MASTER OF TECHNOLOGY

ENVIRONMENTAL ENGINEERING

CURRICULUM

(EFECTIVE FROM 2016-17 ONWARDS)

DEPARTMENT OF CIVIL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
TIRUCHIRAPPALLI-620015

Master of Technology
(Environmental Engineering)

CURRICULUM

(Effective from 2016 – 17 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 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	Transport of Water and Wastewater	3
CE706	Air Pollution Control Engineering	3
	Elective IV	3
	Elective V	3
	Elective VI	3
CE710	Environmental Microbiology and Engineering 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

ELECTIVES

Sl. No.	Code	Course of Study	Credit
1.	CE711	Process Chemistry for Water and Wastewater Treatment	3
2.	CE712	Industrial Wastewater Management	3
3.	CE713	Membrane Technologies for Water and Wastewater Treatment	3
4.	CE714	Solid and Hazardous Waste Management	3
5.	CE715	Biodegradation and Bioremediation Techniques	3
6.	CE716	Environmental Impact Assessment	3
7.	CE717	Ecological and Ecosystems Engineering	3
8.	CE718	Environmental Health and Eco Toxicology	3
9.	CE719	Cleaner Production and Environmental Sustainable Management	3
10.	CE720	Modelling of Natural Systems	3
11.	CE721	Groundwater Flow and Contaminant Transport Through Porous Media	3
12.	CE722	Indoor Air Quality	3
13.	CE723	Analytical Methods for Environmental Monitoring	3
14.	CE724	Environmental Biotechnology	3
15.	CE725	Environmental Geotechnology	3
16.	CE726	Environmental Policies and Legislations	3
17.	CE727	Remote sensing and GIS for environmental applications	3
18.	CE728	Environmental Systems Analysis	3
19.	CE729	Environmental Engineering Structures	3

Open Electives

Sl. No.	Code	Course of Study	Credit
1.	CE719	Cleaner Production and Environmental Sustainable Management	3
2.	CE723	Analytical Methods for Environmental Monitoring	3

COURSE OUTCOME AND PO MAPPING

CORE SUBJECTS

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
MA701	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 chemistry and microbiology	CO1	To develop analytical and conceptual skills required for environmental chemistry research	M	M		H		M			M		M
		CO2	To understand the transport and transformation of chemicals	M	H							M	H	L
		CO3	To categorize various water borne diseases and its transmitting agents	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 soil	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	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
CE706	Air pollution 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 microbiology and engineering laboratory	CO1	To assess the microbial contamination in water	L	L	M	H	M				L		L
		CO2	To quantify the requirement of chemicals for treatment of water	L	M		H	M						M
		CO3	To evaluate the various kinetic and isotherm models	L		M	M	L		L		L		M
		CO4	To measure the performance of biological reactor	M		M	M	L					L	M

ELECTIVES

Course Code	Course Name	CO	Course outcomes	a	b	c	d	e	f	g	h	i	J	k
CE711	Process chemistry for water and wastewater treatment	CO1	To infer the chemical processes involved in the treatment of water and wastewater	M	M	L	M	L	L		L	M	L	M
		CO2	To apply the concepts of solubility equilibria for treatment of industrial wastewater	M	M	M	H	L	L			M		L
		CO3	To differentiate the various biological conditions by measuring redox potential	M	M	H	H	M	L			L		M
		CO4	To quantify the dosage of chemicals requirement based on chemical reactions in water treatment	M	L	M	M	L	L			L		L
CE712	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
CE713	Membrane technology 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
CE714	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
CE715	Biodegradation and bioremediation techniques	CO1	To understand the fate and transport of contaminants in soil and water bodies	H	M	L	H	L	M			M	L	M
		CO2	To evaluate the benefit of microorganisms in degrading organic contaminants	H	M	M	M	M	L	L		L		L
		CO3	To choose suitable microorganism for biodegradation of selected compound	M	H	L	H	L	L			M	M	
		CO4	To select suitable assessment methods for bioremediation	H	H	M	H	M	L	L		M		M
CE716	Environmental impact assessment	CO1	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
CE717	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
CE718	Environmental health and eco-toxicology	CO1	To differentiate the carriers or vectors that promote the transfer of these agents from the environment to humans	H	M	L	H	M	M			M	L	
		CO2	To examine the toxicological and ecological aspects of ecotoxicology	H	H	M	H	H	M			L	M	L
		CO3	To transfer knowledge of ecotoxicological theory to new environmental situations	H	M	H	M	L	M	L		L	M	M
		CO4	To explain detoxification in human body and its mechanisms	H	M	H	H	M	M		L	M		M
CE719	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	M	M	L	H		M	L		L	H	

