CURRICULUM AND DETAILED SYLLABI

FOR

M.E DEGREE (Environmental Engineering) Programme
FIRST SEMESTER TO FOURTH SEMESTER

For the students admitted from the academic year 2020-2021

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided ISO 9001-2008 certified
Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

Approved in 60th Academic Council Meeting held on 25.07.2020

THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI – 625 015
DEPARTMENT OF CIVIL ENGINEERING

Vision

To establish process of learning to meet the global standards for sustainable built environment

Mission

We are committed to:

- Provide quality education through innovation in teaching and learning practices meeting the global standards
- Encourage faculty and students to carry out socially relevant and forward looking research
- Offer consultancy services using state of the art facilities fulfilling the needs of the industry and society
- Enable our students, faculty and staff to play leadership roles for the betterment of the society in a sustainable manner.

Programme Educational Objectives (PEOs) of M.E. (Environmental Engineering)

PEO1: Graduates of the programme will have in depth knowledge to identify and formulate challenging Environmental Engineering problems and apply appropriate research methodologies and use modern engineering tools and provide technically sound, economically feasible and sustainable solutions.

PEO2: Graduates of the programme will possess sound analytical and lateral thinking ability to engage in lifelong learning for professional advancement to cope up with the increasingly multi-disciplinary and rapidly evolving Environmental Engineering profession.

PEO3: Graduates of the programme will become socially responsible and will demonstrate abilities to communicate and work effectively in an ethical way and ready to play leadership roles in their profession, public services and community.

Programme Outcomes (POs) of M.E. (Environmental Engineering)

Graduating Students of M.E. Environmental Engineering programme will have

Programme Outcomes (POs)		Graduate Attributes (GAs)
PO1.	Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.	Scholarship of Knowledge
PO2.	Analyze complex 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.	Critical Thinking
PO3.	Think laterally and originally, conceptualize and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.	Problem Solving
PO4.	Extract information pertinent to unfamiliar 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 engineering.	Research Skill
PO5.	Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations.	Usage of modern tools
PO6.	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.	Collaborative and Multidisciplinary work
PO7.	Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economic and financial factors.	Project Management and Finance
PO8.	Communicate with the engineering community, and with society at large, regarding complex 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.	Communication

PO9.	Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.	Life-long Learning
PO10.	Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.	Ethical Practices and Social Responsibility
PO11.	Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.	Independent and Reflective Learning

Programme Specific Outcomes (PSOs) for M.E Environmental Engineering

Graduates of M.E. Environmental Engineering programme will:

PSO1:

Investigate, analyze, design and evaluate sustainable solutions for environmental issues using scientific and technological principles with the aid of modern tools.

PSO2:

Explore and provide economical, ethical solutions and frame policies through multi-disciplinary and collaborative approach for the betterment of the society.

Department of Civil Engineering

Environmental Engineering programme

Schedule of courses

Semesters	Theory Courses					Theory cum Practical	Practical	Project	Credits
	1	2	3	4	5	6	7	8	
1st	18EN110- Applied Statistics and optimization (3 credits)	18EN120- Environmental Chemistry and Microbiology (3credits)	18EN130 - Air pollution control Engineering and Management (3 credits)	18EN140 - Solid and Hazardous waste management (3 credits)	18ENPX0 (3 credits)	18EN161- Physico-Chemical treatment system (3 credits)	18EN171- Environmental Engineering laboratory (2 credits)	-	20
2nd	18EN210 – Biological treatment process (3credits)	18ENPX0 (3 credits)	18ENPX0 (3 credits)	18ENPX0 (3 credits)	18PGPX0- Open elective (2 credits)	18PG250- Research methodology and IPR (2 credits)	18EN270 – Environmental Systems laboratory (2 credits)	18EN280- Mini project (2 credits)	20
3rd	18ENPX0 (3 credits)	-	-	-	-	18EN360- Environmental Impact and Risk Assessment (3 credits)	-	18EN380- Dissertation Phase I (10 credits)	16
4th	-	-	-	-	-	-	-	18EN480- Dissertation Phase II (15 credits)	15
Total credits									**71**

Passed in Board of Studies meeting held on 02.07.2020

Approved in 60th Academic Council Meeting held on 25.07.2020

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

M.E Degree (Environmental Engineering) Program

COURSES OF STUDY

(For the candidates admitted from 2020-2021 onwards)

FIRST SEMESTER

Course code	Name of the Course	Category **	No. of Hours / Week			Credits
			L	T	P	
THEORY						
18EN110	Applied Statistics and optimization	FC	3	0	-	3
18EN120	Environmental Chemistry and Microbiology	FC	3	0	-	3
18EN130	Air pollution control Engineering and Management	PC	3	0	-	3
18EN140	Solid and hazardous waste management	PC	3	0	-	3
18ENPX0	Programme Elective-I	PE	3	0	-	3
18EN161	Physico-Chemical treatment system	TCP	2	0	2	3
PRACTICAL						
18EN171	Environmental Engineering laboratory	PC	-	-	4	2
Total			**14**	**0**	**6**	**20**

SECOND SEMESTER

Course code	Name of the Course	Category **	No. of Hours / Week			Credits
			L	T	P	
THEORY						
18EN210	Biological treatment process	PC	2	1	-	3
18ENPX0	Programme Elective-II	PE	3	0	-	3
18ENPX0	Programme Elective – III	PE	3	0	-	3
18ENPX0	Programme Elective – IV	PE	3	0	-	3
18PGPX0	Open Elective	OE	2	0	-	2
18PG250	Research methodology and IPR	CC	2	0	-	2
PRACTICAL						
18EN270	Environmental Systems laboratory	PC	-	-	4	2
18EN280	Mini Project	PC	-	-	4	2
Total			**17**	**0**	**8**	**20**

THIRD SEMESTER

Course code	Name of the Course	Category **	No. of Hours / Week			Credits
			L	T	P	
THEORY						
18ENPX0	Programme Elective – V	PE	3	0	-	3
18EN360	Environmental Impact and RiskAssessment	TCP	2	0	2	3
PRACTICAL						
18EN380	Dissertation phase –I	PC	-	-	20	10
Total			**7**	**0**	**22**	**16**

FOURTH SEMESTER

Course code	Name of the Course	Category **	No. of Hours / Week			Credits
			L	T	P	
PRACTICAL						
18EN480	Dissertation phase – II	PC	-	-	30	15
Total			**-**	**-**	**30**	**15**

*** FC- Foundation core; PC- Programme Core; PE-Programme Elective; TCP – Theory cum practical; OE-Open Elective; CC-common core; SS-Self-Study Course (in the list of Programme Electives)*

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit
2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

M.E Degree (Environmental Engineering) Program

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2020-2021 onwards)

FIRST SEMESTER

S.No	Sub. Code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	18EN110	Applied Statistics and optimization	3	50	50	100	25	50
2	18EN120	Environmental Chemistry and Microbiology	3	50	50	100	25	50
3	18EN130	Air pollution control Engineering and Management	3	50	50	100	25	50
4	18EN140	Solid and hazardous waste management	3	50	50	100	25	50
5	18ENPX0	Programme Elective-I	3	50	50	100	25	50
6	18EN161	Physico-Chemical treatment system	3	50	50	100	25	50
PRACTICAL								
7	18EN171	Environmental Engineering laboratory	3	50	50	100	25	50

SECOND SEMESTER

S. No	Sub. Code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	18EN210	Biological treatment process	3	50	50	100	25	50
2	18ENPX0	Programme Elective-II	3	50	50	100	25	50
3	18ENPX0	Programme Elective – III	3	50	50	100	25	50
4	18ENPX0	Programme Elective – IV	3	50	50	100	25	50
5	18PGPX0	Open Elective	3	50	50	100	25	50
6	18PG250	Research methodology and IPR	3	50	50	100	25	50
PRACTICAL								
7	18EN270	Environmental Systems laboratory	3	50	50	100	25	50
8	18EN280	Mini Project	3	100	50	100	25	50

THIRD SEMESTER

S. No	Sub. Code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	18ENPX0	Programme Elective – V	3	50	50	100	25	50
2	18EN360	Environmental Impact and Risk Assessment	3	50	50	100	25	50
PRACTICAL								
3	18EN380	Dissertation phase I	-	50	50	100	50	100

FOURTH SEMESTER

S. No	Sub. Code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
PRACTICAL								
1	18EN480	Dissertation phase – II	-	50	50	100	50	100

* Continuous Assessment evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students.

** Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks.

LIST OF ELECTIVES

S.NO	CODE	NAME OF THE COURSE
1.	18ENPA0	Industrial Wastewater Management
2.	18ENPB0	Environmental Policies and Legislations
3.	18ENPC0	Environmental Systems Analysis
4.	18ENPD0	Occupational Health and Industrial safety
5.	18ENPE0	Environmental Management System and Auditing
6.	18ENPF0	Climate Change and Adaptation
7.	18ENPG0	Environmental Biotechnology
8.	18ENPH0	Environmental Remote Sensing
9.	18ENPJ0	Resource and Energy Recovery from Waste
10.	18ENPK0	Surface and Ground Water Quality Modeling
11.	18ENPL0	Fate and Transport of Contaminants in the Environment
12.	18ENPM0	Air Quality Modeling
13.	18ENPN0	Sustainable Management of Urban Ecology
14.	18ENPP0	Indoor Air Quality Management
15.	18ENPQ0	Sustainable Development and Environment
16.	18ENPR0	Environmental Geotechnology
17.	18ENPS0	Biodegradation and Bioremediation techniques
18.	18ENPT0	Computational Intelligence for hydro systems
19.	18ENPU0	Transport of water and wastewater

OPEN ELECTIVE

S.No	CODE	Course Name
1.	18OEXX0	Project Management

LIST OF AUDIT COURSES

S.No	CODE	Course Name
1.	18PGAA0	Professional Authoring
2.	18PGAB0	Value Education

18EN110	APPLIED STATISTICS AND OPTIMIZATION	Category	L	T	P	Credit
		FC	3	0	0	3

Common to 18IM110

Preamble

The correlation refers to the techniques used in measuring the closeness of relationship between the variables. When three or more variables are studied, it is a problem of either multiple or partial correlation. Estimators refer to the problem of determining the functions of sample observations such that the distribution is concentrated as closely as possible near the true value of the parameter. A statistical hypothesis is a quantitative statement about the probability distribution characterizing a population which we want to verify on the basis of information available from a sample. Non-Parametric or distribution free methods that often assume no knowledge whatsoever about the distributions of the underlying populations, except perhaps that they are continuous. In design of experiments we consider some aspects of experimental design briefly and analysis of data from such experiments using analysis of variance techniques.

Prerequisite

Probability and Statistics

Course Outcomes

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

	Course outcomes	Bloom's level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	Calculate the value which relates the dependent variable to one or more independent variables.	Apply	65	B
CO2	Identify statistical information contained in random samples about the populations from which the samples were obtained.	Understand	75	A
CO3	Calculate the characteristic of the population with degree of confidence from the random sample.	Apply	80	A
CO4	Calculate the most reliable results of the population based on all the information available in a sample using non-parametric methods.	Apply	75	A
CO5	Calculate the experimental error and hence to control the extraneous variables involved in the experiment.	Apply	90	A
CO6	Calculate the optimum values of unconstrained optimization problems using search methods.	Apply	80	A

Mapping with Programme Outcomes

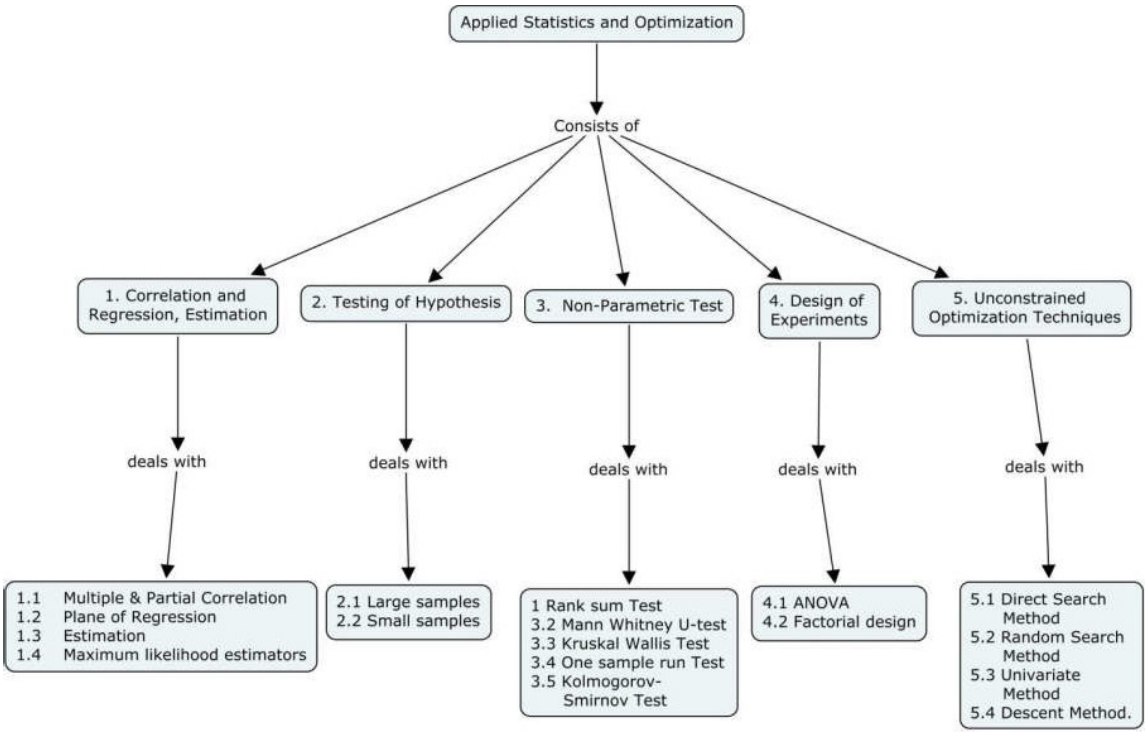
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1.	-	-	-	S	-	-	-	-	-	-	-	M	L
CO2.	-	-	S		M	-	-	-	-	-	-	S	M
CO3	-	L	-	M		-	-	-	-	-	-	S	M
CO4	-	M	-	-	S	-	-	-	-	-	-	S	L
CO5	-	-	-	L	M	-	-	-	-	-	-	S	L
CO6	-	-	S	M	-	-	-	-	-	-	-	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	20	10	10
Understand	30	20	20	20
Apply	60	60	70	70
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Concept Map



Syllabus

Sampling Distribution & Estimation Multiple and Partial Correlation, Yules notation, plane of regression, Coefficient of partial and multiple correlation-properties, Sampling-distribution statistics, Standard error, point and interval estimation for population mean, variance, Maximum likelihood estimators. **Testing of Hypothesis** Testing of hypothesis-inferences concerning to means, variances and proportions, t-test, Chi-Square test, F-test. **Non Parametric Tests** Sign test of paired data**,** Rank Sum test, Mann Whitney U-test, Kruskal Wallis test, One sample run test, Kolmogorov-Smirnov test. **Design of Experiments** Analysis of Variance-One way classification, Two way classification, Block randomized design, Latin Square design, Factorial design, Test of Significance of main and interaction effects. **Unconstrained Optimization Techniques** Direct Search Method, Random Search Method, Univariate Method, Pattern search Method, Descent Method, Steepest Descent Method.

Course Contents and Lecture Schedule

S.No	Topics	No.of Lectures
	Sampling Distribution & Estimation	
1.1	Sampling-distribution statistics, Standard error	2
	Tutorial	1
1.2	Point and interval estimation for population mean & variance, Maximum likelihood estimators	2
	Tutorial	1
	Testing of Hypothesis	
2.1	Testing of hypothesis-inferences concerning to means, variances and proportions	2
	Tutorial	1
2.2	t-test	1
2.4	Chi-Square test, F-test	2
	Tutorial	1
	Non Parametric Tests	
3.1	Sign test of paired data	1
3.2	Rank Sum test	2
	Tutorial	1
3.3	Mann Whitney U-test, Kruskal Wallis test	2
	Tutorial	1
3.4	One sample run test, Kolmogorov-Smirnov test	2
	Tutorial	1
	Design of Experiments	
4.1	Analysis of Variance-One way classification	1
4.2	Two way classification	1
	Tutorial	1
4.3	Block randomized design	1
	Tutorial	1
4.4	Latin Square design	1
	Tutorial	

	Unconstrained Optimization Techniques	
5.2	Univariate Method, Pattern search Method	2
	Tutorial	2
5.3	Descent Method, Steepest Descent Method	2
	Tutorial	1
	Total	**36**

Reference Books

1. Irwin Miller, John E.Freund -Probability and Statistics for Engineers‖ Prentice Hall of India Pvt. Ltd.; New Delhi, 1977.
2. S.S Rao -Optimization Techniques‖. Wiley Eastern Ltd.; 1992.
3. T.Veerarajan -Probability, Statistics and Random Processes‖ Tata McGraw-Hill, New Delhi, 2003.
4. Ronald E.Walpole, Sharon L.Myers -Probability and Statistics for Engineers and Scientists‖. Eighth Edition, Pearson education, New Delhi, 2007.

Course Designers:

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		Category	L	T	P	Credit
18EN120	**ENVIRONMENTAL CHEMISTRY AND MICROBIOLOGY**	FC	3	0	0	3

Preamble

To impart knowledge on various aspects of chemical equilibrium, kinetics, pollution in the environment and its effects on the biological systems. This course would also enable the students to systematically analyze different materials using analytical chemistry and imply them in characterization and treatment of industrial and municipal wastes.

Microbiology is the study of living organisms of microscopic size, which include bacteria, fungi, algae, protozoa and the infectious agents. It is concerned with their form, structure, reproduction, physiology, metabolism and classification. It includes the study of their distribution in nature, their relationship to each other and to other organisms, their effects on human beings and on other animals and plants, their abilities to make physical and chemical changes in our environment, and their reactions to physical and chemical agents

Prerequisite

Basic knowledge on Engineering chemistry, biotic and abiotic components.

Course Outcomes

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

	Course outcomes	Bloom's level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1.	Summarize the chemical concepts of solutions and their reactions in environment	Understand	80	A
CO2.	Identify the nature of adsorption occurring in environmental processes	Apply	80	A
CO3.	Select the appropriate chemical instrumental techniques for analyzing the characteristics of liquid and solid samples	Apply	80	A
CO4.	Explain the characteristics and structure of microbes.	Understand	80	A
CO5.	Generalize the role of microorganisms in pollution control and apply for biological treatment processes	Apply	80	A

Mapping with Programme Outcomes

COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	L	-	L	-	-	L	M	L	M	-	-	-	L
CO2	L	-	L	-	-	L	M	M	-	L	-	-	M
CO3	L	-	L	-	-	L	M	M	-	L	-	-	M
CO4	M	M	M	M	-	M	M	L	L	-	-	M	M

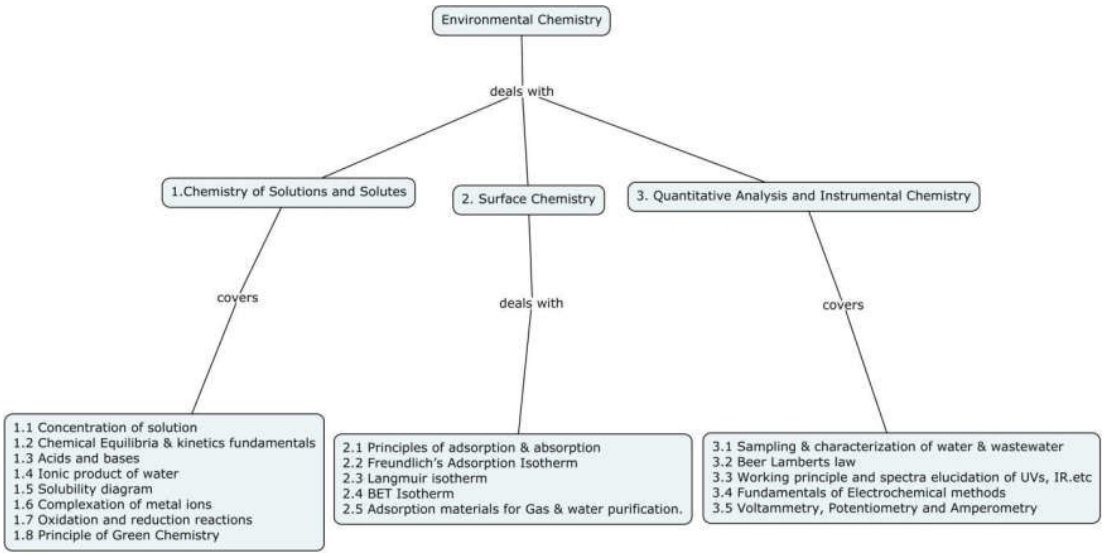
CO5	M	M	M	M	-	M	M	L	L	-	-	L	M

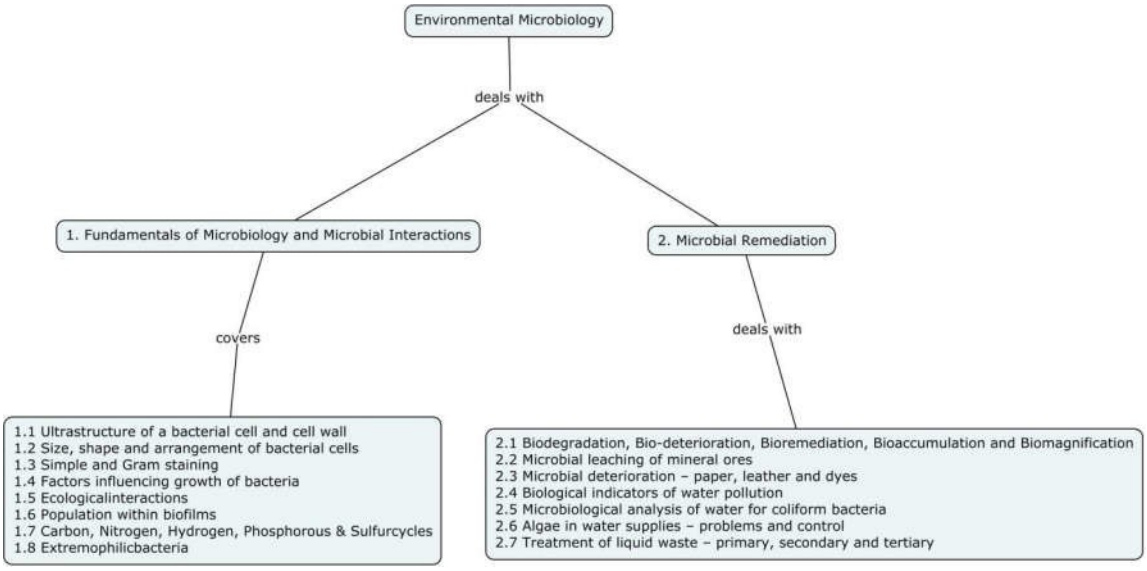
S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	20
Understand	20	20	20	40
Apply	20	20	20	40
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Concept Map





Syllabus

Chemistry of Solutions and Solutes: Concentration of solution, Chemical Equilibria and kinetics fundamentals; Acids and bases; Acidity; Alkalinity; Buffers and buffer intensity; Solubility diagram; Complexation of metal ions and organic complexes in natural water. Oxidation and reduction reactions, Pourbaix diagram; Principle of Green Chemistry**. Surface Chemistry:** Principles of adsorption and absorption-Factors affecting adsorption- Adsorption isotherms - -Langmuir isotherm-BET Isotherm-Applications of adsorption isotherms. Adsorption materials for Gas and water purification**. Quantitative Analysis and Instrumental Chemistry:** Sampling and characterization of water and wastewater by volumetric and colorimetric methods - Beer Lamberts law - Working principle and spectra elucidation of UV-Vis, IR/FTIR spectrophotometers – Fundamentals of Electrochemical methods – Voltammetry, Potentiometry and Amperometry.

