarbons, Metals - Mechanisms of Detoxification -Oxidation - Dehalogenation - Biotransformation of Metals - Biodegradation of Solid Wastes - Biotechnological Remedies for Environmental Pollution - Decontamination of Groundwater - Bioremediation - Production of Proteins - Biofertilizers - Physical, Chemical and Microbiological Factors of Composting - Health Risk - Pathogens -Odor Management - Microbial Cell/Enzyme Technology - Adapted Microorganisms -Biological Removal of Nutrients - Algal Biotechnology - Extra Cellular Polymers - Biogas Technology - Concept of rDNA Technology - Expression Vectors - Cloning of DNA - Mutation - Construction of Microbial Strains - Radioactive Probes - Protoplast Fusion Technology - Applications - Environmental Effects and Ethics of Microbial Technology - Genetically Engineered Organisms - Microbial Containment - Risk Assessment. Bioremediation and Biodegradation - Microbial Catabolism of Organic Pollutant - Catabolic Enzymes - Biodegradation Detoxication Reactions - Biodegradation Kinetics - Requirements of Biodegradation – Nutritional, Environmental and Biological Factors - Monitoring and Assessment Methods - Soil Enzyme Assay - Bacterial Biosensors - Toxicological Risk Assessments - Improved Bioremediation by Engineering Microbes - Bioadsorbents - Metal Precipitation - Enzymatic Transformation of Metals.

References

1. *Chaudhury, G.R., Biological degradation and Bioremediation of toxic chemicals, Dioscorides Press, Oregon, 1994.*
2. *Bhattacharya, B. C. and Banerjee R., Environmental Biotechnology, Oxford University Press, India, 2007.*
3. *Martin.A.M, Biological degradation of wastes, Elsevier Applied Science, London, 1991.*
4. *Blaine Metting.F (Jr.,) Soil Microbiology Ecology, Marcel Dekker Inc., 1993.*

Course Outcomes

At the end of the course student will be able

1. to explain the mechanisms of detoxification and biodegradation of solid wastes
2. to list out the different methods for bioremediation of environment and to design biological system for the removal of nutrients
3. to evaluate the benefit of microorganisms in degrading organic contaminants and to choose suitable microorganism for biodegradation of selected compounds.
4. to select suitable assessment methods for bioremediation

Course Code	**:**	CE722
Title of the Course	**:**	**GEOENVIRONMENTAL ENGINEERING**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	-
Contact Hours, Type of Course	**:**	40
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. To study the sources of soil contamination and its impact on geoenvironment.
2. To familiarize with the retention and flow behavior of contaminants in soil.
3. To realize the significance of sampling techniques in geoenvironmental characterization.
4. To understand the state of the art methodologies for soil decontamination and containment.

Course Content

Basic concepts related to soil pollution; Sources of pollution- industrial, mining, agricultural, and municipal; types of contaminants; Impact of contamination- physical and chemical properties of soil; Retention behavior- governing factors, sorption characteristics, isotherms; Contaminant transport- saturated and unsaturated flow, pore size distribution characteristics; Site investigation- Soil sampling, sample handling, transportation, characterization, preservation and storage; Non-destructive techniques- electromagnetic, thermal and seismic, Soil remediation- need and approach, Techniques- soil washing, permeable reactive barriers, solidification, vacuum extraction, electro kinetic remediation, thermal desorption; Bioremediation, phytoremediation, soil fracturing; Case studies on polluted sites and issues related to environment. Containment systems and basic principles – carbon dioxide sequestration, Grout curtains, Ground freezing, Compacted soil liners, Geosynthetic clay liners.

References

1. *Rowe R.K., "Geotechnical and Geoenvironmental Engineering Handbook" Kluwer Academic Publications, London, 2000.*

2. *Reddi L.N. and Inyang, H. I., "Geoenvironmental Engineering, Principles and Applications" Marcel Dekker Inc. New York, 2000.*
3. *Yong, R. N., "Geoenvironmental Engineering, Contaminated Soils, Pollutant Fate, and Mitigation" CRC Press, New York, 2001.*
4. *Sharma H.D. and Reddy K.R., "Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies" John Wiley & Sons, Inc., USA, 2004.*

Course Outcomes

At the end of the course student will be able
1. To identify the origin, nature, and extent of contamination in field.
2. To predict the retention and flow properties of contaminants.
3. To adopt suitable sampling techniques for geoenvironmental characterization.
4. To suggest the remediation techniques for decontamination.

Course Code	**:**	CE723
Title of the Course	**:**	**ADVANCED GEOENVIRONMENTAL CHARACTERIZATION TECHNIQUES**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	-
Contact Hours, Type of Course	**:**	40
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. To study the limitations of conventional techniques for geoenvironmental characterization.
2. To familiarize the state of the art tools for physio-chemical characterization of geomaterials.
3. To understand the suitability of various imagery techniques for micro- and nano level investigations.
4. To realize the importance of non-destructive testing methodologies for geo environmental applications.