		CO4	To apply environmental sustainable management concepts in industries	M	H	H	M	L	M	H	M	M	H	H
CE720	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
CE721	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
CE722	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

CE723	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		
CE724	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	M	L	L	M	L	M	M		M	L	
		CO3	To design biological system for the removal of nutrients	H	H	H	H	M	M	L		L	M	M
		CO4	To estimate the risk involved through Risk assessment	H	H	M	H	M	M	M	M	L	H	M
CE 725	Environmental geotechnology	CO1	To analyze the mineralogical characteristics of soil	H	M	L	H	L	L			M		M
		CO2	To summarize the impact of contaminants on the properties of soil	H	M		M		M	L		M	H	
		CO3	To explain the concept of various waste containment facilities	M	L		M		M		L	M		
		CO4	To evaluate the stability of landfill liner for waste containment	H	M	M	H	M	L	L		M	M	M
CE726	Environmental policies and legislations	CO1	To relate and analyze Indian and International environmental policies and legislation	H	M	L	M		M		M	M	H	L

		CO2	To summarize the pollution control acts for water and air pollution	H	M		M		M		L	M	H	
		CO3	To analyse global environmental issues and to recommend suitable control methods	H	H	H	M	L	M	L	M	L	H	M
		CO4	To point out principles and various indicators of sustainability	M	H		H	M				M	H	
CE727	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		
CE728	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

CE729	Environmental engineering structures	CO1	To select the fundamental requisites to design an environmental structure	M	M	M	H	M	L			L	L	
		CO2	To describe the inter-relationships between the built environment and natural systems	H	H		H	L	M	L	L	M	M	
		CO3	To evaluate different types of structural and non-structural cracks	H	H	M	H	M	L			M	L	L
		CO4	To analyze suitable alternatives for repair and rehabilitation of structures	H	H	H	H	M	M		L	M	H	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 Chemistry and Microbiology, Modeling of Natural Systems, Groundwater flow and contaminant transport through porous media, Environmental Systems Analysis Solid and Hazardous Waste Management, Industrial Wastewater Management, Environmental Impact Assessment
MD2	**TUTORIAL** A method of instruction in which an instructor works directly with an individual student.	1. A detailed presentation of view, which shows and 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.	PO a, e, f, h, i	Physico-chemical Process for Water and Wastewater Treatment, Biological Process 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 Chemistry and Microbiology, Modeling of Natural Systems, Groundwater flow and contaminant transport through porous media, Environmental Systems Analysis Solid and Hazardous Waste Management, Industrial Wastewater Management, Environmental Impact Assessment
MD4	**SEMINAR / TERM PAPER** An arrangement involving the instructor and groups, rather than instructor and individual.	1. To provide general guidance for a group working on an advanced study or research 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.	PO a, h	Physico-chemical Process for Water and Wastewater Treatment, Biological Process Design for Wastewater Treatment, 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.	PO a, e, h	Physico-chemical Process for Water and Wastewater Treatment, Biological Process Design for Wastewater Treatment, Industrial Wastewater

		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.		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. 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.	PO a, b, c, f, h	Environmental Impact Assessment, Environmental Policies and Legislations

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 Control Engineering, Indoor Air Quality
MD8	**Case Studies / field visit**		PO a, b, d, f, h, i, j	

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.	Professional 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.	Professional Core (Laboratory)	▪ MD1: Lectures with interactions ▪ MD6: Group discussions ▪ MD7: Demonstrations / hands on training (Models, Laboratory) / mini project	▪ Black board ▪ Multimedia Presentation
4.	Professional 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.	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	**:**	MA701
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, Semester Examination

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 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, Semester Examination