Fundamentals of Microbiology and Microbial Interactions Ultra structure of a bacterial cell and cell wall-Size, shape and arrangement of bacterial cells-Simple and Gram staining-Factors influencing growth of bacteria Ecological interactions - symbiosis, mutualism, commensalism, competition, parasitism and predation-Population within biofilm-Carbon, Nitrogen, Hydrogen, Phosphorous and Sulphur cycles-Extremophilic bacteria-**Microbial Remediation** Biodegradation, Bio-deterioration, Bioremediation, Bioaccumulation and Biomagnifications-Microbial leaching of mineral ores-Microbial deterioration – paper, leather and dyes-Biological indicators of water pollution-Microbiological analysis of water for coli form bacteria-Algae in water supplies – problems and control-Treatment of liquid waste – primary, secondary and tertiary.

Course contents and lecture schedule

S.No	Topic	No. of Lectures
	Environmental Chemistry	
	1. Chemistry of Solutions and Solutes	
1.1	Concentration of solution	1
1.2	Chemical Equilibria and kinetics fundamentals	1
1.3	Acids and bases; Acidity; Alkalinity; Buffers and buffer intensity	1
1.4	Ionic product of water – Concept of Solubility	1
1.5	Solubility diagram	1
1.6	Complexation of metal ions and organic complexes in natural water	1
1.7	Oxidation and reduction reactions and Eh-pH diagram	1
1.8	Principle of Green Chemistry	1
	2.Surface Chemistry	
2.1	Principles of adsorption and absorption-Factors affecting adsorption-Adsorption isotherms	1
2.2	Freundlich's Adsorption Isotherm and applications	1
2.3	Langmuir isotherm and applications	1
2.4	BET isotherm and Surface area calculation	1
2.5	Adsorption materials for water and gas purification	1
	3.Quantitative Analysis and Instrumental Chemistry	
3.1	Sampling and characterization of water and wastewater by volumetric methods	1
3.2	Calorimetric methods for Quantitative analysis - Beer Lamberts law – Limitations	1
3.3	Working principle and spectra elucidation of UV-Vis-NIR spectroscopy	1
3.4	Working principle and spectra elucidation of FTIR spectroscopy	1
3.5	Fundamentals of Electrochemical methods –Voltammetry, Potentiometry and Amperometry	1
	Environmental Microbiology	
	1. Fundamentals of Microbiology and Microbial Interactions	
1.1	Ultrastructure of a bacterial cell and cell wall	1
1.2	Size, shape and arrangement of bacterial cells	1
1.3	Simple and Gram staining	1
1.4	Factors influencing growth of bacteria	1
1.5	Ecologicalinteractions - symbiosis, mutualism, commensalism,	1

	competition, parasitism and predation	
1.6	Population within biofilms	1
1.7	Carbon, Nitrogen, Hydrogen, Phosphorous and Sulfurcycles	2
1.8	Extremophilic bacteria	1
	2.2 Microbial Remediation	
2.1	Biodegradation, Bio-deterioration, Bioremediation, Bioaccumulation and Biomagnification	1
2.2	Microbial leaching of mineral ores	1
2.3	Microbial deterioration – paper, leather and dyes	2
2.4	Biological indicators of water pollution.	1
2.5	Microbiological analysis of water for coliform bacteria	1
2.6	Algae in water supplies – problems and control	1
2.7	Treatment of liquid waste – primary, secondary and tertiary	2
	Total	**36**

Reference Books

1. Atlas, R.A. and Bartha, R. 2000. Microbial Ecology- Fundamentals and Application, Benjamin Cummings, New York.
2. Grant, Wd. And Long, PL. 1981. Environmental Microbiology. Blackie Glasgow, London.
3. Madigan, M.T., Martinka, M., Parker, J. and Brock, T.D. 2009. Twelth Edition, Brock Biology of Microorganisms, Mac MillanPress,England.
4. C. N. Sawyer, P. L. McCarty, and G. F. Parkin, Chemistry for Environmental Engineering, 5th Edition, Tata McGraw-Hill, New Delhi, 2003.
5. Anil Kumar De, Environmental Chemistry, Seventh Edition, New Age International (P) Limited, 2014.

Course Designers:

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		Category	L	T	P	Credit
18EN130	**AIR POLLUTION CONTROL ENGINEERING AND MANAGEMENT**	PC	3	0	0	3

Preamble

This course work is designed to undertake preventive control measures of air pollutants that are released from various sources. This course deals with atmospheric sciences to understand the flow pattern of air with the influence of wind, temperature and pressure etc. This course work focus on characterization of air/smoke and various control equipment for particulates and gases. This also deals with properties of sound waves and preventive control measures of noise pollution along with its sources.

Course Outcomes

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

	Course outcomes	Bloom's Taxonomy	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	Classify the sources of air pollution, explain the effects and impacts of air pollutants on the environment.	Understand	85	A
CO2	Apply suitable air sampling techniques to characterize ambient air quality and stack smoke quality.	Apply	75	B
CO3	Apply modeling techniques to predict pollutant transport mechanisms.	Analyse	65	C
CO4	Examine, preventive and control measures for particulate and gaseous pollutants.	Analyse	65	C
CO5	Classify noise pollution sources and Produce control measures for noise pollution.	Analyse	65	C
CO6	Investigate to extract pertinent information through literature survey for the scientific and technological control of Air and Noise Pollution.	Analyse	65	C

Mapping with Programme Outcomes

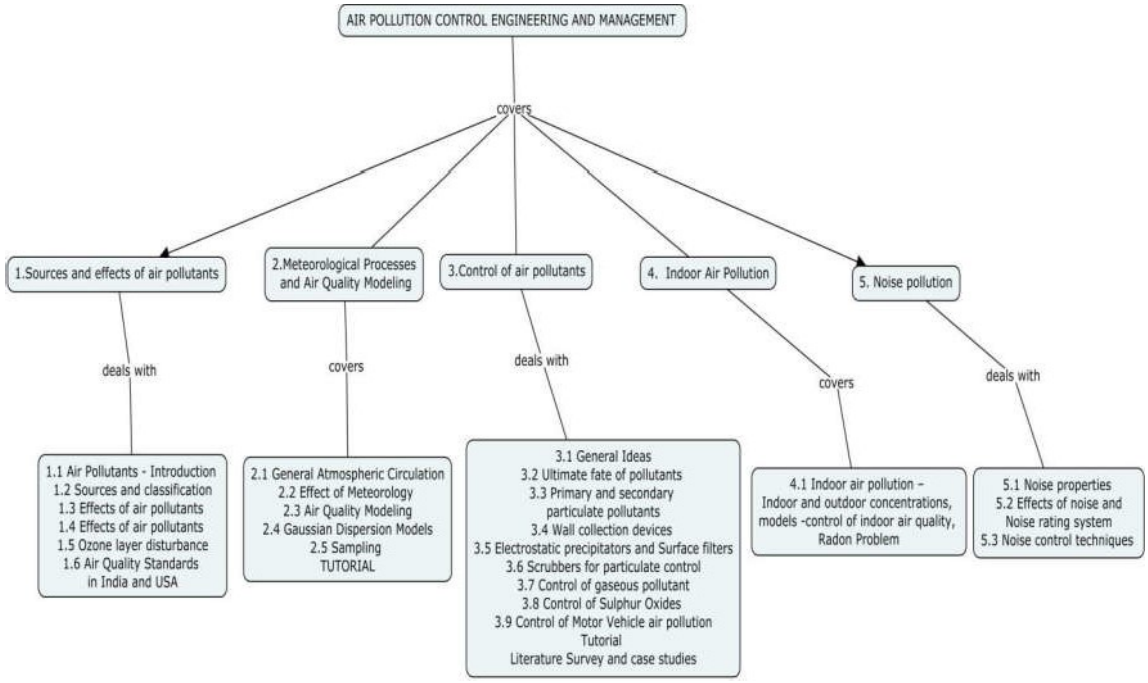
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1.	M	L	L	-	-	-	-	-	-	-	-	L	-
CO2.	M	M	M	-	-	-	-	-	-	-	-	M	-
CO3	S	M	M	-	S	-	-	M	M	-	M	M	M
CO4	S	M	M	-	-	S	-	L	M	-	M	M	L
CO5	S	M	M	-	-	-	-	L	M	-	-	M	L
CO6	S	L	L	S	-	S	-	M	M	-	M	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	50	30	30	30
Apply	30	25	25	25
Analyse	-	25	25	25
Evaluate	-	-	-	-
Create	-	-	-	-

Concept Map



Syllabus

Sources and effects of air pollutants: Industrial Accidents, Air Pollutants, Sources and classification of air pollutants-Effects of air pollutants – on human, plants, animals, materials -Effects of air pollutants - On meteorological conditions-Ozone layer disturbance, green house effects-Air Quality Regulations in India and USA, Air Quality Standards. **Meteorological Processes and Air Quality Modeling:** General Atmospheric Circulation, Atmospheric Thermodynamics, Atmospheric Stability, Boundary Layer Development-Effect of Meteorology on Plume Dispersion, Wind Velocity, Beaufort Scale, Wind Rose, Local Climatological Data-Air Quality Modeling: Types of Plumes, Flow Regimes of a Plume, Plume Rise, Ambient Air Concentration Modeling-Gaussian Dispersion Models, Plume Dispersion Parameters, Computer Programs, USEPA Recommended Models-Sampling –

Ambient air sampling, Stack sampling. **Control of air pollutants:** General Ideas: Reduce emission by process change, pollution control devices, Resource Recovery, Ultimate fate of pollutants Fluid velocities in control equipments – Combustion - Primary and secondary particulate pollutants, Drag force and settling velocity, stokes law- Wall collection devices – Gravity settlers, Cyclone separators-Electrostatic precipitators-Surface filters-Scrubbers for particulate control-Control of gaseous pollutants – control of VOCs – control by prevention – control by concentration and recovery – control by oxidation- Control of Sulphur Oxides – recovery of SO2 – Control of NOx - Control of Motor Vehicle air pollution – IC engines – types of pollutants and emission –Alternative power plant-.Case study of ambient and industrial air pollution and remedies for management-**Indoor air pollution** – Indoor and outdoor concentrations, models -control of indoor air quality, Radon Problem. **Noise pollution:** Noise properties of sound waves, characterization of noise, noise spectrum - Effects of noise-Noise rating system -Noise control techniques – Literature survey.

Course Contents and Lecture Schedule

S.No	Topic	No. of Lectures
	1. Sources and effects of air pollutants	
1.1	Industrial Accidents, Air Pollutants - Introduction	1
1.2	Sources and classification of air pollutants	1
1.3	Effects of air pollutants – on human, plants, animals,	1
1.4	Effects of air pollutants - On materials & meteorological conditions	1
1.5	Ozone layer disturbance, green house effects	1
1.6	Air Quality Standards, Air Quality Regulations in India and USA,	1
	2. Meteorological Processes and Air Quality Modeling	
2.1	General Atmospheric Circulation, Atmospheric Thermodynamics, Atmospheric Stability, Boundary Layer Development	1
2.2	Effect of Meteorology on Plume Dispersion, Wind Velocity, Beaufort Scale, Wind Rose, Local Climatological Data	1
2.3	Air Quality Modeling: Types of Plumes, Flow Regimes of a Plume, Plume Rise, Ambient Air Concentration Modeling,	1
2.4	Gaussian Dispersion Models, Plume Dispersion Parameters, Computer Programs, USEPA Recommended Models	2
2.5	Sampling – Ambient air sampling, Stack sampling	1
	TUTORIAL	5
	3. Control of air pollutants	
3.1	General Ideas: Reduce emission by process change, pollution control devices, Resource Recovery,	1
3.2	Ultimate fate of pollutants Fluid velocities in control equipments – Combustion	1
3.2.1	Primary and secondary particulate pollutants, Drag force and settling velocity, stokes law	1

3.2.2	Wall collection devices – Gravity settlers, Cyclone separators	1
3.2.3	Electrostatic precipitators and Surface filters	1
3.3	Scrubbers for particulate control	1
3.3.1	Control of gaseous pollutants – control of VOCs – control by prevention – control by concentration and recovery – control by oxidation	1
3.3.2	Control of Sulphur Oxides – recovery of SO2 – Control of NOx	1
3.4	Control of Motor Vehicle air pollution – IC engines – types of pollutants and emission – Alternative power plants.	1
	Tutorial Literature Survey of Air and Noise Pollution, and extraction of information and case studies	6
	4. Indoor Air Pollution	
4.0	Indoor air pollution – Indoor and outdoor concentrations, models -control of indoor air quality, Radon Problem	1
5. Noise pollution		
5.1	Noise properties of sound waves, characterization of noise, noise spectrum	1
5.2	Effects of noise and Noise rating system	1
5.3	Noise control techniques	1
Total		**36**

Reference Books

1. Lawrence K.Wang, Norman C Pererla, Yung – Tse Hung, -Air Pollution Control Engineering‖, Tokyo,2004.
2. Noel De Nevers, -Air Pollution Control Engineering‖ (2nd Edn.) McGraw Hill , New York 2000.
3. Wark, C.F. Warner & W.T. Davis -Air Pollution Control: its Origin and Control, Addision-Wesley, 1998.
4. Wayne R. Davis (Editor) Air & Waste Management Association, -Air Pollution Engineering Manual‖, 2nd Edition, Wiley Publications, 2000.

Course Designer

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18EN140	SOLID AND HAZARDOUS WASTE MANAGEMENT	Category	L	T	P	Credit
		PC	3	0	0	3

Preamble

This course work provides an in depth understanding of solid and hazardous waste characteristics and management. The students acquire proficiency in processing technologies and disposal methods for municipal solid waste and hazardous waste generated from a community

Course Outcomes

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

	Course outcomes	Bloom's Taxonomy	Expected Attainment level (%)	Expected Proficiency (grade)
CO1.	Understand the characteristics of different types of solid and Hazardous waste	Understand	80	A
CO2	Explain the functional elements of Municipal solid waste and hazardous waste management system	Understand	80	A
CO3.	Apply the basic scientific principles for solving practical waste management challenges	Apply	80	A
CO4	Design the various elements of waste management system	Apply	80	A
CO5.	Analyze the various processing technologies and suggest suitable solution for MSW and Hazardous Waste	Analyze	80	A
CO6.	Analyze the various options for disposal of MSW and Hazardous Waste	Analyze	80	A

Mapping with Programme Outcomes

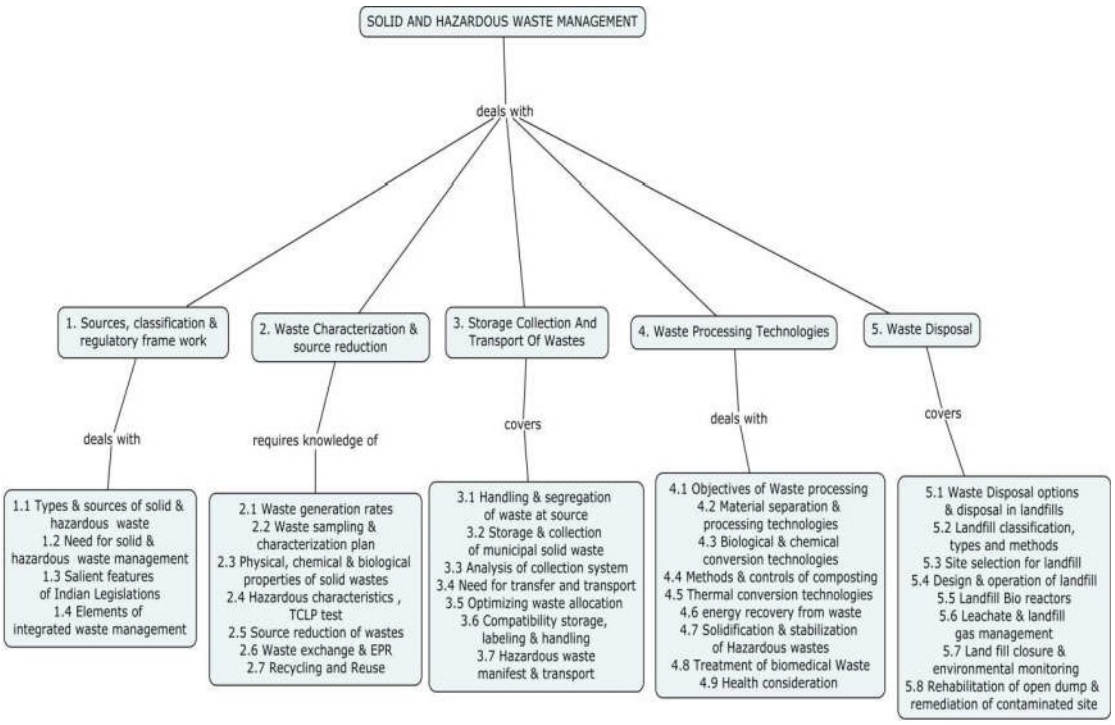
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	L	L	-	-	-	-	-	L	-	-	-	S	L
CO2	M	M	-	-	-	L	L	L	-	-	-	M	M
CO3	M	M	M	-	-	M	L	L	L	-	-	M	M
CO4	M	M	-	-	-	-	-	L	-	-	-	S	L
CO5	S	S	-	-	-	-	L	L	L	-	-	M	M
CO6	M	M	M	-	-	-	L	L	L	-	-	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	40	40	40	40
Apply	30	30	30	30
Analyse	20	20	20	20
Evaluate	-	-	-	-
Create	-	-	-	-

Concept Map



Syllabus

Sources, classification and regulatory frame work-Types and sources of solid and hazardous waste-Need for solid and hazardous waste management-Salient features of Indian Legislations on management and handling of municipal solid wastes, hazardous wastes, biomedical wastes ,E- waste, nuclear waste , lead acid batteries, plastics and fly ash-Elements of integrated waste management , roles of stakeholders and PPP for waste management-**Waste Characterization and source reduction** Waste generation rates,variation Waste sampling and characterization plan-Hazardous characteristics , TCLP test-Physical, chemical and biological properties of solid wastes Source reduction of wastes -Waste exchange and extended producer responsibility Recycling and Reuse-**Storage Collection And Transport Of Wastes** Handling and segregation of waste at source Need for transfer and transport – transfer stations Optimizing waste allocation Storage and collection of municipal solid waste Analysis of collection system Compatibility storage, labeling and handling of hazardous wastes Hazardous waste manifest and transport **-Waste Processing Technologies** Objectives of Waste processing Material separation and processing technologies Biological and chemical conversion technologies Methods and

controls of composting Thermal conversion technologies energy recovery from waste-Solidification and stabilization of Hazardous wastes Treatment of biomedical Waste Health consideration in the context of operation of facilities -**Waste Disposal** Waste Disposal options and disposal in landfills Landfill classification ,types and methods -Site selection for landfill - Design and operation of Sanitary landfill, secured landfill Bio reactors Leachate and landfill gas management -Land fill closure and environmental monitoring Rehabilitation of open dump and remediation of contaminated site.