Course Content

Need for characterization; conventional techniques, limitations. Physical Characterization- particle size distribution, Specific surface area, BET analysis; specific gravity measurements; Volumetric and gravimetric moisture content measurements, Rheological properties of soil, viscometer. Chemical Characterization- soil chemistry, micro and macronutrient in soils, soil water interaction, SWRC, suction measurement; XRF analysis; sorption studies, batch test and column test, gas chromatography. Mineralogical Characterization- soil fabric and structure, crystalline and amorphous

materials, XRD. Morphological characterization: Imagery techniques- SEM, Laser obscuration Time measurement, X-ray tomography, TEM. Nondestructive testing methods: Thermal Characterization- FTIR analysis, TGA-DTA analysis, Heat flux sensor, Thermal consolidometer, GasCon-TP; Electrical Characterization- dielectric constant, digital oscilloscope, Impedance analyzer.

References

1. *Yong, R. N., "Geoenvironmental Engineering, Contaminated Soils, Pollutant Fate, and Mitigation" CRC Press, New York, 2001.*
2. *Chaney, R. C. and Fang, H. Y., "Introduction to environmental geotechnology". CRC press, 2016.*
3. *Mitchell, J. K. and Soga, K., "Fundamentals of soil behavior". Vol. 3. New York: John Wiley & Sons, 2005.*
4. *Smart, P. and Tovey, N. K., "Electron microscopy of soils and sediments: techniques". Oxford University Press, 1982.*
5. *Cooper, J. D., "Soil water measurement: a practical handbook". John Wiley & Sons, 2016.*

Course Outcomes

At the end of the course student will be able

1. To judge the suitability of conventional test protocols for material characterization.
2. To adopt need-based laboratory testing for encountering geoenvironmental issues.
3. To analyze and interpret the data generated from various characterization techniques.
4. To comprehend the knowledge of non-destructive testing techniques for tackling geoenvironmental issues.

Course Code	**:**	CE724
Title of the Course	**:**	**REMOTE SENSING AND GIS FOR ENVIRONMENTAL APPLICATIONS**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	-
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. To learn the fundamentals Geographic Information System and data types
2. To give an idea about the various geospatial operations
3. To familiarize the concepts of Remote Sensing and satellite's products
4. To discuss the various applications of remote sensing and GIS for environmental Engineering

Course Content

Fundamentals of Geographic Information System - geo-data - type - Input Sources - Raster and Vector data structures - Comparison of Raster and Vector data - errors in data - Projection and transformation - Reclassification - proximity analysis - various geo-spatial analysis - Electro Magnetic energy - EMR spectrum - EMR interaction with atmosphere - Scattering - Atmospheric Windows and its Significance - EMR interaction with Earth Surface Materials - Spectral Signature - EMR interaction with water, soil and Earth Surface - Introduction to image processing - Pre-processing and corrections - Visual Interpretation of Satellite Images - Environmental Satellites - GOES, NOAA, AVHRR, CZCR, OCM and MODIS - Water supply and sewerage network modelling - Groundwater vulnerability for pollution - DRASTIC and SINTACS model - Eutrophication and sedimentation in lakes and reservoir - Impact urbanization on catchment - nutrients transport modelling - Remote Sensing application on soil salinity mapping - OCM and MODIS applications on suspended sediment mapping - Monitor and mapping of atmosphere constituents - aerosol mapping using MODIS satellite - Site suitability analysis for disposal of solid waste using Multi Criterion Analysis - GIS for health and emergency management - Impact analysis.

References

1. *Sabins, F., Remote Sensing Principles and Interpretation, W. H. Freeman and Company, New York, Third edition, 2007.*
2. *Allan Brimicombe., GIS Environmental Modeling and Engineering, Taylor & Francis, second edition, 2009.*
3. *Lai, Poh C., Mak, Ann S.H. (Eds.) GIS for Health and Environment, Springer Publication, 2007.*
4. *Uzair M.S., GIS Tools for Water, Wastewater, and Storm water Systems, ASCE Press, 2002.*
5. *George Joseph, Fundamentals of Remote sensing, University Press, Second edition, 2005.*

Course Outcomes

At the end of the course student will be able

1. to summarize the basic spectral mechanism behind remote sensing and GIS techniques
2. to explain different software for data creation, analysis and modelling
3. to understand geo database development and geo-spatial analysis for environmental applications
4. to apply the image processing techniques for various environmental problems

Course Code	**:**	CE725
Title of the Course	**:**	**ENVIRONMENTAL SYSTEMS ANALYSIS**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	Fundamental Knowledge in systems
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives

1. To brief the role of optimization models in planning and design of environmental engineering projects
2. To list out various optimization models and its limitations
3. To learn the application of simulation models in environmental projects
4. To provide an understanding of application of modern tools in different case studies

Course Content

Systems Engineering - Analysis - Design - Synthesis - Applications to Environmental Engineering Systems - Role of Optimization Models - Deterministic Models/Linear Programming - Dynamic Programming - Separable and Nonlinear Programming Models - Formulation of Objective Functions and Constraints for Environmental Engineering Planning and Design - Probabilistic Models - Fuzzy Models - Simulation Models - Modern Tools - Expert Systems - Neural Networks - Genetic Algorithm - Case Studies - Applications.

References

1. *Rich L.G., Environmental Systems Engineering, McGraw Hill, 1973.*
2. *Thoman R.V., Systems Analysis & water Quality control, McGraw Hill, 1978.*

Course Outcomes

At the end of the course student will be able

1. to analyse the system performance using simulation models
2. to optimize environmental engineering Systems using optimization models
3. to employ model-based environmental analysis
4. to choose a suitable environmental systems analysis method and tool for a given decision situation.