Course Learning Objectives

1. To provide detail understating of various aspects of chemistry, which are particularly valuable to environmental scientific practice
2. To give knowledge about the principles and applications of various environmental monitoring instruments
3. To study the techniques for testing the microorganisms
4. To describe the characteristics and growth kinetics of microbial populations

Course Content

Colloids - redox potentials - partition coefficient - beer lambert's law - limitations - uv visible spectroscopy - basic principles - application - atomic spectroscopy -principles and applications - principles of green chemistry - error analysis of environmental data - transport and transformation of chemicals - dissolved oxygen - BOD and COD - photo catalysis - degradation of food stuffs - detergents, pesticides and hydrocarbons - soil chemistry - acid, base and ion exchange reactions in soil - salt affected soil and its remediation - Microbiological concepts - classification of microorganisms - prokaryotic, eukaryotic, structure, characteristics, nucleic acids - DNA, RNA, replication - Culturing of microoraganisms - environmental factors influencing microbial growth - growth kinetics - Distribution of microorganisms - water, air and soil - Indicator organisms - coliforms, fecal coliforms, E.coli, streptococcus, clostridium, MPN and MFT - Algae in water supplies - problems and control - Ecotoxicology - toxicants and toxicity - factors influencing toxicity - effects - acute - chronic - bioaccumulation - bio magnification - bioassay - bio monitoring.

References

1. C. N. Sawyer, P. L. McCarty, and G. F. Parkin, Chemistry for Environmental Engineering, 5th Edition, Tata McGraw-Hill, New Delhi, 2003.

2. G. W. Vanloon and S. J. Duffy Environmental chemistry -a global perspective, Oxford University press,3rd Edition, Newyork, 2010.
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 develop analytical and conceptual skills required for environmental chemistry research
2. to understand the transport and transformation of chemicals
3. to categorize various water borne diseases and its transmitting agents
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, Semester Examination

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 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, Semester Examination

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 measure the concentration of pollutants in ambient air
4. To evaluate the ability of soil sample for cation exchange

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 - Ambient Air Quality Analysis - Determination of SPM, CO, NO_X and SO_X - Soil Analysis - pH, Conductivity, Cation Exchange Capacity, Sodium Adsorption Ratio.

Reference

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

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, soil 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, Semester Examination

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	**:**	**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, Semester Examination

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	**:**	CE706
Title of the Course	**:**	**AIR POLLUTION 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, Semester Examination

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 learn the control technologies for specific air pollutants
5. 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 MICROBIOLOGY AND ENGINEERING LABORATORY**
Designation as a required or elective	**:**	Laboratory
Contact Hours, Type of Course	**:**	45
Course Assessment Methods	**:**	Continuous Assessment, Semester Examination

Course Learning Objectives

1. To study the various techniques for the examination of microorganisms
2. To brief the application of various physico-chemical processes in water and wastewater treatment
3. To familiarise the kinetics of activated sludge process

Microscopic Examination of Microorganisms - Preparation of Bacterial Smear - Staining - Basic Pure Culture Techniques - Plate Count Test, MPN Tests and MFT Tests - 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.

Reference

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

Course Outcomes

At the end of the course student will be able

1. to assess the microbial contamination in water
2. to quantify the requirement of chemicals for treatment of water
3. to evaluate the various kinetic and isotherm models
4. to measure the performance of biological reactor

ELECTIVES

Course Code	**:**	CE711
Title of the Course	**:**	**PROCESS CHEMISTRY FOR WATER AND WASTEWATER TREATMENT**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	Fundamental Knowledge in Process chemistry
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, Semester Examination

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 learn the application of redox potentials in wastewater treatment
4. To discuss the application of redox chemistry for the treatment of water by chemical processes

Course Content

Environmental Chemistry - Basic Concepts from General Chemistry - Chemical Equations - Types of Chemical Reactions - Solutions - Activity and Activity Coefficients - Chemical Equilibria - Chemical Thermodynamics - Factors Affecting Chemical Equilibrium - Gas Laws - Acid Base Equilibria - Fundamentals - Equilibrium Diagrams - Alkalinity and Acidity, Carbonic Acid System, Buffering in Water Systems, Measuring Alkalinity - Solubility Equilibria - Slightly Soluble Salts, Effect of Other Solutes on Salt Solubility - Removal of Heavy Metals from Complex Water and Wastewater Systems - Oxidation Reduction Equlilibria - Oxidation Reduction Processes - Galvanic Cell - Chemical Thermodynamics - Stability Diagrams - Measuring Redox Potentials - Water Stabilization - Electrochemical Aspects of Corrosion - Langelier Saturation Index - Caldwell Lawrence Diagrams - Water Softening and Neutralization - Chemical Precipitation - Ion Exchange - Application of Redox Chemistry.