Course Contents and Lecture Schedule

S. No	Topics	No. of Lectures
	1.Sources, classification and regulatory frame work	
1.1	Types and sources of solid and hazardous waste	1
1.2	Need for solid and hazardous waste management	1
1.3	Salient features of Indian Legislations on management and handling of municipal solid wastes, hazardous wastes, biomedical wastes ,E- waste, nuclear waste , lead acid batteries, plastics and fly ash	2
1.4	Elements of integrated waste management , roles of stakeholders and PPP for waste management	1
	2.Waste Characterization and source reduction	
2.1	Waste generation rates ,variation	1
2.2	Waste sampling and characterization plan	1
2.3	Physical, chemical and biological properties of solid wastes	1
2.4	Hazardous characteristics , TCLP test	1
2.5	Source reduction of wastes	1
2.6	Waste exchange and extended producer responsibility	1
2.7	Recycling and Reuse	1
	3.Storage Collection And Transport Of Wastes	
3.1	Handling and segregation of waste at source	1
3.2	Storage and collection of municipal solid waste	1
3.3	Analysis of collection system	1
3.4	Need for transfer and transport – transfer stations	1
3.5	Optimizing waste allocation	1
3.6	Compatibility storage, labeling and handling of hazardous wastes	1

3.8	Hazardous waste manifest and transport	1
4.Waste Processing Technologies		
4.1	Objectives of Waste processing	1
4.2	Material separation and processing technologies	1
4.3	Biological and chemical conversion technologies	1
4.4	Methods and controls of composting	1
4.5	Thermal conversion technologies	1
4.6	energy recovery from waste	1
4.7	Solidification and stabilization of Hazardous wastes	1
4.8	Treatment of biomedical Waste	1
4.9	Health consideration in the context of operation of facilities	1
5.Waste Disposal		
5.1	Waste Disposal options and disposal in landfills	1
5.2	Landfill classification ,types and methods	1
	Site selection for landfill	1
5.3	Design and operation of Sanitary landfill, secured landfill	1
5.4	Landfill Bio reactors	1
5.5	Leachate and landfill gas management	1
5.6	Land fill closure and environmental monitoring	1
5.7	Rehabilitation of open dump and remediation of contaminated site	1
	Total	**36**

Reference Books

1. Bhide A.D and Sundaresan, B.B. -Solid Waste Management Collection, Processing and Disposal‖, 2001, ISBN 81-7525-282-0
2. George Tchobanoglous, Hilary Theisen and Samuel A, Vigil -Integrated Solid Waste Management‖, McGraw Hill Publishers, New York, 1993.
3. -Manual on Municipal Solid Waste Management‖, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2000.
4. Vesilind P.A., Worrell W and Reinhart, Solid Waste Engineering, Thomson learning Inc., Singapore, 2002.

Course Designers:

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		Category	L	T	P	Credit
18EN161	**PHYSICO-CHEMICAL TREATMENT SYSTEM**	TCP	2	0	2	3

Preamble

Wastewater generated from a community must be properly treated to get rid of from its harmfulness before being disposed into any natural system either water bodies or land. Physical operations are needed for the removal of floating, suspended and colloidal matters present in the wastewater. Chemical processes like coagulation, oxidation, and neutralization are required for the conversion of the harmful chemical components amenable for physical removal subsequently.

Prerequisite

Basic knowledge on treatment of water and wastewater.

Course Outcomes

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

COs for Theory part:

COs	Course outcomes	Bloom's level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1.	Illustrate the significance of equalization and design an equalization tank and realize its necessity on wastewater treatment system.	Apply	80	B
CO2.	Identify different types of settling involved in wastewater treatment analytically and experimentally and design appropriate sedimentation units for the removal of suspended matters.	Apply	90	A
CO3.	Design an appropriate depth filtration and membrane filtration system for the removal of colloidal and dissolved solids from pre-treated water/wastewater stream and select a suitable filter media material experimentally.	Apply	70	C
CO4.	Select an appropriate disinfectant and design the suitable disinfection unit for the removal of dissolved organics and micro-organisms present in water/wastewater.	Analyse	80	B
CO5.	Fix a more suitable isotherm model for the removal of a specific pollutant from water/wastewater by experimental study on different adsorbents and design an appropriate adsorption unit.	Analyse	70	C
CO6.	Choose a most suitable mixing device and aeration device for the treatment system by conducting performance study analytically and experimentally.	Apply	90	A
CO7.	Analyze different chemical treatment techniques available in the chemical conversion and/or change of state of the undesirable components present in water/wastewater in the laboratory or otherwise.	Analyse	90	A

Mapping with Programme Outcomes

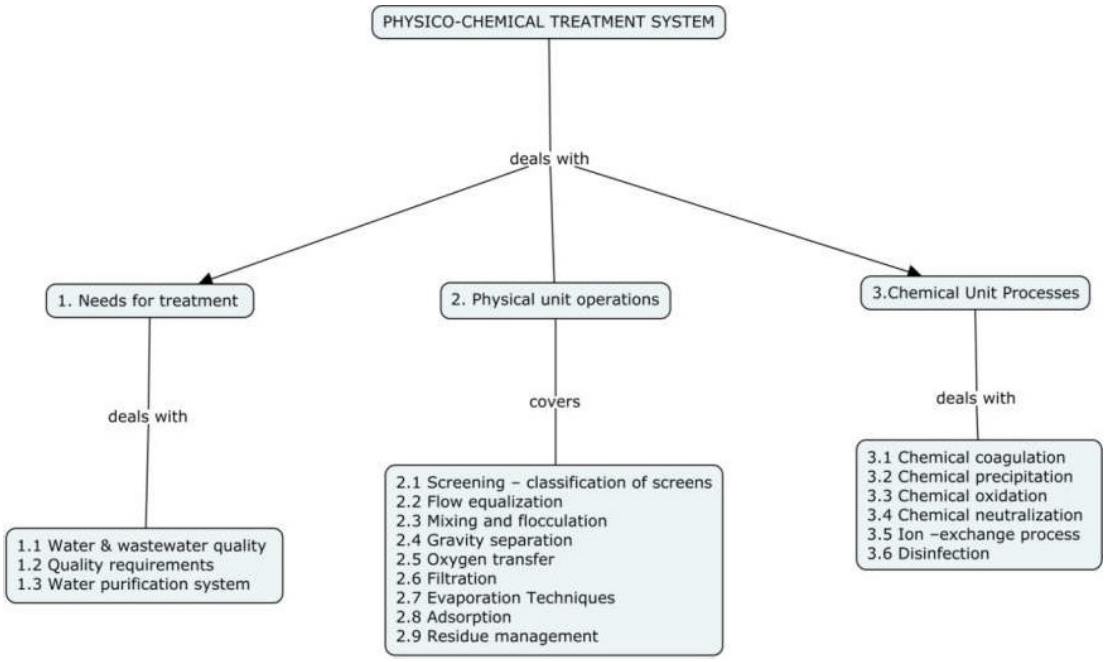
Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	M	M	L	-	-	-	-	-	-	-	-	L	-
CO2	S	S	M	S	M	-	-	-	-	-	-	S	-
CO3	S	S	S	S	M	-	-	-	-	-	-	S	-
CO4	S	S	S	S	-	L	-	L	L	L	-	S	L
CO5	S	S	S	S	M	L	-	-	L	-	-	S	L
CO6	M	M	L	L	-	L	-	-	-	-	-	L	-
CO7	S	S	S	S	-	M	-	-	M	L	-	S	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		Test 3	Terminal Examination (Theory part only for 100 marks)
	1	2	Practical Examination (30 marks)	
Remember	-	-		-
Understand	40	40		40
Apply	60	40		40
Analyse	-	20		20
Evaluate	0	0		0
Create	0	0		0

Concept Map



Syllabus

Needs for treatment - Water and wastewater quality – physical, chemical and biological parameters.Quality requirements – Water quality standards – effluent standards, Water quality indices.Water purification system – physical processes and chemical processes.**Physical unit operations** – screening – classification of screens. Flow equalization – Equalization basin – design. Mixing and flocculation – types of mixers.Gravity separation – theory of sedimentation, types of settling, batch analysis, solid flux analysis- Sedimentation tanks – performances. Flotation – types. Oxygen transfer – two film theory – aeration systems – types. Filtration – depth filtration – process and physical features – filtration process analysis – problems – types of filters – performances.Membrane filtration – process – operation – Application, Evaporation Techniques. Adsorption – fundamentals of adsorption – adsorption isotherms – mass transfer zone – adsorption capacity – breakthrough curve – residue management. **Chemical unit processes** – chemical coagulation – chemical precipitation – chemicals used. Chemical oxidation – applications.Chemical neutralization – Ion –exchange process. Disinfection - chlorination. Disinfection with ozone – disinfection by UV rays.

Course contents and lecture schedule

Module No	Topic	No. of Lectures
	1. Needs for treatment	
1.1	Water and wastewater quality – physical, chemical and biological parameters	1
1.2	Quality requirements – Water quality standards – effluent standards, water quality indices	1
1.3	Water purification system – physical processes and chemical processes	1
	2. Physical unit operations	
2.1	Screening – classification of screens	1
2.2	Flow equalization – Equalization basin – design	1
2.3	Mixing and flocculation – types of mixers for rapid mixing and flocculation	1
2.4	Gravity separation – settling theory – discrete particle settling	1
2.4.1	Flocculant particle settling – tube settling Hindered settling – batch analysis – solid flux analysis.	1
2.4.3	Sedimentation tanks – performances – design criteria and design.	1
2.4.4	Flotation – types	1
2.5	Oxygen transfer – two film theory – aeration systems – types	1
2.6	Filtration – depth filtration – process and physical features - filtration process analysis – problems - Types of filters –performances	1
2.6.3	Membrane filtration – process – operation – Applications	1
2.7	Evaporation Techniques	1

2.8	Adsorption – fundamentals of adsorption - adsorption isotherms	1
2.8.2	mass transfer zone – adsorption capacity – breakthrough curve	1
2.9	Residue management	1
	3. Chemical Unit Processes	
3.1	Chemical coagulation – theory	1
3.2	Chemical precipitation – chemicals used	1
3.3	Chemical oxidation – applications	1
3.4	Chemical neutralization	1
3.5	Ion –exchange process - Chemistry of ion – exchange – applications of ion – exchange	1
3.6	Disinfection – theory – types of chlorination - Chlorination – breakpoint – process variables – chlorine dosage – dechlorination	1
3.6.2	Disinfection with ozone and UV rays	1
	Total	**24**

Reference Books

1. Casey, T.J. Unit treatment process in Water and Waste Water Engineering, John Wiley and sons, London 1993.
2. Mackenzie L.Davis, David A.Cornwell, 'Introduction to Environmental Engineering", McGraw Hill, 1998.
3. Manual on Water supply and treatment, CPHEEO, Ministry of Urban Development, GOI, New Delhi.
4. Metcalf & Eddy, "Waste water Engineering treatment, Disposal & Reuse" Tata- McGraw Hill, 2006.
5. Qasim,S.R.,"Water works Engineering, Planning, Designing & Operation, Prentice Hall(India) Ltd,2006.

List of Exercises for Practical Part

Module No.	Exercise No.
1.	Zone settling studies on ASP reactor content.
2.	Flocculent settling studies using settling column.
3.	Filter media characteristics – Sieve Analysis.
4.	Fixing best isotherm model for an Adsorption study.
5.	Determination of Oxygen transfer co-efficient for an Aerating device.
6.	Coagulation study on wastewater.
7.	Chemical oxidation using different oxidants.

Course Designer

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18EN171	ENVIRONMENTAL ENGINEERING LABORATORY

Category	L	T	P	Credit
PC	0	0	4	2

Preamble

The objective of this laboratory course is to give practical knowledge in fixing water, wastewater and air quality in order to identify the pollution status and arriving at the appropriate treatment techniques and control measures required to keep up their quality standards.

Prerequisite

Basic Knowledge on water, wastewater & air quality characteristics and treatment methods.

Course Outcomes

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

	Course outcomes	Bloom's level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	Explain the operation and mechanism of different analytical equipments and their advantages and limitations	Understand	90	A
CO2	Analyze the quality of water in order to fix its pollution status	Analyze	90	A
CO3	Examine wastewater to identify their characteristics so as to produce suitable treatment methods	Analyze	90	A
CO4	Calculate the dosage of coagulants and disinfectants required for the treatment of water/ wastewater	Apply	90	A
CO5	Calculate the quality of ambient air with respect to various particulate matters	Apply	90	A

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	S	S	M	M	M	L	L	L	-	M	L	S	S
CO2	S	S	M	M	M	M	M	L	-	M	L	S	S
CO3	S	S	M	M	M	M	M	L	-	M	L	S	S
CO4	S	M	M	M	M	M	M	L	-	M	L	S	S
CO5	S	M	M	M	M	M	M	L	-	M	L	S	S

S- Strong; M-Medium; L-Low

List of Experiments

1. Determination of pH, conductivity and turbidity.
2. Determination of various Solid components in water/Wastewater.
3. Estimation of hardness and chlorides water.
4. Determination of Nitrates present in water.
5. Estimation of amount of fluorides and sulphates present in water and wastewater
6. Determination of Residual chlorine in water
7. Estimation of Dissolved Oxygen and BOD ofwastewater.
8. Determination of Chemical Oxygen Demand ofwastewater.
9. Jar test for determining optimum dosage of coagulant.
10. Determination of Oil and greasy matter in wastewater.
11. Determination of PM10 and PM2.5 in ambient air.

Course Designers

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18EN210	BIOLOGICAL TREATMENT PROCESS	Category	L	T	P	Credit
		PC	2	1	0	3

Preamble

This course work is designed to introduce the treatment of wastewater by using microorganisms. This course work deals with the process kinetics and bio-kinetics which are essential inputs in the design of Biological treatment system. This course work is essentially focused to reduce the concentration of organic and inorganic compounds of wastewater using microorganisms which are harmful to the environment. The pre-treatment concepts of some of the constituents and compounds found in industrial wastewater which are toxic to microorganisms is also dealed in here.

Prerequisite

Fundamental knowledge on microbiology and secondary treatment of wastewater.

Course Outcomes

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

	Course outcomes	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1.	Understand the characteristics of wastewater, Enzymes reaction, Effect of temperature and Reactor analysis	Understand	85	A
CO2.	Apply the basic principles of process kinetics and microbial growth(bacteria)-reaction kinetics for reactor design	Apply	75	B
CO3.	Classify the suspended growth treatment processes with its suitability to treat municipal wastewater.	Analyse	65	C
CO4.	Classify the attached growth treatment processes with its suitability to treat municipal wastewater.	Analyse	65	C
CO5	Investigate a suitable sludge treatment system with the basic principles of sludge transformation process and its kinetics	Apply	75	B
CO6	Investigate to extract pertinent information through literature survey for the advancement of BTP.	Analyse	65	C

Mapping with Programme Outcomes

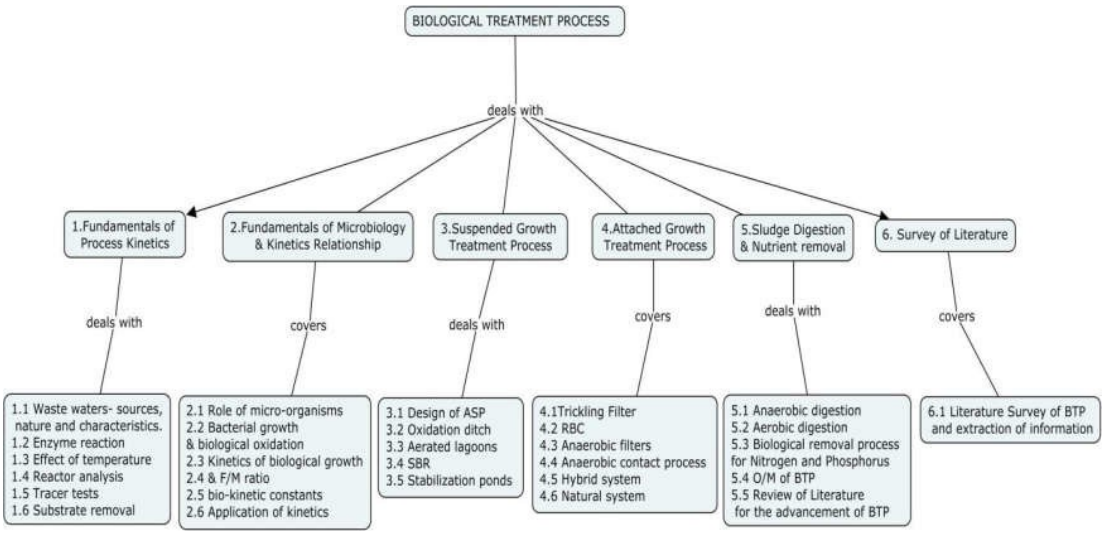
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	L	-	-	-	-	-	-	-	-	-	-	-	-
CO2	M	M	L	-	-	L	-	-	L	L	-	L	L
CO3	S	S	M	-	-	M	-	-	M	L	-	M	M
CO4	S	S	M	-	-	M	-	-	M	L	-	M	M
CO5	S	M	L	-	-	L	-	-	L	L	-	M	L
CO6	S	S	S	S	-	S	-	-	M	L	M	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	50	30	30	30
Apply	30	25	25	25
Analyse	-	25	25	25
Evaluate	-	-	-	-
Create	-	-	-	-

Concept Map



Syllabus

Fundamentals Of Process Kinetics: Reaction rates - enzyme reaction - effect of temperature. Reactor analysis - batch reactor - continuous flow stirred tank reactor, plug flow reactor. Tracer tests - estimation of dispersion coefficient. Substrate removal - reactors in parallel - reactors in series; **Fundamentals Of Microbiology And Kinetics Relationship:** Role of micro-organisms, bacterial growth and biological oxidation. Kinetics of biological growth, logarithmic growth (batch culture), substrate limited growth cell yield, biological solids retention time, F/M ratio. Determination of bio-kinetic constants, application of kinetics to biological treatment; **Suspended Growth Treatment Process:** Design of activated sludge process – modifications. Oxidation ditch, aerated lagoons, oxygen requirements, arrangement for transfer of oxygen, SBR. Stabilization ponds - classification, applications, process design; **Attached Growth Treatment Process:** Trickling Filter – Process – design based on popular design equations – rotating biological contactors, anaerobic filters. Anaerobic contact process – anaerobic up flow sludge blanket reactor. Hybrid system – MBR, MBBR and HUASB: Natural system**-** PGF, Constructed wetlands, Duckweed pond; **Sludge digestion and Nutrients removal:** sources, characteristics, quantities. Anaerobic digestion – process, kinetic relationship, gas production, design considerations. Aerobic digestion – kinetics, oxygen requirements, design considerations, Biological removal process for Nitrogen and Phosphorus, Operation and Maintenance for biological treatment system. **Survey of Literature**- Literature Survey of BTP and extraction of information

Course content and lecture schedule

S.No	Topic	No. of Lectures
	1. Fundamentals of Process Kinetics	
1.1	Waste waters – sources, nature and characteristics. Reaction rates	1
1.2	Enzyme reaction	1
1.3	Effect of temperature	1
1.4	Reactor analysis - batch reactor - continuous flow stirred tank reactor, plug flow reactor	1
1.5	Tracer tests - estimation of dispersion coefficient	1
1.6	Substrate removal - reactors in parallel - reactors in series	1
	2. Fundamentals of Microbiology and Kinetics Relationship	
2.1	Role of micro-organisms	1
2.2	Bacterial growth and biological oxidation	1
2.3	Kinetics of biological growth, logarithmic growth (batch culture), substrate limited growth cell yield	1
2.4	Biological solids retention time, F/M ratio	1
2.5	Determination of bio-kinetic constants	2
2.6	Application of kinetics to biological treatment	2
	3. Suspended Growth Treatment Process	
3.1	Design of activated sludge process - modifications	2

3.2	Oxidation ditch	1
3.3	Aerated lagoons, oxygen requirements, arrangement for transfer of oxygen	2
3.4	Sequential Batch Reactor	1
3.4	Stabilization ponds - classification, applications, process design	1
4. Attached Growth Treatment Process		
4.1	Trickling Filter – Process – design based on popular design equations	2
4.2	Rotating biological contactors	1
4.3	Anaerobic filters	1
4.4	Anaerobic contact process – anaerobic up flow sludge blanket reactor	2
4.5	Hybrid system – MBR, MBBR and HUASB	1
4.6	Natural system - PGF, Constructed wetlands, Duckweed pond.	2
5. Sludge Digestion and Nutrient removal		
5.1	Anaerobic digestion – process, kinetic relationship, gas production, design considerations	2
5.2	Aerobic digestion – kinetics, oxygen requirements, design considerations	2
5.3	Biological removal process for Nitrogen and Phosphorus	1
5.4	Operation and Maintenance for Biological Treatment Processes	1
5.5	Review of Literature for the advancement of BTP	2
6. Survey of Literature		
6.0	Literature Survey of BTP and extraction of information	1
Total		**36**

Reference Books

1. Arceivala S.J., Shyam R Asolekar., -Wastewater Treatment for Pollution Control and Reuse, 3rd Edition, Tata McGraw Hill Publishers, New Delhi, 2007
2. Manual on Sewerage and sewage treatment, CPHEEO, Ministry of Urban development, GOI, New Delhi, 1993.
3. Metcalf and Eddy, -Wastewater Engineering Treatment, disposal and reusell Tata McGraw-Hill, New Delhi 2011.
4. Qasim, S.R., Wastewater treatment plant, Planning, Design and Operation, Technomic Publications, New York, 1994.

Course Designers

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18PG250	RESEARCH METHODOLOGY AND IPR	Category	L	T	P	Credit
		CC	2	0	0	2

Preamble

The course on the Research Methodology and IPR is offered as common Core course. The objective of this course is to understand and analyze Research Methodology and IPR protection.

Prerequisite

NIL

Course Outcomes

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

1. Understand research problem formulation.
2. Analyze research related information
3. Follow research ethics
4. Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
5. Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
6. Understand that IPR protection provides an incentive to inventors for further research work and investment in R&D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			End Semester Examination
	1	2	3	
Remember	20	20	20	20
Understand	40	40	40	40
Apply	40	40	40	40
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Syllabus

Module 1: Meaning of research problem, Sources of research problem, Criteria, Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem, Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Module 2: Effective literature studies approaches, analysis Plagiarism, Research ethics

Module 3: Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Module 4: Nature of Intellectual Property: Patents, Designs, Trade and Copyright, Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Module 5: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Module 6: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs

Reference Books

1. Stuart Melville and Wayne Goddard, -Research methodology: an introduction for science & engineering students'2nd Edition,
2. -Research Methodology: A Step by Step Guide for beginners
3. Halbert, -Resisting Intellectual Property, Taylor & Francis Ltd ,2007.
4. Mayall, -Industrial Design, McGraw Hill, 1992.
5. Niebel, -Product Design, McGraw Hill, 1974.
6. Asimov, -Introduction to Design, Prentice Hall, 1962.
7. Robert P. Merges, Peter S. Menell, Mark A. Lemley, — Intellectual Property in New Technological Age, 2016.
8. T. Ramappa, -Intellectual Property Rights Under WTO, S. Chand, 2008

Course Designers:

1. Adapted from AICTE Model Curriculum for Postgraduate Degree Courses in Engineering & Technology, Volume-I, January 2018.

18EN270	ENVIRONMENTAL SYSTEMS LABORATORY	Category	L	T	P	Credit
		PC	0	0	4	2

Preamble

The objective of this laboratory course is to give practical knowledge in fixing quality of wastewater and characteristics of solid waste using advanced equipment in order to identify the pollution status, arriving appropriate treatment techniques and control measures.

Prerequisite

Basic knowledge on wastewater and solid waste characteristics

Course Outcomes

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

	Course outcomes	Bloom's level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	Characterize the sludge from the biological reactor	Analyse	90	A
CO2	Determine the bacterial count in the given sample	Apply	90	A
CO3	Examine the pollutant concentrations using AAS, spectrophotometer, HPLC and flame photometer.	Apply	90	A
CO4	Analyse the characteristics and composition of solid waste.	Analyse	90	A
CO5	Assess the noise level in an area	Apply	90	A

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	S	M	M	M	M	M	M	L	-	M	L	S	S
CO2	S	S	M	M	M	M	M	L	-	M	L	S	S
CO3	S	S	S	M	S	M	M	L	-	M	L	S	S
CO4	S	S	S	M	M	M	M	L	-	M	L	S	S
CO5	S	S	S	S	S	M	M	L	-	M	L	S	S

S- Strong; M-Medium; L-Low

List of Experiments

1. MLSS/MLVSS/SVI of biological reactor content.
2. Determination of MPN index for water /wastewater samples.
3. Determination of Sodium Adsorption Ratio for soil samples.
4. Compost characterization – N,P,K values.
5. Determination of indoor air quality in a work place.
6. Noise assessment in an area.

7. Heavy metal analysis using AAS.
8. Determination of physical composition of MSW
9. Determination of Calorific value of MSW.
10. Water softening using lime and soda.
11. Chlorine dosage for disinfection of water/ wastewater.
12. Estimation of Total organic carbon in wastewater.
13. Estimation of organic compounds using HPLC.

Course Designer

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18EN360 ENVIRONMENTAL IMPACT AND RISK ASSESSMENT

Category	L	T	P	Credit
TCP	2	0	2	3

Preamble

To expose the students to the need, methodology, documentation and application of Environmental Impact Assessment and to develop the skill to prepare Environmental Management Plan.

Prerequisite

Basic knowledge on biotic and abiotic components of environment.

Course Outcomes

COs for Theory part:

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

	Course outcomes	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1.	Understand the necessity to study the impacts and risks that will be caused by projects or industries and the methods to overcome these impacts	Understand	80	A
CO2	Describe the legal requirements of environmental and risk assessment for projects	Understand	80	A
CO3.	Prepare terms of reference for environmental impact and socio- economic impact for any developmental project	Apply	80	A
CO4	Prepare environmental management plan by considering environmental aspects, and impacts.	Apply	80	A
CO5.	Understand the field of environmental risk assessment and prepare risk mitigation plan by predicting human health risks.	Apply	80	A

COs for Practical part

	Course outcomes	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO6.	Prepare baseline data for water and air environment	Apply	70	A
CO7	Prepare baseline data for soil, and biological environment	Apply	70	A
CO8.	Identify the hazards in an industrial environment	Apply	70	A
CO9.	Prepare relevant primary base line data required for EIA report	Apply	70	A
CO10.	Prepare Terms of Reference and EMP for any developmental projects.	Apply	70	A

Mapping with Programme Outcomes

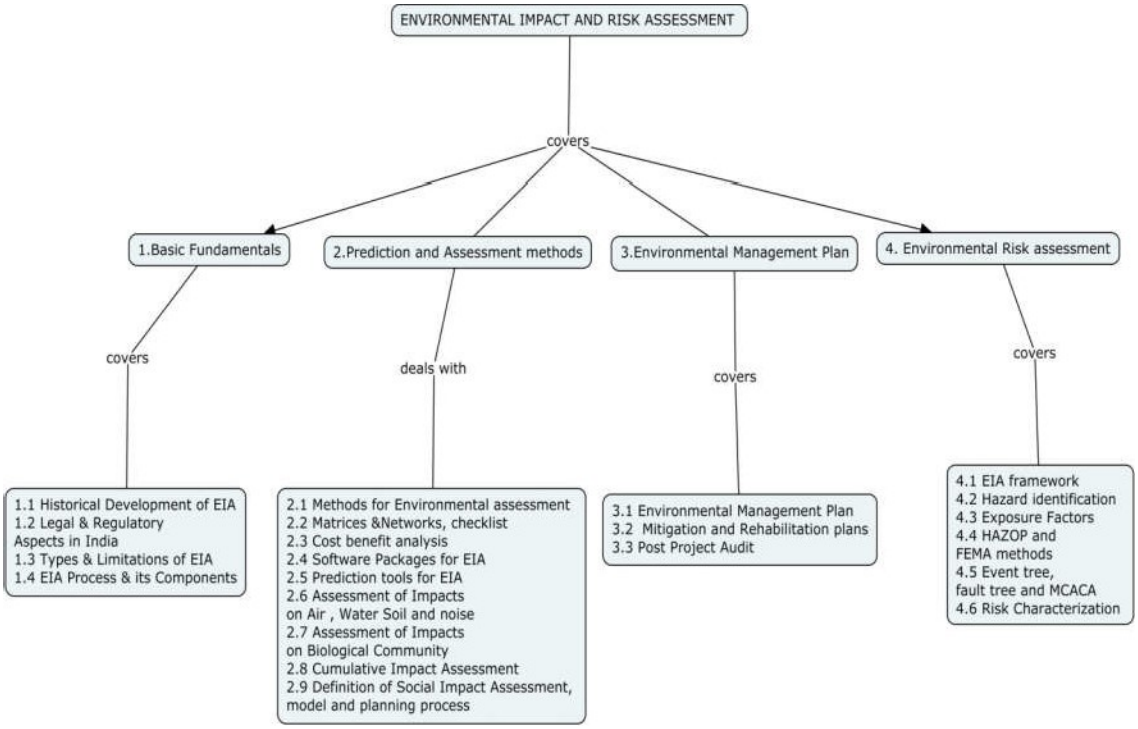
COS	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	M	-	M	M	-	-	M	M	M	-	-	M	-
CO2	M	-	L	-	-	-	-	M	M	-	-	-	M
CO3	M	M	M	M	M	M	-	M	M	M	L	S	-
CO4	M	M	M	M	-	M	M	M	M	M	-	S	-
CO5	M	-	S	-	M	M	M	M	L	M	L	M	M
CO6	S	-	-	L	M	M	-	-	L	L	L	M	M
CO7	S	-	-	L	M	M	-	-	L	L	L	M	M
CO8	S	-	-	L	M	M	-	-	L	L	L	M	M
CO9	S	-	-	L	M	M	-	-	L	L	L	M	M
CO10	S	-	-	L	M	M	-	-	L	L	L	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern: Theory Part:

Bloom's Category	Continuous Assessment Tests		Test 3	Terminal Examination (Theory part only for 100 marks)
	1	2	Practical Examination (30 marks)	
Remember	20	20		20
Understand	40	40		40
Apply	40	40		40
Analyse	0	0		0
Evaluate	0	0		0
Create	0	0		0

Concept Map



Syllabus

Basic fundamentals: Historical Development of Environmental Impact Assessment-EIA in Project Cycle-Legal and Regulatory Aspects in India-Types and Limitations of EIA-Cross Sectoral Issues and terms of references in EIA**.** Components of EIA environmental risk assessment: EIA Process-Screening and Scoping-Public Participation in EIA-Mitigation. Methodology : Methods for Environmental assessment-Matrices &Networks-Checklists-Cost benefit analysis-Analysis of Alternative-Software Packages for EIA and Expert Systems in EIA. **Prediction and Assessment:** Prediction tools for EIA-Mathematical modeling for impact prediction-Assessment of Impacts on Air and Water-Assessment of Impacts on Soil and Noise -Assessment of Impacts on Biological Community-Cumulative Impact Assessment-Documentation of EIA Findings &Report Preparation. Socio-economic impact assessment: Definition of Social Impact Assessment-Social Impact Assessment model and the --planning process-Relationship between social impacts and change in community and institutional arrangements-Individual and family level impacts -Communities in transition. **Environmental Management Plan:** Environmental Management Plan – Preparation and implementation and Rehabilitation plans-Policy and guidelines for planning and monitoring programmes-Post Project Audit-Ethical and Quality aspects of Environmental Impact Assessment—case studies. **Environmental risk assessment**: Environmental risk assessment framework-Hazard identification -Dose Response Evaluation – Exposure Assessment – Exposure Factors, Tools for Environmental Risk Assessment– HAZOP and FEMA methods – Event tree, fault tree and MCACA - Risk Characterization Risk communication - Emergency Preparedness Plans – Design of risk management programs.

Course Contents and Lecture Schedule

Module No	Topics	No. of Lectures
	1.Basic Fundamentals	
1.1	Historical Development of Environmental Impact Assessment and EIA in Project Cycle	1
1.2	Legal and Regulatory Aspects in India	1
1.3	Types and Limitations of EIA, Cross Sectoral Issues in EIA	1
1.4	EIA Process and its Components	2
	2.Prediction and Assessment methods	
2.1	Methods for Environmental assessment	1
2.2	Matrices &Networks, checklist	1
2.3	Cost benefit analysis	1
2.4	Software Packages for EIA and Expert Systems in EIA	1
2.5	Prediction tools for EIA and Mathematical modeling for impact prediction	1
2.6	Assessment of Impacts on Air , Water Soil and noise	1
2.7	Assessment of Impacts on Biological Community	1
2.8	Cumulative Impact Assessment	1
2.9	Definition of Social Impact Assessment, model and planning process	2
	3.Environmental Management Plan	
3.1	Environmental Management Plan – Preparation and implementation	1
3.2	Mitigation and Rehabilitation plans	1
3.3	Post Project Audit	1
	4. Environmental Risk assessment	
4.1	Environmental risk assessment framework	1
4.2	Hazard identification and Dose Response Evaluation and Exposure Assessment	1
4.3	Exposure Factors, Tools for Environmental Risk Assessment	1
4.4	HAZOP and FEMA methods	1
4.5	Event tree, fault tree and MCACA	1

4.6	Risk Characterization Risk communication - Emergency Preparedness Plans	1
	Total	**24**

Reference Books

1. Canter, L.W., Environmental Impact Assessment, McGraw Hill, New York, 1996.
2. Lawrence, D.P., Environmental Impact Assessment – Practical Solutions to recurrent problems, Wiley-Interscience, New Jersey, 2003.
3. Petts, J., Handbook of Environmental Impact Assessment, Vol., I and II, Blackwell science, London, 1999.
4. World Bank – Source Book on EIA.

List of Exercises for Practical Part

Module No.	Exercise No.
	Primary base line data collection for –
1.	a) Air-Meteorology data
2.	b) Water balance and water use audit
3.	c) Soil sampling and analysis
4.	d) Noise and vibration
5.	e) Biotic environment-Biodiversity-flora-fauna
6.	f) Socio-economic status
7.	g) Land use analysis
8.	h) Risk assessment and Hazard management
9.	i) Solid and hazard management
10.	Preparation of Terms Of Reference
11.	Preparation Environmental Management Plan
12.	Documentation for EIA report

Course Designers:

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		Category	L	T	P	Credit
18ENPA0	**INDUSTRIAL WASTEWATER MANAGEMENT**	PE	3	0	0	3

Preamble

As a fastly growing country, India is flooded with very good numbers of small, medium and large sized industries. The liquid effluent generated from such industries would pose a great danger to the environment, if they are not managed properly. Hence, industrial wastewater management will be of great importance in maintaining the quality of the environment for sustainable living. This course work deals with characterization of industrial effluents, its impact on the environment, possible preventive measures against generation of wastes and treatment and reuse option for the generated wastewater.

Prerequisite

Knowledge on characterization of wastewater, physico-chemical treatment and biological treatment.

Course Outcomes

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

	Course outcomes	Bloom's level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1.	Identify the wastewater generated from a specific industry and understand the possible impacts on the environment.	Understand	90	A
CO2.	Analyze the means and methods to reduce the quantity of generation of wastewater from industrial premises by performing source reduction techniques and waste audit.	Analyze	80	B
CO3.	Analyze appropriate treatment systems for the wastewater generated from the industries.	Analyze	80	B
CO4.	Analyze the possible recycling and reuse opportunities for the generated wastewater and residuals by employing suitable treatment units.	Analyze	80	B
CO5.	Examine the feasibility and benefits of individual, common and joint treatment of industrial wastewater.	Apply	80	B

Mapping with Programme Outcomes

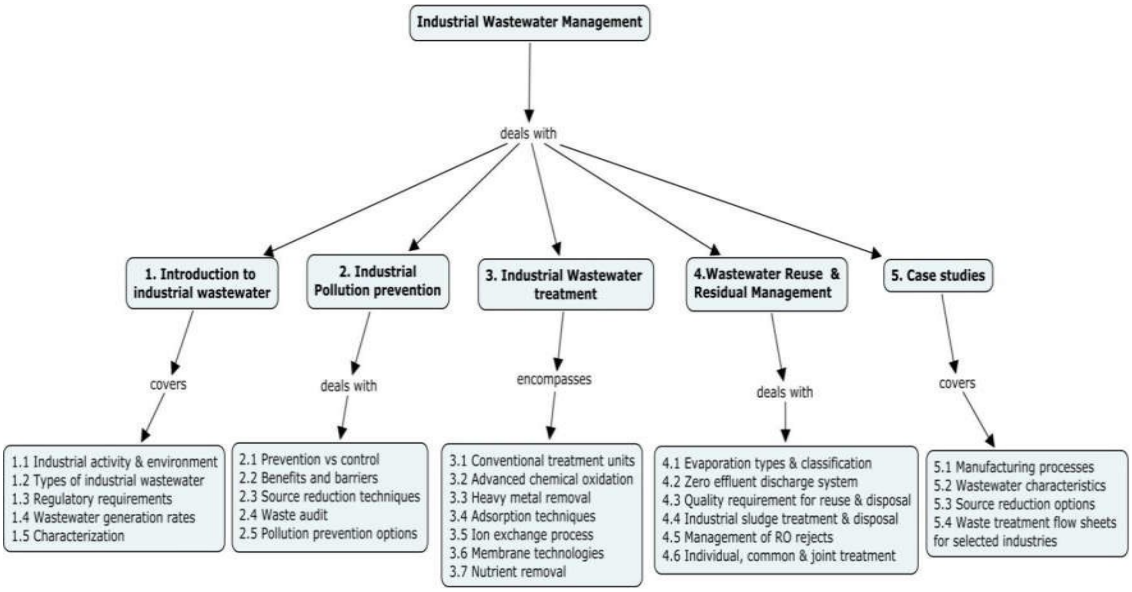
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	M	M	M	-	-	-	-	-	M	-	-	M	-
CO2	M	M	M	-	-	M	M	L	M	-	-	M	M
CO3	M	M	M	-	-	L	L	-	M	-	-	M	M
CO4	M	M	M	-	-	L	M	L	M	-	-	M	M
CO5	M	M	M	-	-	M	M	L	M	-	-	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	-	-	-	-
Understand	50	30	30	30
Apply	50	50	50	50
Analyse	-	20	20	20
Evaluate	-	-	-	-
Create	-	-	-	-

Concept Map



Syllabus

Introduction to industrial wastewater: Industrial scenario in India – industrial activity and environment, uses of water by industry, sources and types of industrial wastewater. Regulatory requirements for treatment of industrial waste water, industrial waste survey, industrial waste water generation rates, characterization and variables, population equivalent. **Industrial Pollution Prevention:** Prevention Vs Control of industrial pollution – benefits and barriers. Source reduction techniques – waste audit, evaluation of pollution prevention options, environmental statement as a tool for pollution prevention, waste minimization circles. **Industrial Wastewater Treatment:** Equalization – neutralization, oil separation, flotation, precipitation, Aerobic and anaerobic biological treatment – sequencing batch reactors, high rate reactors(Recall) Advanced Chemical oxidation – Electro chemical oxidation, wet air oxidation, ozonation, photocatalysis, Other Treatment Processes Heavy metal removal, Refractory organics separation by adsorption. ion exchange, membrane technologies, nutrient removal. **Wastewater Reuse and Residual management:** Evaporation- Evaporators types and classification. Zero effluent discharge systems - Quality requirements for wastewater reuse, industrial reuse, disposal on water and land. Residuals from industrial wastewater treatment units - quantification and characteristics of sludge – thickening, digestion, conditioning, dewatering and disposal of sludge. Management of RO rejects. Individual and common effluent treatment plants – combined treatment of industrial waste water and domestic/municipal wastewater**. Case Studies:** Industrial manufacturing process description, waste water characteristics, source reduction options and waste treatment flow sheet for textiles, tanneries, pulp and paper, metal finishing, sugar and distilleries.

Course contents and lecture schedule

S.No	Topic	No. of Lectures
	1. Introduction to industrial wastewater	
1.1	Industrial scenario in India – industrial activity and environment	1
1.1.1	Uses of water by industry	1
1.2	Sources and types of industrial wastewater	1
1.3	Regulatory requirements for treatment of industrial wastewater	1
1.4	Wastewater generation rates	1
1.5	Characterization and variables, population equivalent	1
	2. Industrial Pollution Prevention	
2.1	Prevention Vs Control of industrial pollution	1
2.2	Benefits and barriers	1
2.3	Source reduction techniques	1
2.4	Waste audit	1
2.5	Evaluation of pollution prevention option	1
2.5.1	Environmental statement	1
2.5.2	Waste minimization circles – PCB Norms for water usage in industries	1

3. Industrial Wastewater Treatment		
3.1	Recall of Conventional treatment system	1
3.2	Advanced chemical oxidation- Electro-chemical oxidation	1
3.2.1	Wet air oxidation	1
3.2.2	Ozonation	1
3.2.3	Photocatalysis	1
3.3	Heavy metal removal	1
3.4	Refractory organics separation by adsorption	1
3.5	Ion exchange	1
3.6	Membrane technologies	1
3.7	Nutrient removal	1
4. Wastewater Reuse and Residual Management		
4.1	Evaporation- Types of evaporators and classification	1
4.2	Zero effluent discharge systems	1
4.3	Quality requirement for reuse and disposal	1
4.4	Quantification and characteristics of sludge	1
4.4.1	Thickening, digestion, conditioning, dewatering and disposal of sludge.	2
4.5	Management of RO reject	1
4.6	Individual, common and joint treatment	1
5. Case Studies		
5.1	Industrial manufacturing processes, wastewater characteristics, Source reduction options and waste treatment flow sheet for textiles, tanneries, pulp and paper, metal finishing, sugar and distilleries.	5
Total Periods		**36**

Reference Books

1. Arceivala, S.J., -Wastewater Treatment for Pollution Control‖, Tata McGraw Hill, 1998.
2. Eckenfelder, W.W., -Industrial Water Pollution Control‖, McGraw – Hill, 2000.
3. Frank Woodard, Industrial Waste Treatment Handbook, Butterworth Heinemann, New Delhi, 2001.
4. Paul L. Bishop -Pollution Prevention: - Fundamentals and Practice‖, McGraw – Hill International, 2000.
5. World Bank Group, -Pollution Prevention and Abatement Handbook – Towards Cleaner Production‖, World Bank and UNEP, Washington.D.C, 1998.

Course Designers

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Mr. R. K. C. Jeyakumar rkcjciv@tce.edu

		Category	L	T	P	Credit
18ENPB0	**ENVIRONMENTAL POLICIESAND LEGISLATIONS**	PE	3	0	0	3

Preamble

This course work provides an in-depth understanding of the vast field of Environmental law and policy and the study would be familiar with the overall legal regime of the country as well as international obligations. To impart knowledge on the policies, legislations, institutional framework and enforcement mechanism for environmental management in India.