References

1. Benfield, L.D.; Weand, B.L.; Judkins, J.F. (1982) *Process chemistry for water and wastewater*. Prentice Hall Inc, Englewood Cliffs, New Jersey.
2. Weber Jr., W.J. (1972) *Physico-chemical Process for Water Quality Control*. Wiley Inc. Newyork.

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 for treatment of industrial wastewater

3. to differentiate the various biological conditions by measuring redox potential
4. to quantify the dosage of chemicals requirement based on chemical reactions in water treatment

Course Code	**:**	CE712
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, Semester Examination

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	**:**	CE713
Title of the Course	**:**	**MEMBRANE TECHNOLOGIES FOR WATER AND WASTEWATER TREATMENT**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	CE712/ Industrial wastewater Management
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, Semester Examination

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	**:**	CE714
Title of the Course	**:**	**SOLID AND HAZARDOUS WASTE MANAGEMENT**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	Fundamental knowledge in Waste management
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, Semester Examination

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. *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	**:**	CE715
Title of the Course	**:**	**BIODEGRADATION AND BIOREMEDIATION TECHNIQUES**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	CE714 / Solid and Hazardous waste Management
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, Semester Examination

Course Learning Objectives

- To give a basic knowledge of the bioremediation and biodegradation techniques
- To study the fate and transport of contaminants in soil and water bodies.
- To provide an understanding of the bioremediation monitoring and toxicological risk assessment
- To learn current engineering methods/design used to enhance biodegradation

Course Content

Bioremediation and Biodegradation - Historical Perspectives of Biodegradation and Bioremediation - Contaminant Bioavailability - Microbial Catabolism of Organic Pollutant - Catabolic Enzymes - Properties - Designing of Microorganisms - Biodegradation Measurement Potential - Impediments to Microbial Biodegradation - Biodegradation Detoxication Reactions - Principles of Biodegradation -

Biodegradation Kinetics - Effect of Pollutant Chemical Structure on Biodegradation - Fate and Transport of Contaminants in Soils and Water Bodies - Requirements of Biodegradation - Nutritional Factors - Chemical Structure - Environmental Factors - Biological Factors - Bioavailability and Aging, Bioremediation Monitoring and Assessment Methods - Conventional Plating and Microbial Enumeration - Biochemical and Physiological Methods - BIOLOG - Soil Enzyme Assay - Immunochemical Methods - Phospholipids Fatty Acid Analysis - Molecular Biology Based Methods - Bacterial Biosensors - Molecular Techniques - Toxicological Risk Assessments - Biodegradation of Organic Compounds - Anaerobic Biodegradation of Benzene and Ethyl Benzene - Polyaromatic Transformation and Degradation - Co-Metabolic Process for Polychlorinated Biphenyl Degradation - Aerobic Hexa chloro cyclohexane Biodegradation - Co Posting of Contaminated Soil - Improved Bioremediation by Engineering Microbes - Bioadsorbents - Metal Precipitation - Enzymatic Transformation of Metals - Strains for Enhanced Biodegradation - Improved Biodegradation by Protein.

References

1. *A. Singh and O.P. Ward Biodegradation and bioremediation, Springer-Verlag Berlin Heidelberg New York, 2004.*
2. *K.H. Baker and D.S. Herson, Bioremediation, McGraw-Hill, Inc., New York, 1994.*
3. *M. Alexander, Biodegradation and Bioremediation, 2nd Edition, Academic Press, 1999.*

Course Outcomes

At the end of the course student will be able
1. to understand the fate and transport of contaminants in soil and water bodies
2. to evaluate the benefit of microorganisms in degrading organic contaminants
3. to choose suitable microorganism for biodegradation of selected compound
4. to select suitable assessment methods for bioremediation
5. to understand the role of different strains and protein in the enhanced biodegradation