Course Outcomes

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

	Course outcomes	Bloom's level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1.	Describe the Indian Legal System and the fundamentals of Indian Constitution	Understand	80	A
CO2	Explain the philosophy, principles and environmental justice for pollution control	Understand	80	A
CO3.	Apply the provision for legal control of industrial pollution by legislations	Apply	80	A
CO4.	Make critical comment on environmental legal framework	Apply	80	A
CO5.	Possess adequate knowledge on legal system operating in India to prepare compliance report for getting Environmental clearance	Apply	80	A

Mapping with Programme Outcomes

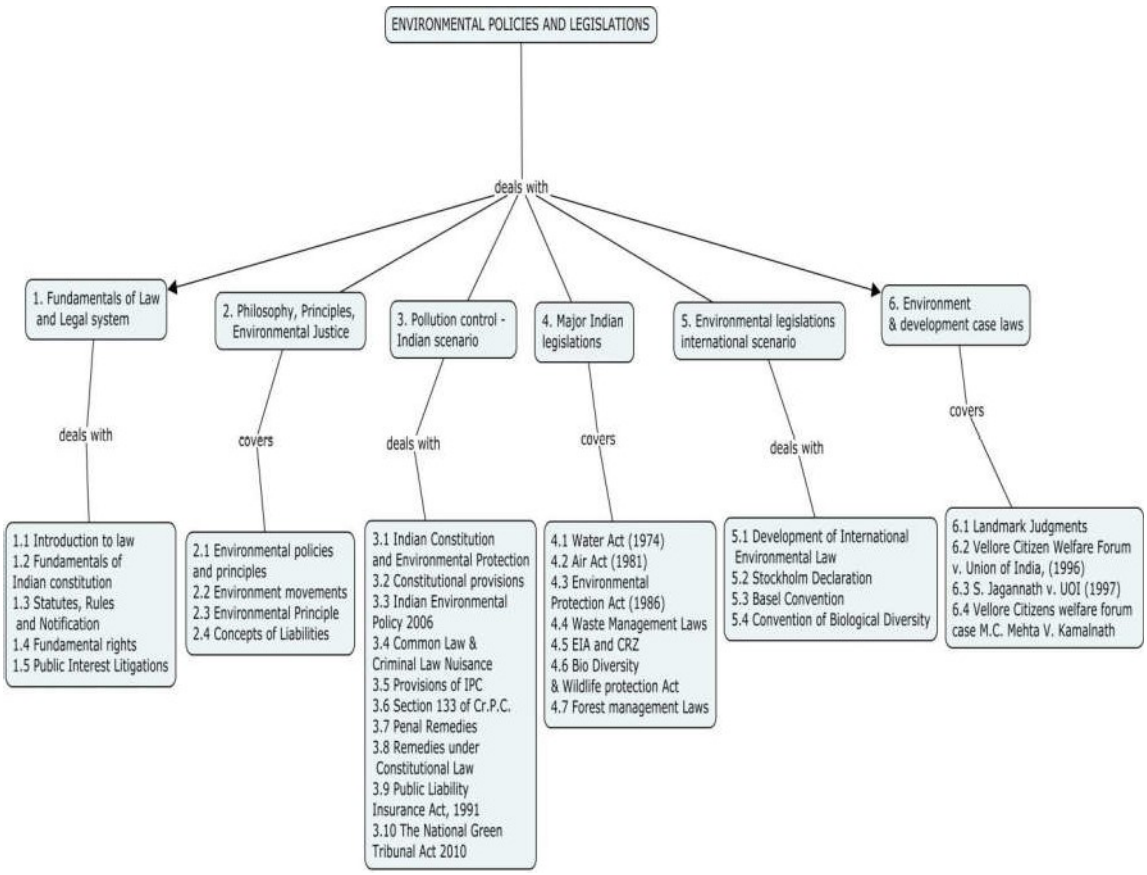
COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	M	M	-	-	-	M	-	L	M	M	M	M	L
CO2	M	M	-	-	-	M	-	L	M	L	M	M	S
CO3	M	M	M	M	-	M	-	M	M	M	-	M	M
CO4	M	M	M	M	-	M	-	M	L	M	-	M	S
CO5	M	L	L	L	M	M	M	M	M	M	M	M	S

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	40	40	40	40
Apply	40	40	40	40
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Concept Map



Syllabus

Fundamentals of Law and Legal system: Introduction to law – Indian legal system – Indian Legal system –Fundamentals of Indian constitution – Statutes, Rules and Notification - Fundamental rights, - Writ petitions –Public Interest Litigations-RTI Act

Philosophy, Principles, Environmental Justice : Environmental policies and principles – Environment movements - Precautionary – Polluter Pays - Concepts of Liabilities and Public Trust Doctrine **pollution control - Indian scenario.** Indian Constitution and Environmental Protection -Constitutional provisions concerning Environment Articles 14,15,(2) (b) 19 (e),21,31,32,38,39,42,47, 48-A,49,51,51-A: Indian Environmental Policy 2006 Common Law & Criminal Law Nuisance, Negligence, Provisions of IPC relating to environmental problems (public nuisance u/s 268 and others (Sections 269,270,277,284,285,286,425 to 440) Section

133 of Cr.P.C.Common Law Remedies/Remedies under Law of Tort – Penal Remedies – Indian Penal Code and Code of Criminal Procedure – Remedies under Constitutional Law – Writs –- Public Liability Insurance Act, 1991 – The National Green Tribunal Act 2010.**major Indian legislations** -Water Act (1974) Air Act (1981) Environmental Protection Act (1986)Genesis of the act – Delegation of Powers. Waste Management Rules-Environment Impact Assessment and Coastal Regulation Zone-Bio Diversity and Wildlife protection Act, Forest managementLaws. **environmental legislations international scenario-** Development of International Environmental Law-General Issues of the international law related to environmental protection-Stockholm Declaration**-**Rio Declaration on Environment and Development**-**Montreal Protocol on Substances that deplete Ozone Layer**-** Basel Convention on the Control of Trans boundary Movement of Hazardous Wastes and their disposal**-**Convention of Biological Diversity**-**U.N Frame Work Convention on Climate Change**- -**Kyoto Protocol. **Environment and development case laws** Landmark Judgments **-**Olium gas leakage case, Rural Litigation and Entitlement Kendra, Dehradun, (1985) Supp SCC 487) Vellore Citizen Welfare Forum v. Union of India, (1996) 5SCC 647) Ganga Pollution case (1988) I SCC) S. Jagannath v. UOI (1997) SCC867) Vellore Citizens welfare forum case M.C. Mehta V. Kamalnath (1997) I SCC 388).

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
	1.0 Fundamentals of Law and Legal system	
1.1	Introduction to law- Indian legal system	1
1.2	Fundamentals of Indian constitution	1
1.3	Statutes, Rules and Notification	1
1.4	Fundamental rights- Writ petitions	1
1.5	Public Interest Litigations-RTI Act	1
	2.0 Philosophy, Principles, Environmental Justice	
2.1	Environmental policies andprinciples	1
2.2	Environment movements	1
2.3	Environmental Principle- Precautionary – Polluter Pays	1
2.4	Concepts of Liabilities and Public Trust Doctrine	1
	3.0 Pollution control - Indian scenario	
3.1	Indian Constitution and Environmental Protection	1
3.2	Constitutional provisions concerning Environment Articles 14,15,(2) (b) 19 (e),21,31,32,38,39,42,47, 48-A,49,51,51-A	1
3.3	Indian Environmental Policy 2006	1
3.4	Common Law & Criminal Law Nuisance	1
3.5	Provisions of IPC relating to environmental problems (public nuisance u/s 268 and others (Sections 269,270,277,284,285,286,425 to 440)	1
3.6	Section 133 of Cr.P.C.Common Law Remedies/Remedies under Law of Tort	1
3.7	Penal Remedies – Indian Penal Code and Code of Criminal Procedure	1
3.8	Remedies under Constitutional Law – Writs	1
3.9	Public Liability Insurance Act, 1991	1
3.10	The National Green Tribunal Act 2010	1

4.0 Major Indian legislations		
4.1	Water Act (1974)- Power & Functions of Regulatory	2
4.2	Air Act (1981)- Power & Functions of Regulatory	2
4.3	Environmental Protection Act (1986)Genesis of the act – Delegation of Powers	1
4.4	Waste Management Laws- Noise Pollution rules	1
4.5	Environment Impact Assessment and Coastal Regulation Zone Notifications	1
4.6	Bio Diversity and Wildlife protection Act	1
4.7	Forest management Laws	1
5.0 Environmental legislations international scenario		
5.1	Development of International Environmental Law-General Issues of the international law related to environmental protection	1
5.2	Stockholm Declaration-Rio Declaration on Environment and Development-Montreal Protocol on Substances that deplete Ozone Layer	1
5.3	Basel Convention on the Control of Trans boundary Movement of Hazardous Wastes and their disposal	1
5.4	Convention of Biological Diversity-U.N Frame Work Convention on Climate Change-Kyoto Protocol	1
6.0 Environment and development case laws		
6.1	Landmark Judgments -Olium gas leakage case, Rural Litigation and Entitlement Kendra, Dehradun, (1985)	1
6.2	Vellore Citizen Welfare Forum v. Union of India, (1996) 5SCC 647) Ganga Pollution case (1988)	1
6.3	S. Jagannath v. UOI (1997) SCC867	1
6.4	Vellore Citizens welfare forum case M.C. Mehta V. Kamalnath (1997) I SCC 388	1
	Total Periods	**36**

Reference Books

1. CPCB, -Pollution Control acts, Rules and Notifications issued there under‖ Pollution Control
Series, Central Pollution Control Board, Delhi.
2. Greger I.Megregor, -Environmental law and enforcement‖, Lewis Publishers, London, 1994.
3. Shyam Divyan and Armin Roseneranz -Environmental law and policy in India‖ Oxford University Press,New Delhi,2001.
4. TNPCB and YOU -A Ready Reckoner for Entrepreneurs‖ – Tamil Nadu Pollution Control Board 2013

Course Designers:

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		Category	L	T	P	Credit
18ENPC0	**ENVIRONMENTAL SYSTEMS ANALYSIS**	PE	3	0	0	3

Preamble

Environmental Systems Analysis introduces systems concept as applicable for environmental systems. This course deals with the fundamental optimization theories and modern expert tools along with their real world application potentials for environmental systems planning, design and pollution control. Introduction of operational research techniques includes: linear programming, and nonlinear programming; modern tools include ANN and Genetic algorithm. Most examples cover typical planning, design, and operation problems for environmental systems with regard to complex multidisciplinary decision-making.

Prerequisite

Knowledge on probability and optimization

Course Outcomes

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

	Course outcomes	Bloom's level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1.	Identify environmental systems	Understand	70	B
CO2.	Solve environmental optimization models for systems analysis and decision making	Apply	70	B
CO3.	Produce simulation models within optimization context to confirm cost-effective principles in large-scale environmental systems	Apply	60	C
CO4.	Apply the principle of soft computing for solving Environmental problems	Apply	70	B
CO5.	Design optimal environmental systems related to water, air and solid waste management satisfying conflicting constraints	Create	70	B

Mapping with Programme Outcomes

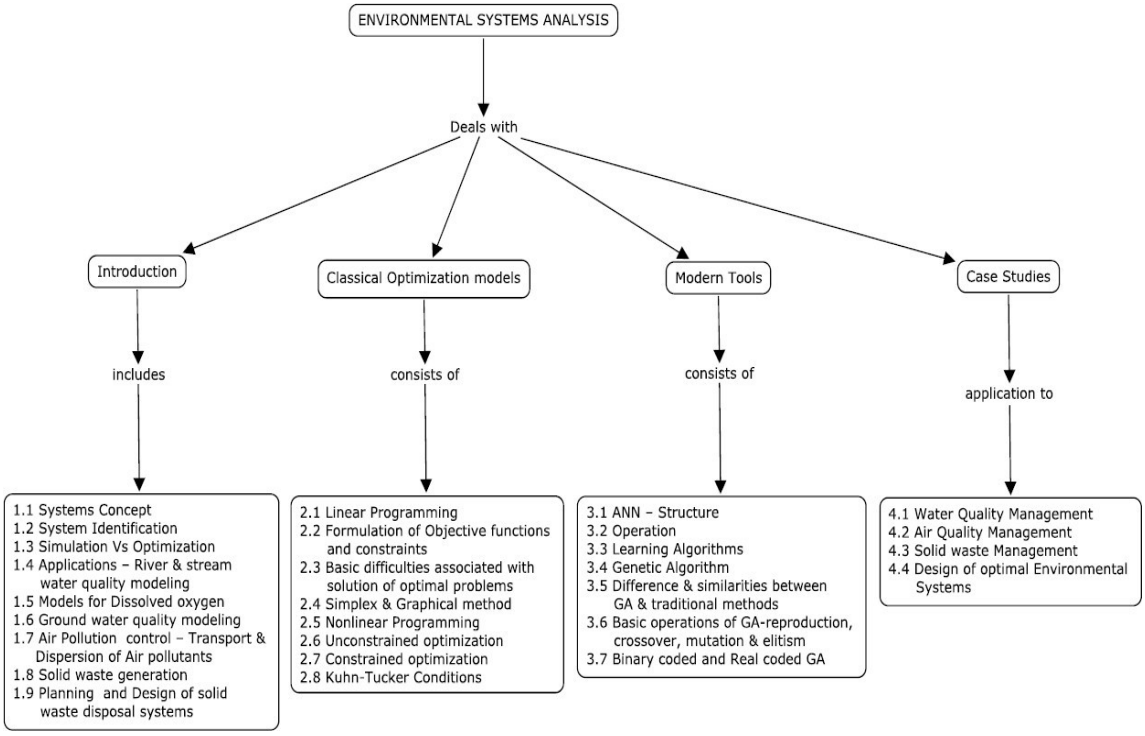
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	L	-	-	-	-	L	L	-	L	-	-	S	M
CO2	M	M	M	-	L	L	L	-	M	-	-	S	M
CO3	M	M	M	-	L	L	L	-	M	-	-	S	M
CO4	M	M	-	-	-	L	-	-	M	-	-	S	M
CO5	S	S	S	-	L	L	M	-	M	-	-	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	-	-	-	-
Understand	50	30	30	30
Apply	50	50	50	50
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	20	20	20

Concept Map



Syllabus

Introduction – System Identification – Simulation vs Optimization – Application to Environmental Engineering Systems – River and stream water quality modeling – Models for Dissolved oxygen - Ground water quality modeling - Air Pollution control – Transport and Dispersion of Air pollutants – Solid waste generation – Planning and Design of solid waste disposal systems; **Classical Optimization methods** – Linear Programming –Formulation of Objective functions and constraints – Simplex method – Graphical method – Nonlinear Programming – Unconstrained optimization techniques, Direct search methods, Descent methods; Constrained optimization, Direct and indirect methods – Kuhn-Tucker Conditions; **Modern Tools** - ANN – Structure – Operation – Learning Algorithms – Genetic Algorithm - Difference and similarities between GA and traditional methods - Basic operations of GA – reproduction, crossover, mutation and elitism – Binary coded and Real coded GA; **Case Studies –** Water quality management, Air quality management, Solid waste management – Design optimal environmental systems.

Course Contents and Lecture Schedule

S. No	Topic	No. of Lectures
	1. Introduction	
1.1	Systems concept	1
1.2	System Identification	1
1.3	Simulation vs Optimization	1
1.4	Applications – River and stream water quality modeling	1
1.5	Models for Dissolved oxygen	1
1.6	Ground water quality modeling	1
1.7	Air Pollution control – Transport and Dispersion of Air pollutants	1
1.8	Solid waste generation	1
1.9	Planning and Design of solid waste disposal systems	1
	2. Classical Optimization methods	
2.1	Linear Programming	1
2.2	Formulation of Objective functions and constraints	1
2.3	Basic difficulties associated with solution of optimal problems	1
2.4	Simplex method - Graphical method	2
2.5	Nonlinear Programming	1
2.6	Unconstrained optimization techniques - Direct search methods - Descent methods	2
2.7	Constrained optimization - Direct and indirect methods	2
2.8	Kuhn-Tucker Conditions	2
	3. Modern Tools	
3.1	ANN – Structure	1
3.2	Operation	1
3.3	Learning Algorithms	1
3.4	Genetic Algorithm	1
3.5	Difference and similarities between GA and traditional methods	1
3.6	Basic operations of GA - reproduction, crossover, mutation and elitism	1

3.7	Binary coded and Real coded GA	1
	4. Case Studies	
4.1	Water Quality Management	2
4.2	Air Quality Management	2
4.3	Solid waste Management	2
4.4	Design optimal environmental systems related to water, air and solid waste management satisfying conflicting constraints	2
	Total	**36**

Reference Books

1. Aliev R. A, and Aliev Rashad, "Soft Computing and its Applications", World Scientific Publications Co. Pte. Ltd. Singapore, 2001.
2. Deb, Kalyanmoy. *Optimization for engineering design: Algorithms and examples*. PHI Learning Pvt. Ltd., 2012.
3. Environmental Systems Optimization, Douglas A. Haith, John Wiley & Sons, 1982.
4. Mathews, John H., and Kurtis D. Fink. *Numerical methods using MATLAB*. Vol. 3. Upper Saddle River, NJ: Prentice hall, 1999.
5. Taha, Hamdy A. *Operations research: an introduction*. Pearson/Prentice Hall, 2007.

Course Designer

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		Category	L	T	P	Credit
18ENPD0	**OCCUPATIONAL HEALTH AND INDUSTRIAL SAFETY**	PE	3	0	0	3

Preamble

The goal of the course is to provide sufficient knowledge related to environmental exposure and providing a foundation for understanding the risks. To educate about the health hazards and the safety measures to be followed in the industrial environment.

Prerequisite

Basic Environmental Engineering knowledge

Course Outcomes

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

	Course outcomes	Bloom's level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1.	Describe environmental hazards in communities and occupational health and hygiene in work place.	Understand	80	A
CO2	Explain safety practices and environmental issues in construction.	Understand	80	A
CO3.	Identify potential hazards and make a risk assessment report for highly polluting industries.	Apply	80	A
CO4	Adapt with work place safety acts and rules and establish safety systems for any industry.	Apply	80	A
CO5.	Analyze the possible common work related diseases and accidents in occupational setting to mitigate it	Apply	80	A

Mapping with Programme Outcomes

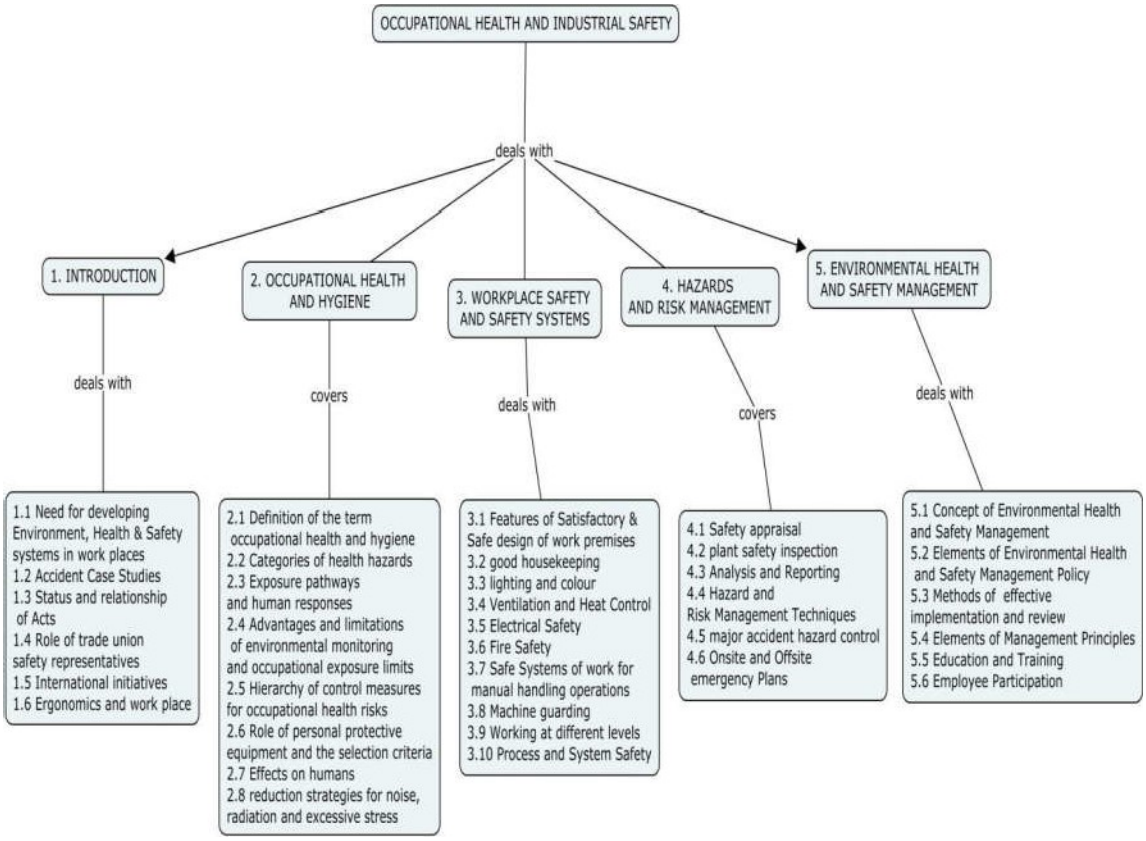
COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	L	L	-	-	-	-	-	L	-	-	L	M	L
CO2	L	L	-	-	-	-	-	L	-	-	-	M	L
CO3	M	M	L	-	-	L	L	L	L	M	L	M	L
CO4	M	M	L	-	-	L	L	L	L	M	-	M	L
CO5	M	S	S	L	M	M	M	M	M	L	M	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	0
Understand	50	50	50	60
Apply	40	40	40	40
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Concept Map



Syllabus

Introduction-Need for developing Environment, Health and Safety systems in work places - Accident Case Studies - Status and relationship of Acts - Regulations and Codes of Practice - Role of trade union safety representatives. International initiatives - Ergonomics and work place- **Occupational health and hygiene**- Definition of the term occupational health and hygiene - Categories of health hazards - Exposure pathways and human responses to hazardous and toxic substances - Advantages and limitations of environmental monitoring and occupational exposure limits - Hierarchy of control measures for occupational health risks - Role of personal protective equipment and the selection criteria - Effects on humans - control methods and reduction strategies for noise, radiation and excessive stress. **Workplace safety and safety systems** - Features of Satisfactory and Safe design of work premises – good housekeeping - lighting and colour, Ventilation and Heat Control –

Electrical Safety – Fire Safety – Safe Systems of work for manual handling operations – Machine guarding – Working at different levels – Process and System Safety. **Hazards and risk management -** Safety appraisal - analysis and control techniques – plant safety inspection – Accident investigation - Analysis and Reporting – Hazard and Risk Management Techniques – major accident hazard control – Onsite and Offsite emergency Plans. **Environmental health and safety management** - Concept of Environmental Health and Safety Management – Elements of Environmental Health and Safety Management Policy and methods of its effective implementation and review – Elements of Management Principles – Education and Training – Employee Participation.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
	1.0 Introduction	
1.1	Need for developing Environment, Health and Safety systems in work places	1
1.2	Accident Case Studies	1
1.3	Status and relationship of Acts - Regulations and Codes of Practice	1
1.4	Role of trade union safety representatives	1
1.5	International initiatives	1
1.6	Ergonomics and work place	1
	2.0 Occupational health and hygiene	
2.1	Definition of the term occupational health and hygiene	1
2.2	Categories of health hazards	1
2.3	Exposure pathways and human responses to hazardous and toxic substances	1
2.4	Advantages and limitations of environmental monitoring and occupational exposure limits	1
2.5	Hierarchy of control measures for occupational health risks	1
2.6	Role of personal protective equipment and the selection criteria	1
2.7	Effects on humans - control methods	1
2.8	reduction strategies for noise, radiation and excessive stress	1
	3.0 Workplace safety and safety systems	
3.1	Features of Satisfactory and Safe design of work premises	1
3.2	good housekeeping	1
3.3	lighting and colour	1
3.4	Ventilation and Heat Control	1
3.5	Electrical Safety	1
3.6	Fire Safety	1
3.7	Safe Systems of work for manual handling operations	1
3.8	Machine guarding	1
3.9	Working at different levels	1
3.10	Process and System Safety	1
	4.0 Hazards and risk management	
4.1	Safety appraisal - analysis and control techniques	1
4.2	plant safety inspection – Accident investigation	1
4.3	Analysis and Reporting	1

4.4	Hazard and Risk Management Techniques	1
4.5	major accident hazard control	1
4.6	Onsite and Offsite emergency Plans	1
	5.0 Environmental health and safety management	
5.1	Concept of Environmental Health and Safety Management	1
5.2	Elements of Environmental Health and Safety Management Policy	1
5.3	Methods of effective implementation and review	1
5.4	Elements of Management Principles	1
5.5	Education and Training	1
5.6	Employee Participation	1
	Total Periods	**36**

Reference Books

1. Effective Environmental, Health, and Safety Management Using the Team Approach by Bill Taylor, Culinary and Hospitality Industry Publications Services, 2005.
2. Environmental and Health and Safety Management by Nicholas P. Cheremisinoff and Madelyn L. Graffia , William Andrew Inc. NY, 1995
3. The Facility Manager‘s Guide to Environmental Health And Safety by Brian Gallant, Government Inst Publ., 2007.

Course Designers:

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		Category	L	T	P	Credit
18ENPE0	**ENVIRONMENTAL MANAGEMENT SYSTEM AND AUDITING**	PE	3	0	0	3

Preamble

EMS educates students to become environmental managers who not only understand all aspects of the environmental industry/or corporate but also have -new work skillsǁ, including skills in critical and analytical thinking, problem solving, project management, interpersonal relations and team work. To impart an understanding of systems approach to Environmental Management as per ISO 14001 and skills for environmental performance in terms of legal compliance, pollution prevention and continual improvement.

Prerequisite

Basic knowledge on biotic and abiotic components of environment.

Course Outcomes

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

	Course outcomes	Bloom's level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1.	Explain the major environmental concepts and issues confronting managers working in corporations, businesses, government, industries and non- profit groups	Understand	80	A
CO2	Describe the strategic and operational approaches to environmental management that can be taken by business and society	Understand	80	A
CO3.	Explain the concept of regulatory compliance, recent technological changes, emergency management, health and safety management, global resource conservation and sustainable development	Apply	80	A
C04	Apply the concept of environmental management systems and identify the actions needed to prepare for an ISO 14000 certification audit for any industry	Apply	80	A
CO5.	Develop, implement, maintain and audit Environmental management systems for organizations.	Understand	80	A

Mapping with Programme Outcomes

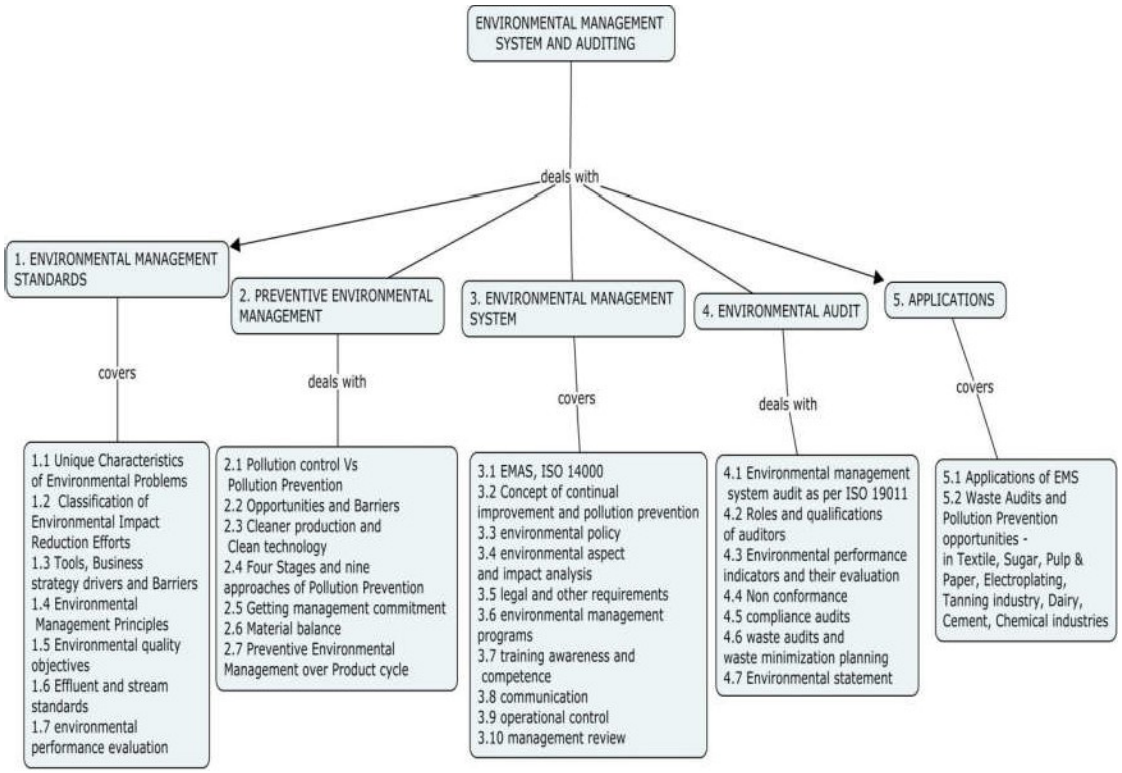
COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	L	-	L	-	-	L	M	L	M	-	-	M	S
CO2	L	-	L	-	-	L	M	M	-	L	L	M	L
CO3	L	-	L	-	-	L	M	M	-	L	-	M	L
CO4	M	M	M	M	-	M	M	L	L	-	-	M	S
CO5	M	M	M	-	M	M	L	M	L	S	L	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	50	50	50	50
Apply	40	40	40	40
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Concept Map



Syllabus

Environmental management standards - Unique Characteristics of Environmental Problems - Systems approach to Corporate environmental management - Classification of Environmental Impact Reduction Efforts -Business Charter for Sustainable Production and Consumption – Tools, Business strategy drivers and Barriers - Evolution of Environmental Stewardship – Environmental Management Principles - National policies on environment, abatement of pollution and conservation of resources - Charter on Corporate responsibility for Environmental protection - Environmental quality objectives –Concentration and Mass standards, Effluent and stream standards, Emission and ambient standards, Minimum national standards, environmental performance evaluation: Indicators, benchmarking. **Preventive environmental management** - Pollution control Vs Pollution Prevention - Opportunities and Barriers –– Analysis of Process Steps- source reduction, raw material substitution, toxic use reduction and elimination, process modification –Material balance – Technical, economical and environmental feasibility evaluation of Pollution Prevention options in selected industries – **Environmental management system**- EMAS, ISO 14000 - EMS as per ISO 14001– benefits and barriers of EMS – Concept of continual improvement and pollution prevention - environmental policy – initial environmental review – training awareness and competence- communication – documentation and document control – operational control – monitoring and measurement – management review- **Environmental audit**-Environmental management system audit as per ISO 19011 – Roles and qualifications of auditors-Environmental performance indicators and their evaluation – Non conformance – Corrective and preventive actions -compliance audits – waste audits and waste minimization planning – Environmental statement (form V) - Due diligence audit- **Applications-** Waste Audits and Pollution Prevention opportunities in Textile, Sugar, Pulp & Paper, Electroplating, Tanning industry, Dairy, Cement, Chemical industries, etc

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
	1.0 Environmental management standards	
1.1	Unique Characteristics of Environmental Problems - Systems approach to Corporate environmental management	1
1.2	Classification of Environmental Impact Reduction Efforts -Business Charter for Sustainable Production and Consumption	1
1.3	Tools, Business strategy drivers and Barriers - Evolution of Environmental Stewardship	1
1.4	Environmental Management Principles - National policies on environment, abatement of pollution and conservation of resources - Charter on Corporate responsibility for Environmental protection	1
1.5	Environmental quality objectives – Rationale of Environmental standards: Concentration and Mass standards,	1
1.6	Effluent and stream standards, Emission and ambient standards, Minimum national standards	1
1.7	environmental performance evaluation: Indicators, benchmarking	1
	2.0 Preventive environmental management	
2.1	Pollution control Vs Pollution Prevention	1
2.2	Opportunities and Barriers	1
2.3	Cleaner production and Clean technology, closing the loops, zero discharge technologies	1

2.4	Four Stages and nine approaches of Pollution Prevention	1
2.5	Getting management commitment – Analysis of Process Steps- source reduction, raw material substitution, toxic use reduction and elimination, process modification	1
2.6	Material balance – Technical, economical and environmental feasibility evaluation of Pollution Prevention options in selected industries	1
2.7	Preventive Environmental Management over Product cycle.	1
	3.0 Environmental management system	
3.1	EMAS, ISO 14000 - EMS as per ISO 14001– benefits and barriers of EMS	1
3.2	Concept of continual improvement and pollution prevention	1
3.3	. environmental policy – initial environmental review	1
3.4	environmental aspect and impact analysis	1
3.5	legal and other requirements- objectives and targets	1
3.6	environmental management programs – structure and responsibility	1
3.7	training awareness and competence	1
3.8	communication – documentation and document control	1
3.9	operational control – monitoring and measurement	1
3.10	management review	1
	4.0 Environmental audit	
4.1	Environmental management system audit as per ISO 19011	1
4.2	Roles and qualifications of auditors	1
4.3	Environmental performance indicators and their evaluation	1
4.4	Non-conformance – Corrective and preventive actions -	1
4.5	compliance audits	1
4.6	waste audits and waste minimization planning	1
4.7	Environmental statement (form V) - Due diligence audit	1
	5.0 Applications	
4.8	Applications of EMS	1
4.9	Waste Audits and Pollution Prevention opportunities in Textile, Sugar	1
4.10	Waste Audits and Pollution Prevention opportunities in Pulp & Paper, Electroplating	1
4.11	Waste Audits and Pollution Prevention opportunities in Tanning industry, Dairy	1
4.12	Waste Audits and Pollution Prevention opportunities in Cement, Chemical industries	1
	Total Periods	**36**

Reference Books

1. Environmental management in organizations, the IEMA Handbook edited by John Brady, Earth scan, 2005
2. Environmental Management Systems, (third edition) Christopher Sheldon and Mark Yoxon, Earth scan Publications, First South Asian Edition 2007
3. Environmental planning and management, Christian N Madu, Imperial college press, 2007
4. Hazardous waste management, M D LaGrega, P L Buckingham, J C Evans, McGraw Hill International Edition, 2001
5. Introduction to environmental engineering and science, Gilbert M Masters, Second edition, Pearson Education, 2004
6. ISO 14000 Environmental Management, David L Goetsch and Stanley B Davis, Prentice Hall, 2001.

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18ENPF0 CLIMATE CHANGE AND ADAPTATION Category L T P Credit

PE 3 0 0 3

Preamble

This course work is focused on the climate change scenario of the world due to industrialization, transportation and use of fossil fuels and to manage this scenario effectively for sustainability. The course work is designed to understand the earth‘s climate system, change in climate, causes for the climate change. The concept of global warming and regional changes, the impact of climate change on society and its mitigation measures are well addressed.

Course Outcomes

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

	Course outcome	Bloom‘s level	Expected Attainment Percentage (%)	Expected Proficiency (Grade)
CO1.	Explain the earth‘s climate change and its system classification	Understand	90	A
CO2.	Recognize the observed changes in the climate and concept of modeling and Institutional arrangements existing for monitoring this phenomenon	Understand	80	B
CO3.	Show the impact of climate change on various sectors and its irreversibility	Apply	90	A
CO4.	Make the adaptation and mitigation measures of climate change on various sectors.	Apply	90	A
CO5.	Practice the clean Technology for the Fuel and energy through natural and eco friendly techniques	Apply	95	B

Mapping with Programme Outcomes

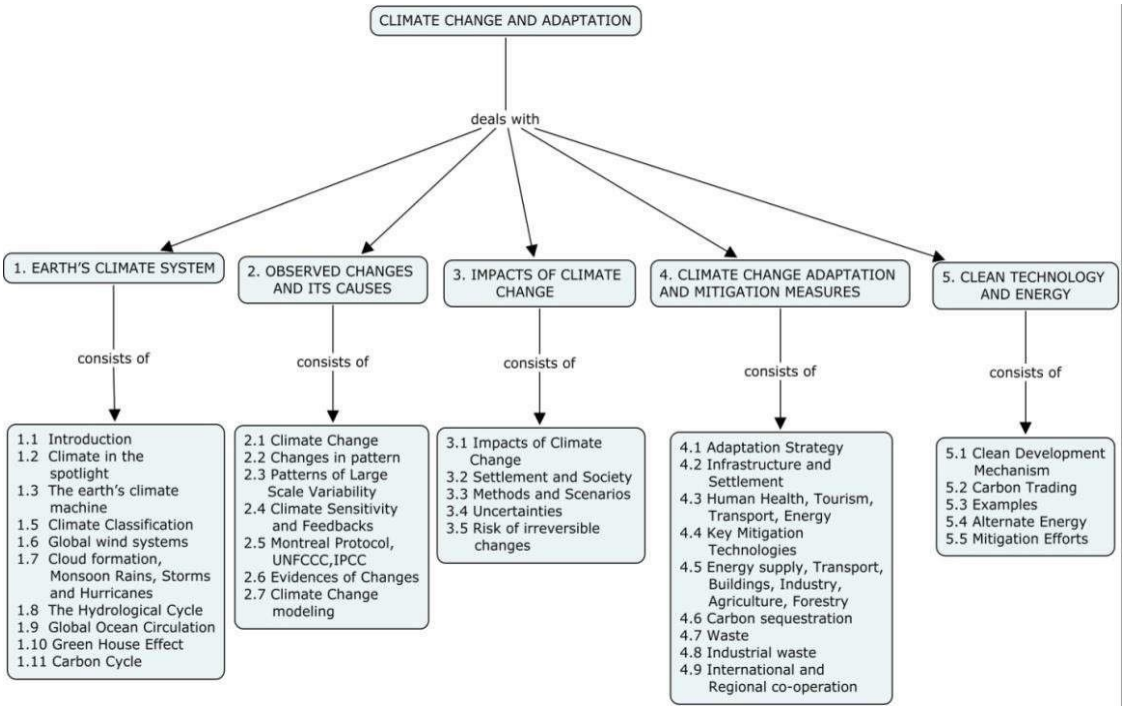
Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	L	-	-	-	-	L	-	-	L	-	L	S	L
CO2	L	-	-	-	-	L	L	-	L	-	L	M	L
CO3	M	M	M	-	-	L	L	-	L	-	L	S	L
CO4	M	M	M	-	-	L	L	L	L	-	L	S	M
CO5	M	M	M	-	-	L	M	L	L	-	L	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	60	60	50	50
Apply	20	20	30	30
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Concept Map



Syllabus

Earth's Climate System: Introduction-Climate in the spotlight-The Earth's Climate Machine – Climate Classification – Global wind systems – Trade Wind Systems – Trade Winds and the Hadley Cell – The Westerlies – Cloud formation and Monsoon Rains – Storms and Hurricanes – The Hydrological Cycle – Global Ocean Circulation – El Nino and its Effect – Solar Radiation – The Earth's Natural Green House Effect – Green House Gases and Global Warming – Carbon Cycle. **Observed Changes and Its Causes:** Observation of Climate Change – Changes in pattern of temperature, precipitation and sea level rise – Observed effects of Climate Changes – Patterns of Large Scale Variability – Drivers of Climate Change – Climate Sensitivity and Feedbacks –– Climate Change modeling. **Impacts Of Climate Change:** Impacts of Climate Change on various sectors – Agriculture, Forestry and Ecosystem – Water resources – Human Health – Industry, Settlement and Society – Methods and Scenarios – Projected Impacts for different regions **Climate Change Adaptation and Mitigation Measures:** Adaptation and mitigation Strategy/options in various sectors – Water – Agriculture –

Infrastructure and Settlement including coastal zones. Human Health – Tourism – Transport – Energy – Key Mitigation Technologies and practices Carbon sequestration – Carbon Capture and Storage (CCS) -Geoengineering– International and Regional co-operation Institutional arrangements- Protocol and agreements. Strategic Frameworks and Policy Low Carbon Development-Sectors with High Mitigation Potential **Clean Technology and Energy:** Clean Development Mechanism – Carbon Trading – Examples of future Clean Technology – Biodiesel – Natural Compost – Eco-friendly Plastic – Alternate Energy – Hydrogen – Bio-fuels – Solar Energy – Wind – Hydroelectric Power – Mitigation Efforts in India and Adaptation funding.

Course Contents and Lecture Schedule

S.No	Topic	No. of Lectures
	1. Earth's Climate System	
1.1	Introduction	1
1.2	Climate in the spotlight	1
1.3	The earth's climate machine	1
1.4	Climate Classification	1
1.5	Global wind systems, Trade Wind Systems and the Hadley Cell The Weserlies .	1
1.6	Cloud formation and Monsoon Rains, Storms and Hurricanes	1
1.7	The Hydrological Cycle	1
1.8	Global Ocean Circulation, El Nino and its Effect, Solar Radiation	1
1.9	The Earth's Natural Green House Effect, Green House Gases and Global Warming	1
1.10	Carbon Cycle	1
	2. Observed Changes And Its Causes	
2.1	Observation of Climate Change	1
2.2	Changes in pattern of temperature, precipitation and sea level rise – Observed effects of Climate changes	1
2.3	Patterns of Large Scale Variability – Drivers of Climate Change –	1
2.4	Climate Sensitivity and Feedbacks	1
2.5	The Montreal Protocol – UNFCCC – IPCC	1
2.6	Evidences of Changes in Climate and Environment – on a Global Scale and in India	1
2.7	Climate Change modeling	1
	3. Impacts Of Climate Change	
3.1	Impacts of Climate Change on various sectors Agriculture, Forestry ,Ecosystem, Water resources , Human Health ,Industry,——	1

3.2	Settlement and Society	1
3.3	Methods and Scenarios – Projected Impacts for different regions	1
3.4	Uncertainties in the Projected Impacts of Climate Change	1
3.5	Risk of irreversible changes.	1
4. Climate Change Adaptation and Mitigation Measures		
4.1	Adaptation Strategy/options in various sectors	1
4.2	Water – Agriculture – Infrastructure and Settlement including coastal zones.	1
4.3	Human Health – Tourism – Transport – Energy	1
4.4	Key Mitigation Technologies and practices	1
4.5	Energy supply – Transport – Buildings – Industry – Agriculture – Forestry	1
4.6	Carbon sequestration – Carbon Capture and Storage (CCS)	1
4.7	Waste (MSW & Biowaste, Biomedical)	1
4.8	Industrial waste	1
4.9	International and Regional co-operation.	1
5. Clean Technology and Energy		
5.1	Clean Development Mechanism ——— Hydrogen – Bio-fuels – Solar Energy – Wind – Hydroelectric Power – Mitigation Efforts in India and Adaptation funding.	1
5.2	Carbon Trading	1
5.3	Examples of future Clean Technology – Biodiesel – Natural Eco-friendly Plastic Compost,	1
5.4	Alternate Energy Hydrogen – Bio-fuels – Solar Energy – Wind – Hydroelectric Power	1
5.5	Mitigation Efforts in India and Adaptation funding.	1
Total Periods		**36**

Reference Books

1. Al core ‗Inconvenient Truth‘ – video form
2. Dash Sushil Kumar, -Climate Change – An Indian Perspective‖, CambridgeUniversity Press India Pvt. Ltd, 2007.
3. IPCC Fifth Assessment Report – www.ipcc.ch
4. Jan C. van Dam, Impacts of -Climate Change and Climate Variability on Hydrological Regimes‖, Cambridge University Press, 2003
5.UNFCCC (2006).UNFCCC Handbook

Course Designers

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		Category	L	T	P	Credit
18ENPG0	**ENVIRONMENTAL BIOTECHNOLOGY**	PE	3	0	0	3

Preamble

The course is aimed at providing information about micro-organisms, their interaction with contaminants and their kinetics. And also, to impart the knowledge on mass balancing of Activated sludge process and other reactors and to biodegrade the contaminants using biotechnological means.

Prerequisite

Completion of Undergraduate level courses on Environmental engineering.