Course Code	**:**	CE716
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, Semester Examination

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 - Methodologies - Screening - Scoping - Base Line Studies - Mitigation - Matrices - Check List - Rapid and Comprehensive EIA - Legislative and Environmental Clearance Procedures in India - 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 - EMS - 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	**:**	CE717
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, Semester Examination

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, 2nd Edition, 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	**:**	CE718
Title of the Course	**:**	**ENVIRONMENTAL HEALTH AND ECO-TOXICOLOGY**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	CE717/ Ecological and Ecosystems Engineering
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, Semester Examination

Course Learning Objectives

1. To provide a broad overview of different aspects of Ecotoxicology
2. To learn the principles and methods of occupational safety and health administration
3. To discuss the health risk assessment and its management in different industries
4. To study the transport of toxicants in air and water

Course Content

Need for Developing Environment - Health and Safety Systems in Work Places - Extent of Industrial Pollution - Public Exposure from Industrial Sources - Major Chemical Contaminants at Workplace - Hazards by Industry and its Environmental Effects - Status and Relationship of Acts - Regulations and Codes of Practice - Relationship of Occupational Hygiene/ Safety and Disease - Occupational Safety

and Health Administration - Principles and Methods of Occupational Health - Occupation Health and Safety Policy - OH & SMS Documentation - Health Problem due to Industrial Dust, Heat, Chemicals, Noise, Toxic Gases and Metals - Health Hazard in Agriculture - Pesticides and Environment - Pesticides and Human Health - Right to Know Laws - Overview, Planning, Hazard Identification and Risk Assessment - Biological, Chemical, Physical and Psychological Health Hazard - Health Risk Assessment and Management in Tanneries, Pharmaceutical, Construction, Textiles, Petroleum Refineries, Iron and Steel Industries - Toxic Substances in the Environment - their Sources and Entry Roots - Routes of Toxicants to Human Body - Entry through Inhalation, Skill Absorption, Indigestion and Injection - Eco-System Influence on the Fate and Transport of Toxicants - Transport of Toxicants by Air and Water - Transport through Food Chain - Bio Transformation and Bio Magnification, Accident Causation - Need for Accident Investigation, Accident Investigation Plan, Methods of Acquiring Accident Facts, 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 - Education and Training in Health Hygiene.

References

1. *H. Koren, Handbook of Environmental Health and Safety -principle and practices, Lewis Publishers, 3rd Edition, 1995.*
2. *I. C. Shaw and J. Chadwick, Principles of Environmental Toxicology, Taylor & Francis ltd, 2000.*

Course Outcome

At the end of the course student will be able

1. to differentiate the carriers or vectors that promote the transfer of these agents from the environment to humans
2. to examine the toxicological and ecological aspects of ecotoxicology
3. to transfer knowledge of ecotoxicological theory to new environmental situations
4. to explain detoxification in human body and its mechanisms

Course Code	**:**	CE719
Title of the Course	**:**	**CLEANER PRODUCTION AND ENVIRONMENTAL SUSTAINABLE MANAGEMENT**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	CE714 / Solid and Hazardous Waste Management
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, Semester Examination

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 enumerate the various elements of life cycle assessment
4. To discuss the green building and green energy management in various industries

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, Cleaner Production (CP) in Achieving Sustainability - Principles and Concepts of Cleaner Production - Definition - Importance - Historical Evolution - Benefits - Promotion - Barriers - Role of Industry, Regulations to Encourage Pollution Prevention and Cleaner Production - Regulatory versus Market Based Approaches - Environmental Management Hierarchy - Source Reduction Techniques - Process and Equipment Optimization, Reuse, Recovery, Recycle, Raw Material Substitution - Internet Information & other CP Resources - Overview of CP Assessment Steps and Skills - Preparing for the Site Visits - Information Gathering - Process Flow Diagram - Material Balance - CP Option Generation - Technical and Environmental Feasibility Analysis - Economic Valuation of Alternatives - Total Cost Analysis - CP Financing - Establishing a Program - Organizing a Program - Preparing a Program Plan - Measuring Progress - 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 - Elements of Life Cycle Assessment (LCA) - Life Cycle Costing - Eco Labelling - Design for the Environment - International Environmental Standards - ISO 14001 - Environmental Audit, Green Building & Green Energy Concepts and Management - Industrial Applications of CP, LCA, EMS and Environmental Audits - 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.*

Course Outcome

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
4. to apply environmental sustainable management concepts in industries

Course Code	**:**	CE720
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, Semester Examination

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	**:**	CE721
Title of the Course	**:**	**GROUNDWATER FLOW AND CONTAMINANT TRANSPORT THROUGH POROUS MEDIA**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	CE720/ Modeling of natural systems
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, Semester Examination

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	**:**	CE722
Title of the Course	**:**	**INDOOR AIR QUALITY**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	CE706 / Air pollution control engineering
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, Semester Examination

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	**:**	CE723
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, Semester Examination

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,5th Ed. Thomson Asion (P) Ltd. Singapore, 2004.*
2. *H. H. Willard, L. L. Merit, J. A. Dean and F. A. Settle, Instrumental Methods of Analysis, 7th Ed. 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	**:**	CE724
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, Semester Examination

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.

References

1. *Chaudhury, G.R., Biological degradation and Bioremediation of toxic chemicals, Dioscorides Press, Oregon, 1994.*

2. *Bhattacharya, B. C. and Banerjee R., (2007) Environmental Biotechnology, Oxford University Press, India*
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
3. to design biological system for the removal of nutrients
4. to estimate the risk involved through Risk assessment

Course Code	**:**	CE725
Title of the Course	**:**	**ENVIRONMENTAL GEOTECHNOLOGY**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	Civil
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, Semester Examination

Course Learning Objectives

1. To discuss the role of environmental geotechnology in waste management
2. To brief the mechanisms of the soil, water and contaminant interactions
3. To provide the concept of waste containment facilities
4. To familiarize the advanced soil characterization techniques

Course Content

Soil as a Multiphase System - Soil -Environment Interaction - Properties of Water in Relation to the Porous Media - Water Cycle with Special Reference to Soil Medium - Soil Mineralogy - Significance of Mineralogy in Determining Soil Behavior - Mineralogical Characterization - Mechanisms of Soil-Water Interaction - Diffused Double Layer Models - Force of Attraction and Repulsion - Soil-Water-Contaminant Interaction - Theories of Ion Exchange - Influence of Organic and Inorganic Chemical Interaction - Introduction to Unsaturated Soil Mechanics - Water Retention Property and Soil Water Characteristic Curve - Flow of Water in Unsaturated Soil - Concept of Waste Containment Facilities - Desirable Properties - Contaminant Transport and Retention - Contaminated Site Remediation - Introduction to Advanced Soil Characterization Techniques - Volumetric Water Content - Gas Permeation in Soil - Electrical and Thermal Properties - Pore Size Distribution - Contaminant Analysis.

References

1. *Mitchell, J.K and Soga, K Fundamentals of soil behavior, John Wiley and sons Inc., 3rd Edition, 2005.*

2. *Fang, H-Y, Introduction to Environmental Geotechnology, CRC Press, 1997.*
3. *Daniel, D.E, Geotechnical practice for waste disposal, Chapman and Hall, 1993.*
4. *Rowe, R.K, Quigley, R.M and Booker, Clay Barrier systems for Waste disposal facilities, J.R., E & FN Spon, 1995.*
5. *Rowe, R.K, Geotechnical and Geoenvironmental Engineering Handbook , Kluwer Academic publishers, 2001.*
6. *Reddi, L.N. and Inyang H.F, Geoenvironmental Engineering -Principles and Applications, Marcel Dekker Inc., 2000.*
7. *Sharma, H.D. and Lewis, S.P, Waste Containment systems, Waste stabilization and Landfills: Design and evaluation, John Wiley & sons Inc., 1994.*

Course Outcomes

At the end of the course student will be able
1. to analyse the mineralogical characteristics of soil
2. to summarize the impact of contaminants on the properties of soil
3. to explain the concept of various waste containment facilities
4. to evaluate the stability of landfill liner for waste containment

Course Code	**:**	CE726
Title of the Course	**:**	**ENVIRONMENTAL POLICIES AND LEGISLATIONS**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	Fundamental knowledge in Environmental policies
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, Semester Examination