Course Outcomes

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

	Course outcome	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	Understand the role of micro-organisms in degrading contaminants	Understand	85	A
CO2	Investigate mass balancing of reactors and activated sludge processes	Apply	75	B
CO3	Apply biological processes to degrade contaminants	Apply	75	B
CO4	Apply kinetic parameters in designing bio reactors	Apply	75	B
CO5	Interpret and extract pertinent information from literature survey	Analyse	65	C

Mapping with Programme Outcomes

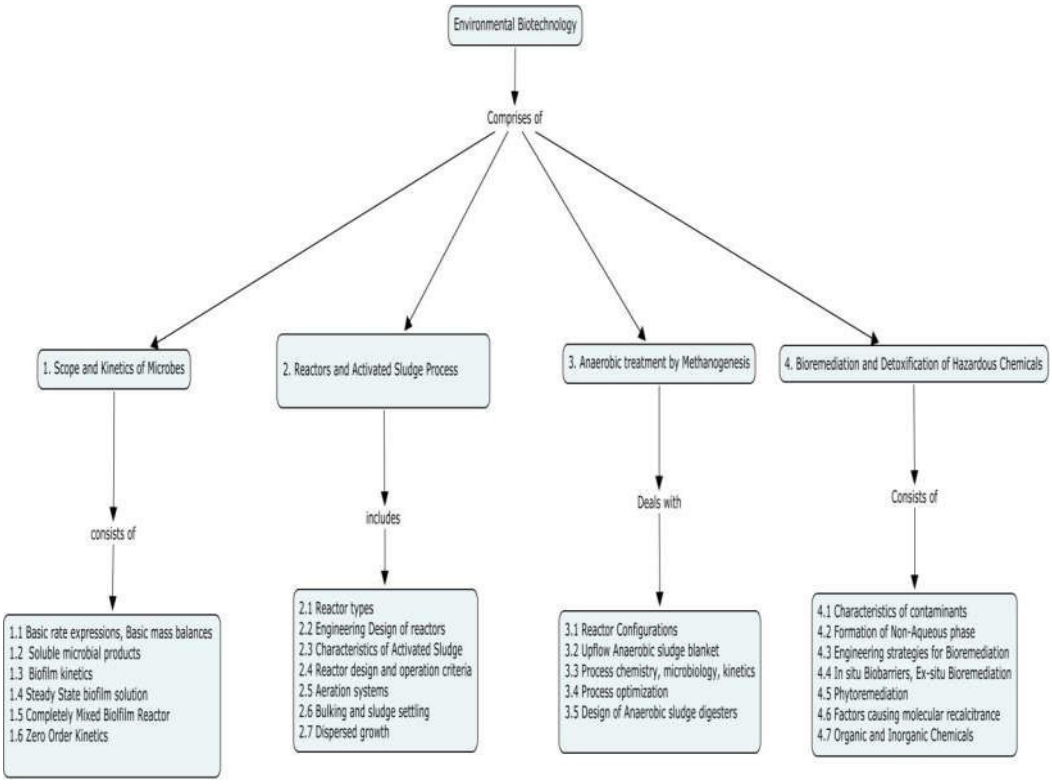
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1.	L	-	L	-	-	-	-	L	-	-	-	-	-
CO2.	L	M	M	-	-	L	-	L	-	-	-	L	-
CO3.	M	M	M	-	-	L	-	M	L	M	-	M	L
CO4.	M	M	M	-	-	L	-	M	L	M	-	M	L
CO5	S	S	S	S	-	S	-	S	M	M	S	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	50	50	30	30
Apply	30	30	25	25
Analyse	-	-	25	25
Evaluate	-	-	-	-
Create	-	-	-	-

Concept Map



Syllabus

Scope and Kinetics of Microbes: Basic Rate Expressions-Parameter Values, Basic Mass Balances, Mass Balances on Inert Biomass and Volatile Solids -Soluble Microbial Products, Nutrients and electron Acceptors -Input Active Biomass, Hydrolysis of Particulate and Polymeric Substrates; Biofilm Kinetics : Microbial Aggregation, Importance of Biofilms, The Idealized Biofilm, The Steady-State Biofilm, The Steady-State Biofilm Solution - Estimating Parameter Values, Average Biofilm SRT -Completely Mixed Biofilm Reactor, soluble microbial products and inert biomass, Trends in CMBR performance, Normalized surface loading, Nonsteady-state biofilms. **Reactors and Activated Sludge Process:** Reactor types,Mass Balances: Biofilm Reactors, batch reactor, continuous-Flow Stirred Tank reactor with effluent recycle, plug flow reactor. – Reactor with Recycle of Settled cells, Engineering Design of Reactors. -Characteristics of Activated Sludge, Process

Configurations, Design and Operation Criteria, Aeration Systems, Bulking and Other Sludge-Settling, Activated Sludge Design. **Anaerobic Treatment by Methanogonesis:** Uses of Methanogenic Treatment, Reactor Configurations, Process Chemistry and Microbiology; Process Kinetics. **Bioremediation and Detoxification of Hazardous Chemicals:** Scope and Characteristics of Contaminants, Biodegradability -Contaminant Availability for Biodegradation, Treatability Studies, Engineering Strategies for Bioremediation, Phytoremediation, Bioremediation of Gas-Phase VOCs, Evaluating Bioremediation.

Course content and lecture schedule

S.No	Topic	No. of Lectures
	1. Scope and Kinetics of Microbes	
1.1	Basic Rate Expressions, Parameter Values, Basic Mass Balances, Mass Balances on Inert Biomass and Volatile Solids.	1
1.2	Soluble Microbial Products, Nutrients and electron Acceptors, Input Active Biomass, Hydrolysis of Particulate and Polymeric Substrates, Inhibition, Other Alternate Rate Expressions.	1
1.3	Biofilm Kinetics, Microbial Aggregation, Importance of Biofilms, The Idealized Biofilm, The Substrate Phenomena, The Steady-State Biofilm.	2
1.4	The Steady-State Biofilm Solution, Estimating Parameter Values, Average Biofilm SRT.	2
1.5	Completely Mixed Biofilm Reactor, soluble microbial products and inert biomass, Trends in CMBR performance, Normalized surface loading, Non steady-state biofilms.	2
1.6	Special-Case Biofilm Solutions, Deep Biofilms, Zero-Order Kinetics	1
	2. Reactors and Activated Sludge Process	
2.1	Mass Balances: Suspended-Growth reactors, Biofilm Reactors, Reactor Arrangements, batch reactor, Reactor types,	2
2.2	CSTR with settling and cell recycling, Evaluation of assumptions, Plug-Flow reactor with settling and cell recycle,	2
2.3	Characteristics of Activated Sludge, Microbiology Ecology, Oxygen and Nutrient Requirements, Impacts of Solid retention Time, Process Configurations, Physical Configurations,	2
2.4	Design and Operation Criteria, Food to Microorganism ratio, Solid Retention Time, Comparison of Loading Factors, Mixed-liquor suspended solids, the SVI, and the Recycle Ratio	2
2.5	Aeration Systems, Oxygen-Transfer and Mixing Rates, Diffused Aeration Systems, Mechanical Aeration Systems.	2
2.6	Bulking and Other Sludge-Settling Problems, Bulking Sludge Foaming and Scum Control, Rising Sludge,	1
2.7	Dispersed Growth and Pinpoint Floc, Viscous Bulking,	1
	3. Anaerobic Treatment by Methanogenesis	
3.1	Uses of Methanogenic Treatment, Reactor Configurations, Completely Mixed, Anaerobic Contact, Upflow and Downflow Packed Beds, Fluidized Beds.	2

3.2	Upflow Anaerobic Sludge Blanket, Miscellaneous Anaerobic Reactors.	1
3.3	Process Kinetics, Temperature Effects, Reaction Kinetics for a CSTR, Complex Substrates,	1
3.4	Process Optimization, Reaction Kinetics for Biofilm Processes, Kinetics with Hydrolysis as the Limiting Factor.	1
3.5	Special Factors for the Design of Anaerobic Sludge Digesters, Loading Criteria, Mixing, Heating, Gas Collection.	1
4. Bioremediation and Detoxification of Hazardous Chemicals		
4.1	Scope and Characteristics of Contaminants, Organic Compounds, Mixtures of Organic Compounds, Mixtures Created by Co disposal, Biodegradability.	1
4.2	Contaminant Availability for Biodegradation, sorption to Surfaces, Formation of Non-aqueous Phase.	1
4.3	Treatability Studies, Engineering Strategies for Bioremediation, Site Characterization, Engineering In Situ Bioremediation, Intrinsic In Situ Bioremediation and Natural Attenuation.	1
4.4	In Situ Bio barriers, Ex Situ Bioremediation.	1
4.5	Phytoremediation, Bioremediation of Gas-Phase VOCs, Evaluating Bioremediation.	1
4.6	Factors Causing Molecular Recalcitrance, Molecular Structure, Energy Metabolism Versus Co-metabolism, Electron Donor Versus Electron Acceptor, Biodegradation of Environmental Contaminants.	2
4.7	Synthetic Detergents, Pesticides, Hydrocarbons, Chlorinated Solvents and Other Halogenated Aliphatic Hydrocarbons, Chlorinated Aromatic Hydrocarbons, Explosives, General Fate Modelling for Organic Chemicals, Inorganic Elements.	2
Total Periods		**36**

Reference Books

1. Bruce E. Rittmann, Perry L. McCarty (2001), -Environmental Biotechnology: Principles and Applications‖ (2001), McGraw-Hill, publications.
2. Olguin, J.E., Sanchez, G. and Hernandez, E. -Environmental Biotechnology and cleaner bioprocess‖, Taylor and Francis Ltd., U.S.A., 2000
3. Wainwright, M. -An Introduction to Environmental Biotechnology‖, 1999

Course Designer

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		Category	L	T	P	Credit
18ENPH0	**ENVIRONMENTAL REMOTE SENSING**	PE	3	0	0	3

Preamble

Remote sensing techniques are very much useful for environmental data acquisition and analysis. Geographical Information System is another important scientific tool in making decisions in environmental management issues based on the input data. This course work deals with the principles and techniques and the data processing in remote sensing, concepts of GIS, database management, GIS softwares and the applications of RS and GIS.

Course Outcomes

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

	Course Outcomes	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1.	Understand the fundamental principles of EMR.	Understand	85	A
CO2.	Understand remote sensing data transmission and collection systems.	Understand	85	A
CO3	Apply basic image analysis techniques for environmental issues.	Apply	75	B
CO4.	Analysis of GIS data through the concepts of GIS data input and management.	Apply	75	B
CO5	Application of Remote Sensing and GIS techniques to real-world environmental issues	Apply	65	C
CO6	Interpret and extract pertinent information from survey of literature	Analyse	65	C

Mapping with Programme Outcomes

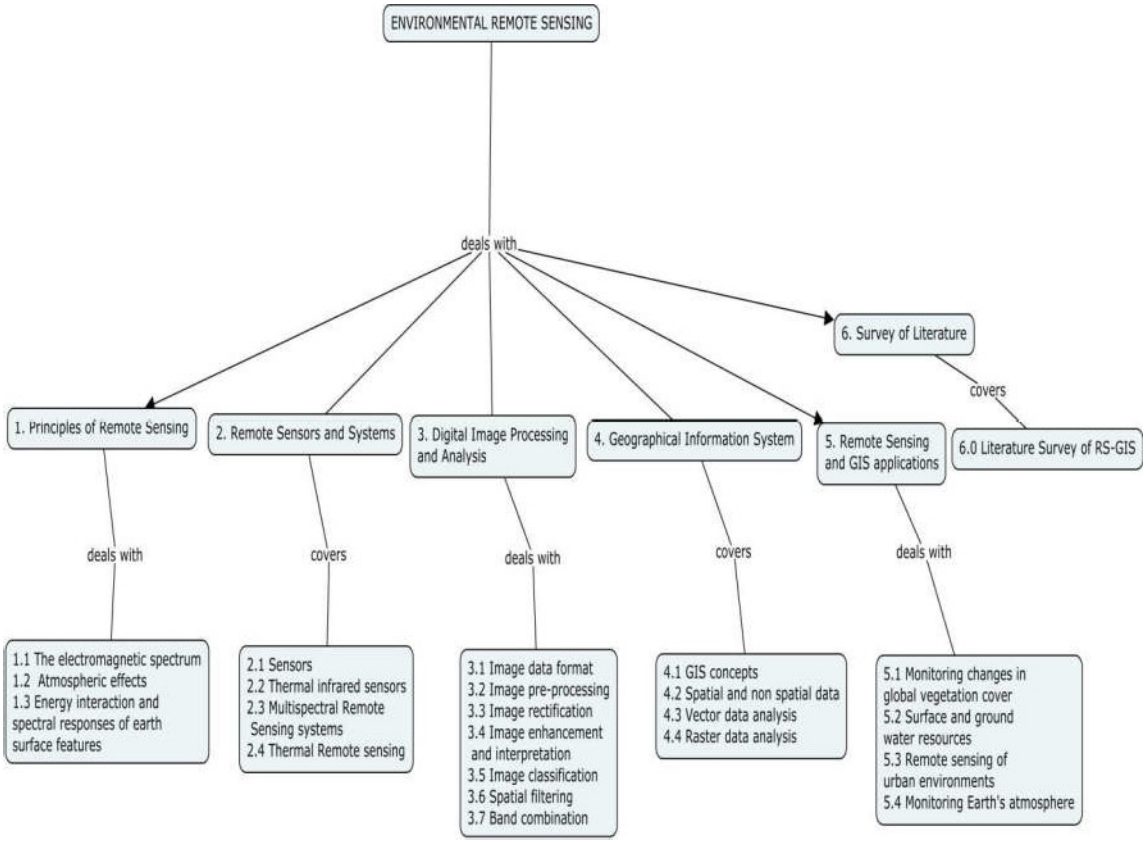
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	M	M	-	-	-	L	L	-	-	-	-	-	-
CO2	M	M	-	-	-	L	L	-	-	-	-	L	-
CO3	M	M	-	-	-	L	L	-	-	-	-	M	L
CO4	S	S	S	S	S	M	M	M	L	L	-	M	L
CO5	-	-	M	S	S	M	S	-	-	-	-	S	S
CO6	S	S	S	S	L	M	-	M	S	S	S	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	30	30	30	30
Apply	50	50	25	25
Analyse	-	-	25	25
Evaluate	-	-	-	-
Create	-	-	-	-

Concept Map



Syllabus

Principles of Remote Sensing: The electromagnetic spectrum - Atmospheric effects - Energy interaction and spectral responses of earth surface features. **Remote Sensors and Systems:** Sensors - Resolution types **-** Multispectral remote sensing systems **-** Thermal infrared remote sensing **Digital Image Processing and Analysis**: Image data format and types. Image interpretation techniques - Image pre-processing and rectification- Image enhancement **-** Image classification – Spatial filtering- Band combination. **Geographical Information System:** GIS concepts**-** Spatial and non spatial data, Vector and raster data structures**-** Data analysis**. Remote Sensing and GIS applications:** Monitoring changes in global vegetation cover-. Surface and ground water resources - Remote sensing of urban

environments - Monitoring Earth's atmosphere**, Survey of Literature**- Literature Survey of RS-GIS.

Course content and lecture schedule

S.No	Topic	No. of Lectures
	1. Principles of Remote Sensing	
1.1	The electromagnetic spectrum – source, properties, radiation laws.	1
1.2	Atmospheric effects – scattering, absorption and reflection. Atmospheric windows –spectral rerflectance-spectral signatures.	1
1.3	Energy interaction and spectral responses of earth surface features – land, water, vegetation and soils.	1
	2. Remote Sensors and Systems	
2.1	Sensors- types and its reolutions	1
2.2	Thermal infrared sensors, Radar and microwave radiometers.	1
2.3	Multispectral Remote Sensing systems – data collection, multispectral imaging using detectors, scanning mirrors, linear arrays, scanners.	2
2.4	Thermal Remote sensing- properties, laws, data collection and examples.	1
	3. Digital Image Processing and Analysis	
3.1	Image data format, types of data and its significance.	1
3.2	Image pre-processing– radiometric corrections- line drop, de stripping, scattering correction, geometric distortions and earth rotation and correction.	2
3.3	Image rectification - – Generation of images to map by various important models.	2
3.4	Image enhancement and interpretation – linear contrast stretch, histogram equalization, logarithmic and exponential contrast enhancement.	2
3.5	Image classification - Image band selection-spervised and Unsupervised techniques.	2
3.6	Spatial filtering – noise removal, edge enhancement, edge extraction and normalization.	2
3.7	Band combination – linear, ratioing, Principal component analysis.	2
	4. Geographical Information System	
4.1	GIS concepts, map projection and coordinate system.	1
4.2	Spatial and non spatial data, Vector and raster data structures	1
4.3	Vector data analysis – buffering and overlaying	2
4.4	Raster data analysis – local, neighborhood, zonal operations and distance measureoperations.	2
	5. Remote Sensing and GIS applications	
5.1	**Monitoring changes in global vegetation cover:** EM spectrum of vegetation. Vegetation indices. Biophysical properties and processes of vegetation. Classification systems. Global vegetation and land cover mapping programmes.	2
5.2	**Surface and ground water resources:** Remote sensing of inland water quality and sediment load. Mapping watersheds and groundwater recharge and discharge site at the regional scale.	2
5.3	**Remote sensing of urban environments:** Urbanization, landuse and	2

	landcover, critical environmental assessment and disaster emergency response..	
5.4	**Monitoring Earth's atmosphere:**The status of Earth's atmosphere – ozone, carbon dioxide and atmospheric dust.	1
6. Survey of Literature		
6.0	Literature Survey of RS-GIS	2
Total Periods		**36**

Reference Books

1. Burrough, P. A. and McDonnell, R. A., Principles of Geographic Information Systems, Oxford University Press, New York, 2001.
2. John R Jensen, -Remote Sensing of the Environment: An Earth Resource Perspective (2nd Edition, 2006) Pearson Publication.
3. Samuel Purkis and Victor Klemas, — Remote Sensing and Global Environmental Changell (2011), Wiley-Blackwell, A John Wiley & Sons, Ltd. Publication.
4. Thomas Lillesand, Ralph W. Kiefer, Jonathan Chipman, -Remote Sensing and Image Interpretation, 6th Edition(2008) John Wiley & Sons, Publications.

Course Designer

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18ENPJ0	RESOURCES AND ENERGY RECOVERY FROM WASTE	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

Solid waste is generated in tonnes a day throughout the world especially in urban centres. The disposal of solid waste is becoming much more complex due to toxic materials which pollutes the environment and underground water. This course work is focused to deal with recovery of resources and energy from the waste for sustainable development particularly from solid waste which includes sludge sedimented from wastewater. The process of material recovery from solid waste to recycle is dealt in this course work. The process of energy recovery in the form of Thermal, Biofuels and green manure product from the solid waste is covered in detail. The course work also covers several case studies to recycle the usable materials recovered from solid waste with its socio-economic and legal considerations.

Prerequisite

Solid Waste Management and Biological Treatment System

Course Outcomes

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

	Course Outcomes	Bloom's level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1.	Apply the various recovery process and volume reduction process of solid waste for sustainable development	Apply	80	A
CO2.	Examine biological process for transformation of solid waste to useful by- products such as green manure for beneficial use	Apply	80	A
CO3.	Examine Bio-chemical process for transformation of solid waste to useful by-products such as bio-gas for beneficial use.	Apply	80	A
CO4.	Examine Thermal-chemical process for transformation of solid waste to useful by-products such as Heat energy for beneficial use	Apply	80	A
CO5.	Analyze the recycling and recovery concepts of various solid waste and E waste practiced in the world from case studies	Apply	80	A

Mapping with Programme Outcomes

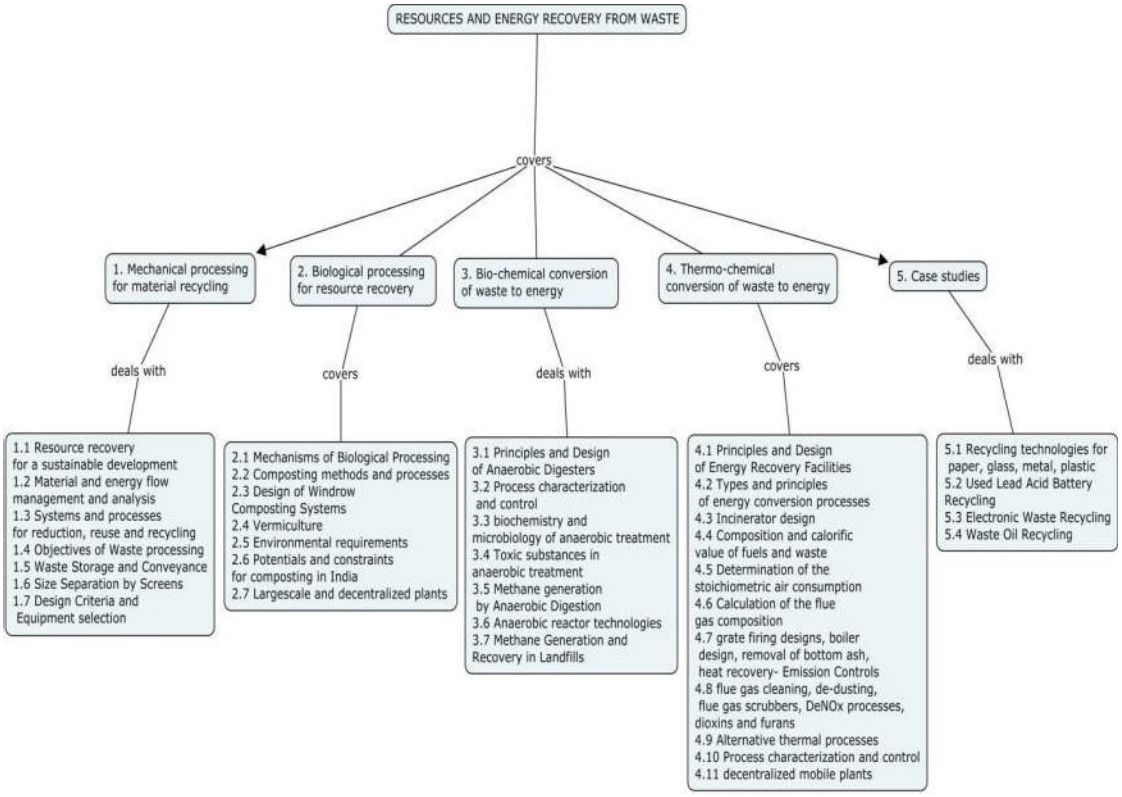
COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	M	M	M	-	-	L	M	L	L	-	-	M	M
CO2	S	M	M	-	-	L	L	-	L	-	-	M	M
CO3	S	M	M	-	-	L	L	-	L	-	-	M	M
CO4	S	M	M	-	-	L	L	-	L	-	-	M	M
CO5	S	M	M	-	-	M	M	M	L	-	-	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	40	40	40	40
Apply	40	40	40	40
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Concept Map