Course Learning Objectives

1. To give an idea about the most relevant environmental legislations and policies
2. To provide an overview of the development of statutory environmental law in India
3. To discuss about the global environmental issues and international laws to control them
4. To familiarize the various environmental movements for sustainable developments

Course Content

Common Environmental Laws - Role of Judiciary in Environmental Protection - Criminal Law, Common Law - Criminal Procedure Code - Indian Penal Code - Fundamental Rights and Fundamental Duties - International and National Efforts at Environmental Protection - Green Funding and Taxes - National Environmental Policies - Framework for Environmental Impact Assessment - Pollution Control Acts for Water and Air Pollution - Water Prevention and Control of Pollution) Act, 1974- Water (Prevention and Control of Pollution) Cess Act, 1977 - Air (Prevention & Control of Pollution) Act, 1981 - Other Environmental Protection Acts -

Environmental (Protection) Act, 1986 - Forest Conservation Act, 1980 - National Forest Policy 1988 - Wild Life (Protection) Act, 1972 - Public Insurance & Liabilities Act, 1991- Biomedical Wastes (Management and Handling)- Noise Pollution - Eco-Labelling - EIA Coastal Zone Notification (1991) - International Laws - Stockholm Conference - The Rio Earth Summit, 1992 - Montreal Protocol - Kyoto Summit, 1997 - Nairobi Declaration - World Summit on Sustainable Development, 2002 - Role of UN Authorities in Protection of Global Environment - Global Environmental issues and international Laws: to Control Global Warming, Ozone Depletion, Acid Rains, Hazardous Waste - Sustainable Developments and Environmental Movements - Sustainable Development Principles - Indicators of Sustainability - Sustainable Development Models - National and International Sustainable Development Scenarios (POP)

References

1. *S. Divan and A. Roseneranz, Environmental law and policy in India, Oxford University Press, New Delhi, 2001.*
2. *R. K. Sapru, Environmental Management in India Vol. I & II): Ashish Publishing House, 2004.*
3. *Gupta, K.R., Environmental Legislation of India, Atlantic Publishers, 2006.*

Course Outcome

At the end of the course student will be able
1. to relate and analyze Indian and International environmental policies and legislation
2. to summarize pollution control acts for water and air pollution
3. to analyse global environmental issues and to recommend suitable control methods
4. to point out principles and various indicators of sustainability

Course Code	**:**	CE727
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, Semester Examination

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 Outcome

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	**:**	CE728
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, Semester Examination

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

Course Code	**:**	CE729
Title of the Course	**:**	**ENVIRONMENTAL ENGINEERING STRUCTURES**
Designation as a required or elective	**:**	Elective
Prerequisites	**:**	-
Contact Hours, Type of Course	**:**	36
Course Assessment Methods	**:**	Continuous Assessment, Semester Examination

Course Learning Objectives

1. To study the design concepts of various environmental engineering structures
2. To enumerate the various repair and rehabilitation methods for various waste treatment units
3. To differentiate the design concepts of surface and subsurface structures
4. To identify different types of structural failures in treatment units

Course Content

Structural Design of Concrete - Prestressed Concrete - Anchorage for Pipes - Massive Outfalls - Design of Concrete Roofing Systems a) Cylindrical b) Spherical and c) Conical Shapes using Membrane Theory - Design of Water Retaining Structures - Design of Circular, Rectangular, Spherical and Intze Type of Tanks - Design of Prestressed Concrete Cylindrical Tanks - Underground Reservoirs and Swimming Pools - intake Towers - Structural Design of Settling Tanks - Clarifloculators - Aeration Tanks - Effect of Earth Pressure and Uplift Considerations - Identification of Different types of Structural and Non-Structural Cracks - Repair and Rehabilitation Methods for Masonry, Concrete and Steel Structures.

References

1. *Krishna Raju, Prestressed Concrete, Tata McGraw Hill, 2012.*
2. *Sinha N.C., Roy S.K., Reinforced Concrete, S. Chand and Co, 2013.*

Course Outcome

At the end of the course student will be able

1. to select the fundamental requisites to design an environmental structure
2. to describe the inter-relationships between the built environment and natural systems
3. to evaluate different types of structural and non-structural cracks
4. to analyze suitable alternatives for repair and rehabilitation of structures