Syllabus

Mechanical processing for material recycling : Resource recovery for a sustainable development- Material and energy flow management and analysis - Systems and processes for reduction, reuse and recycling -Objectives of Waste processing-Source Segregation and Hand Sorting-Waste Storage and Conveyance – Shredding – Pulping - Size Separation by Screens- Density Separation by Air Classification –magnetic and electromechanical separation processes- Design Criteria and Equipment selection**. Biological processing for resource recovery :** Mechanisms of Biological Processing – Aerobic Processing of Organic fraction - Composting methods and processes- factors affecting- Design of Windrow Composting Systems- - Vermiculture: definition, scope and importance – common species for culture - Environmental requirements - culture methods- Applications of vermiculture- Potentials and constraints for composting in India-Largescale and decentralized plants. **Bio-chemical conversion of waste to energy :** Principles and Design of Anaerobic Digesters – Process characterization and control**-** The biochemistry and microbiology of anaerobic treatment - Toxic substances in anaerobic treatment -Methane generation by Anaerobic Digestion- Anaerobic reactor technologies – Commercial anaerobic Technologies- -Methane Generation and Recovery in Landfills – Biofuels from Biomass**. Thermo-chemical conversion of waste to energy:** Principles and Design of Energy Recovery Facilities - Types and principles of energy conversion processes - Incinerator design - Mass Burn and RDF Systems- Composition and calorific value of fuels and waste, Determination of the stoichiometric air consumption, Calculation of the flue gas composition - grate firing designs, boiler design, removal of bottom ash, heat recovery- Emission Controls – flue gas cleaning, de-dusting, flue gas scrubbers, DeNOx processes, dioxins and furans - Alternative thermal processes: co-incineration, pyrolysis, gasification, plasma arc – Process characterization and control- waste heat recovery- disposal- Facility design- decentralized mobile plants- Planning and construction of incineration plants**. Case studies:** Recycling technologies for paper, glass, metal, plastic – Used Lead Acid Battery Recycling –End of Life Vehicle Recycling – Electronic Waste Recycling – Waste Oil Recycling.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
	1.0 Mechanical processing for material recycling	
1.1	Resource recovery for a sustainable development	1
1.2	Material and energy flow management and analysis	1
1.3	Systems and processes for reduction, reuse and recycling	1
1.4	Objectives of Waste processing-Source Segregation and Hand Sorting	1
1.5	Waste Storage and Conveyance- Shredding – Pulping	1
1.6	Size Separation by Screens- Density Separation by Air Classification- Magnetic and electromechanical separation processes	1
1.7	Design Criteria and Equipment selection	1
	2.0 Biological processing for resource recovery	
2.1	Mechanisms of Biological Processing- Aerobic Processing of Organic fraction	1
2.2	Composting methods and processes- factors affecting	1

2.3	Design of Windrow Composting Systems	1
2.4	Vermiculture: definition, scope and importance – common species for culture	1
2.5	Environmental requirements - culture methods- Applications of vermiculture	1
2.6	Potentials and constraints for composting in India	1
2.7	Largescale and decentralized plants	1
	3.0 Bio-chemical conversion of waste to energy	
3.1	Principles and Design of Anaerobic Digesters	1
3.2	Process characterization and control	1
3.3	The biochemistry and microbiology of anaerobic treatment	1
3.4	Toxic substances in anaerobic treatment	1
3.5	Methane generation by Anaerobic Digestion	1
3.6	Anaerobic reactor technologies	1
3.7	Methane Generation and Recovery in Landfills	1
	4.0 Thermo-chemical conversion of waste to energy	
4.1	Principles and Design of Energy Recovery Facilities	1
4.2	Types and principles of energy conversion processes	1
4.3	Incinerator design- Mass Burn and RDF Systems	1
4.4	Composition and calorific value of fuels and waste	1
4.5	Determination of the stoichiometric air consumption	1
4.6	Calculation of the flue gas composition	1
4.7	grate firing designs, boiler design, removal of bottom ash, heat recovery- Emission Controls	1
4.8	flue gas cleaning, de-dusting, flue gas scrubbers, DeNOx processes, dioxins and furans	1
4.9	Alternative thermal processes: co-incineration, pyrolysis, gasification, plasma arc	1
4.10	Process characterization and control- waste heat recovery- disposal- Facility design	1
4.11	decentralized mobile plants- Planning and construction of incineration plants	1
	5.0 Case studies	
5.1	Recycling technologies for paper, glass, metal, plastic	1
5.2	Used Lead Acid Battery Recycling- End of Life Vehicle Recycling	1
5.3	Electronic Waste Recycling	1
5.4	Waste Oil Recycling	1
	Total Periods	**36**

Reference Books

1. Aarne Veslind and Alan E Rimer (1981), -Unit operations in Resource Recovery Engineering -, Prentice Hall Inc., London.
2. Charles R Rhyner (1995),Waste Management and Resource Recovery, Lewis Publishers
3. Chiumenti, Chiumenti, Diaz, Savage, Eggerth, and Goldstein *, Modern Composting Technologies* , JG Press October 2005.
4. Gary C. Young (2010)Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons , John Wiley & Sons
5. Manser A G R, Keeling A A (1996). Practical handbook of processing and recycling on municipal waste. Pub CRC Lewis London, ISBN 1-56670-164.

Course Designers:

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		Category	L	T	P	Credit
18ENPK0	**SURFACE AND GROUND WATER QUALITY MODELLING**	PE	3	0	0	3

Preamble

Modeling is a very useful tool in studying and forecasting the environmental quality parameters. The mathematical models would be of great support in taking managerial decisions towards the mitigation and remedial measure against the environmental degradation. This course work addresses the modeling techniques for surface and ground water quality.

Prerequisite

Completion of Undergraduate level courses on Environmental engineering.

Course Outcomes

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

	Course outcomes	Bloom's level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1.	Describe water and ground quality processes such as reaction kinetics, diffusion and eutrophication.	Understand	80	B
CO2.	Apply the results of water and examine groundwater quality models such as QUAL2K, and USGS models such as MODFLOW	Apply	80	B
CO3.	Use the basics of modeling to stratified lakes and reservoirs	Understand	80	B
CO4.	Principles of groundwater quality modeling	Understand	80	B
CO5	Illustrate problem solving skills including model calibration, validation, and verification	Apply	70	C

Mapping with Programme Outcomes

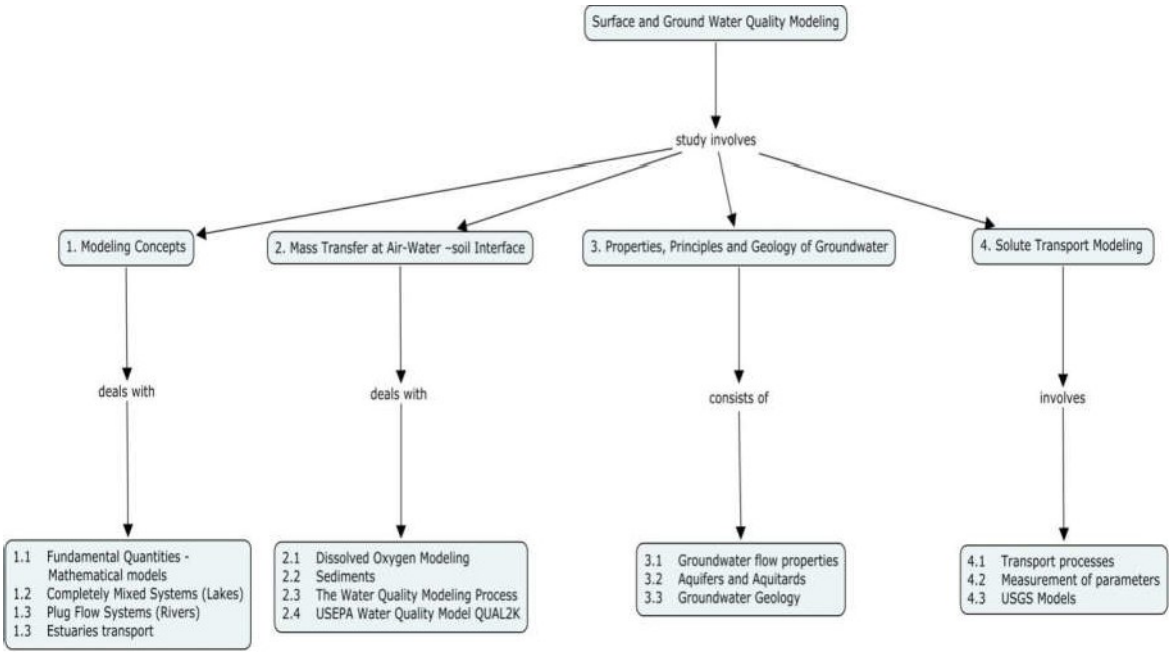
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	L	L	L	L	-	-	L	L	L	-	-	M	S
CO2	M	L	L	L	L	L	L	-	L	-	-	M	S
CO3	L	L	L	L	L	L	L	-	L	-	-	M	S
CO4	L	L	L	L	L	L	L	-	L	-	-	M	S
CO5	M	M	M	M	L	L	L	-	L	-	-	M	S

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	30	30	30	30
Apply	50	50	50	50
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Concept Map



Syllabus

Modeling Concepts: Introduction: Water Quality-Fundamental Quantities-Mathematical models, Historical Development of Water-Quality Models.- Basic modeling concepts - Reaction Kinetics-Reaction fundamentals-Analysis of Rate Data-Stochiometry-Temperature Effects.- Completely Mixed Systems (Lakes)- Mass Balance , Applied Loadings, Step Input, Impulse Input.- Plug Flow Systems (Rivers): Types, Hydrogeometry- Low-flow Analysis. Dispersion and Mixing - Flow, Depth and velocity-Routing and Water Quality.- Estuaries: Estuary transport-Net Estuarine Flow-Estuary Dispersion coefficient-Vertical Stratification. **Mass Transfer at Air-Water –soil Interface:** Dissolved Oxygen Modeling-Reaeration-Carbonaceous BOD, Nitrogenous BOD, Photosynthesis/Algal Respiration, Benthal Demands.- Sediments: Sediment transport overview-Suspended Solids-the Bottom Sediments-Simple Solids Budgets-Bottom Sediments as a Distributed Systems-Resuspension..- The Water Quality Modeling Process- Model Sensitivity.- Presentations of Case Study information and USEPA Water Quality Model QUAL2K. **Properties, Principles and Geology of Groundwater:** Hydraulic head and fluid potential, Hydraulic Conductivity and Permeability, heterogeneity and Anisotropy of hydraulic Conductivity-porosity, void ratio, unsaturated flow and water table.- Aquifers and Aquitards-Steady state flow and Transient flow-Transmissivity

and Storativiy, Equation of ground water flow-Limitation of Darcian Approach-Hydrodynamic dispersion.- Groundwater Geology: Lithology, Stratigraphy and Structure, FluvialDeposits, Aeolian Deposits, Glacial Deposits, Sedimentary Rocks. **Solute Transport Modeling :** Transport processes: Non-reactive constituents in homogenous and heterogeneous media –Governing equations.- Hydrochemical behavior of contaminants-Nitrogen, trace metals organic substances.- Measurement of parameters: Determination of Velocity, Dispersivity and chemical partitioning -sources of contamination Presentation of case study-USGS Models.

Course Contents and Lecture Schedule

S.No	Topics	No. of Lectures
	1. Modeling Concepts	
1.1	Introduction, Water Quality-Fundamental Quantities-Mathematical models, Historical Development of Water-Quality Models.	2
1.1.1	Basic modeling concepts - Reaction Kinetics-Reaction fundamentals-Analysis of Rate Data-Stochiometry-Temperature Effects	2
1.2	Completely Mixed Systems (Lakes)- Mass Balance , Applied Loadings, Step Input, Impulse Input	2
1.3	Plug Flow Systems (Rivers): Types, Hydrogeometry- Low-flow Analysis	2
1.3.1	Dispersion and Mixing -Flow, Depth and velocity-Routing and Water Quality.	2
1.4	Estuaries: Estuary transport-Net Estuarine Flow-Estuary Dispersion coefficient-Vertical Stratification	2
	2. Mass Transfer at Air-Water –soil Interface	
2.1	Dissolved Oxygen Modeling-Reaeration-Carbonaceous BOD, Nitrogenous BOD, Photosynthesis/Algal Respiration, Benthal Demands	2
2.2	Sediments: Sediment transport overview-Suspended Solids-the Bottom Sediments-Simple Solids Budgets-Bottom Sediments as a Distributed Systems-Resuspension.	2
2.3	The Water Quality Modeling Process- Model Sensitivity.	2
2.4	Presentations of Case Study information and USEPA Water Quality Model QUAL2K	4
	3. Properties, Principles and Geology of Groundwater	
3.1	Hydraulic head and fluid potential, Hydraulic Conductivity and Permeability, heterogeneity and Anisotropy of hydraulic Conductivity-porosity, void ratio, unsaturated flow and water table	2
3.2	Aquifers and Aquitards-Steady state flow and Transient flow-Transmissivity and Storativity, Equation of ground water flow-Limitation of Darcian Approach-Hydrodynamic dispersion	2

3.3	Groundwater Geology: Lithology, Stratigraphy and Structure,	1
	FluvilalDeposits, Aeolian Deposits, Glacial Deposits, Sedimentary Rocks	1
4. Solute Transport Modeling		
4.1	Transport processes: Non-reactive constituents in homogenous and heterogeneous media –Governing equations.	2
	Hydrochemical behavior of contaminants-Nitrogen, trace metals organic substances	1
4.2	Measurement of parameters: Determination of Velocity, Dispersivity and chemical partitioning -sources of contamination	2
4.3	Presentation of case study-USGS Models	3
Total Periods		**36**

Reference Books

1. Allen Free R. and John A. Cherry, -Groundwater| Printice Hall Inc. 1979
2. Steven C.Chapra, Surface Water Quality Modelling, The McGraw-Hill Companies, Inc., New Delhi, 1997.

Course Designer

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		Category	L	T	P	Credit
18ENPL0	**FATE AND TRANSPORT OF CONTAMINANTS IN THE ENVIRONMENT**	PE	3	0	0	3

Preamble

To expose the fundamentals of pollutant transport mechanism to the students of environmental engineering and familiarize to chemical and thermal equilibrium at EnvironmentalInterfaces.

Prerequisite

Completion of Undergraduate level courses on Environmental engineering.

Course Outcomes

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

	Course outcomes	Bloom's level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	Explain the fundamental phenomenon of transport of pollutants in the environment specifically at the interfaces between air-water-soil.	Understand	80	B
CO2	Compute the concentrations of pollutants at the interfaces between air and water-water and soil-air and soil.	Apply	70	C
CO3.	Examine the Fate and transport of Conservative and non-conservative pollutants.	Apply	70	C
CO4.	Analyse the chemical exchange within different phases	Analyse	70	C
CO5.	Explain the transport of turbulence and heat transfer	Understand	80	B

Mapping with Programme Outcomes

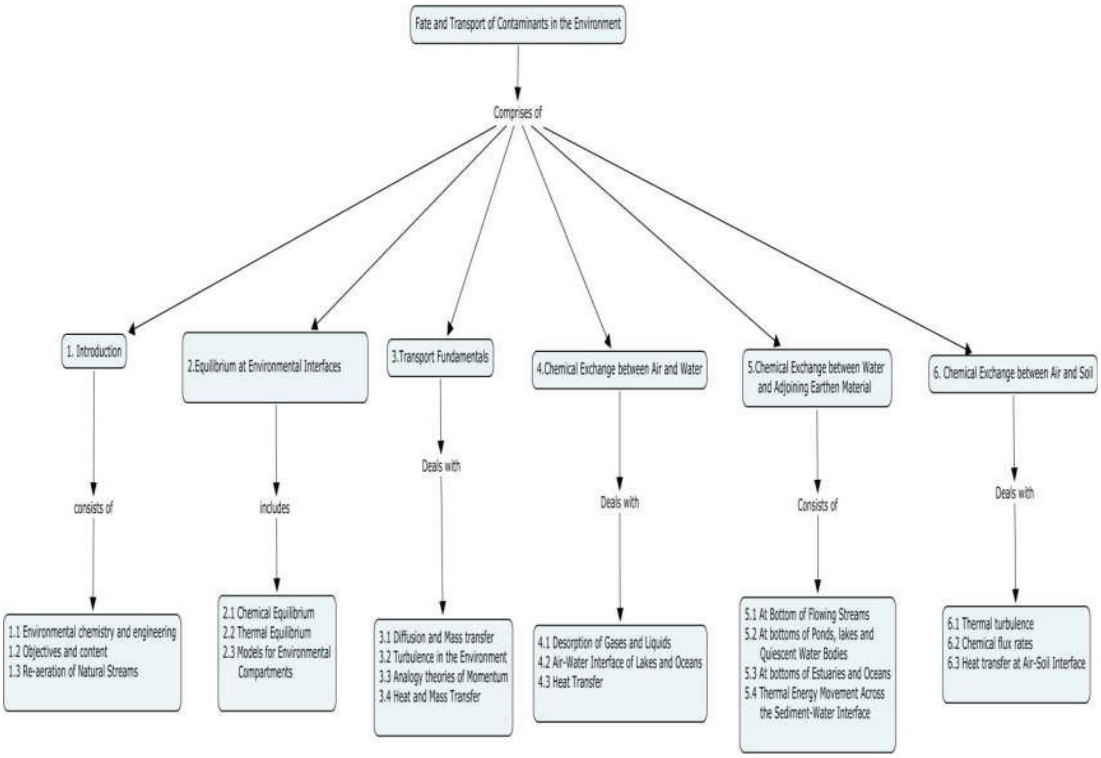
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	L	L	L	-	L	L	L	L	L	L	-	M	M
CO2	M	L	L	-	L	L	L	-	L	L	-	M	S
CO3	L	L	L	L	L	L	L	-	L	-	-	M	S
CO4	L	L	L	L	L	L	L	-	L	-	-	M	S
CO5	M	M	M	M	L	L	L	-	L	-	-	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	30	30	30	30
Apply	50	50	50	50
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Concept Map



Syllabus

Introducion: Introduction to environmental chemistry and engineering-Illustration of objectives and content: Reaeration of Natural Streams. **Equilibrium at Environmental Interfaces:**Chemical Equilibrium at Environmental Interfaces- Thermal Equilibrium at Environmental Interfaces- Chemical Equilibrium models for Environmental Compartments. **Transport Fundamentals** :Diffusion and Mass transfer - turbulence in the Environment-Fundamentals of Heat Transfer. Analogy theories of Momentum, Heat and Mass Transfer-Particles and Porous Media.**Chemical Exchange between Air and Water** :Desorption of Gases and Liquids from Aerated Basins and Rivers- Exchange of Chemicals Across the Air-Water Interface of Lakes and Oceans- Heat Transfer Across the Air-Water interface. **Chemical Exchange between Water and Adjoining Earthen Material:** Chemical Transport at Bottom of Flowing Streams- Chemical Movement at bottoms of Ponds, lakes

and Quiescent Water Bodies- Chemical Movement at bottoms of Estuaries and Oceans- Thermal Energy Movement Across the Sediment-Water Interface. **Chemical Exchange between Air and Soil**: Thermal turbulence Above Air-Soil Interface- Chemical flux rates Through upper layer of Earthen material-Heat transfer at Air-Soil Interface.

Course Contents and Lecture Schedule

S.No	Topic	No. of Lectures
	1. Introduction	
1.1	Introduction to environmental chemistry and engineering	1
1.2	Illustration of objectives and content	1
1.3	Re-aeration of Natural Streams	1
	2. Equilibrium at Environmental Interfaces	
2.1	Chemical Equilibrium at Environmental Interfaces: Air-water;	2
2.1.1	Water-soil; soil-Air	1
2.2	Thermal Equilibrium at Environmental Interfaces: Air-water;	2
2.2.2	Water-soil; soil-Air	1
2.3	Chemical Equilibrium models for Environmental Compartments	2
	3. Transport Fundamentals	
3.1	Diffusion and Mass transfer	1
3.2	Turbulence in the Environment-Fundamentals of Heat Transfer	2
3.3	Analogy theories of Momentum	2
3.4	Heat and Mass Transfer-Particles and Porous Media	1
	4. Chemical Exchange between Air and Water	
4.1	Desorption of Gases and Liquids from Aerated Basins and Rivers	2
4.2	Exchange of Chemicals Across the Air-Water Interface of Lakes and Oceans	2
4.3	Heat Transfer Across the Air-Water interface	1
	5. Chemical Exchange between Water and Adjoining Earthen Material	
5.1	Chemical Transport at Bottom of Flowing Streams	2
5.2	Chemical Movement at bottoms of Ponds, lakes and Quiescent Water Bodies	2
5.3	Chemical Movement at bottoms of Estuaries and Oceans	2
5.4	Thermal Energy Movement Across the Sediment-Water Interface	2
	6. Chemical Exchange between Air and Soil	
6.1	Thermal turbulence Above Air-Soil Interface	2
6.2	Chemical flux rates through upper layer of Earthen material	2
6.3	Heat transfer at Air-Soil Interface	2
	Total	**36**

Reference Books

1. Clark, M. M. -Transport Modeling for Environmrntal Engineers and Scientist‖ John Wiley & SonsInc., New York.,1996
2. Louis J. Thibodeaux -Environmental Chemodynamics: Movements of Chemicals in Air, Water and Soil‖ John Wiley & Sons, Inc. New York., 1996

Course Designer

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18ENPM0 **AIR QUALITY MODELLING**

Category	L	T	P	Credit
PE	2	1	0	3

Preamble

This course work expose the students in the field of air quality modelling and understand the fundamentals of meteorology and dispersion phenomena of air in the environment and develop the skills for modelling with different plume dispersion models.

Prerequisite

Basics of air pollution & control engineering.

Course Outcomes

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

	Course outcomes	Bloom's level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1.	Understand the fundamentals of meteorological processes.	Understand	80	B
CO2.	Investigate air pollutant atmospheric dispersion phenomena	Apply	70	C
CO3.	Develop atmospheric pollutant transport processes mechanism.	Apply	70	C
CO4	Apply air quality dispersion models such as ISC-3,CALINE for point source and line source.	Apply	70	C
CO5	Investigate and extract the pertinent information from literature survey and case studies	Analyse	80	B

Mapping with Programme Outcomes

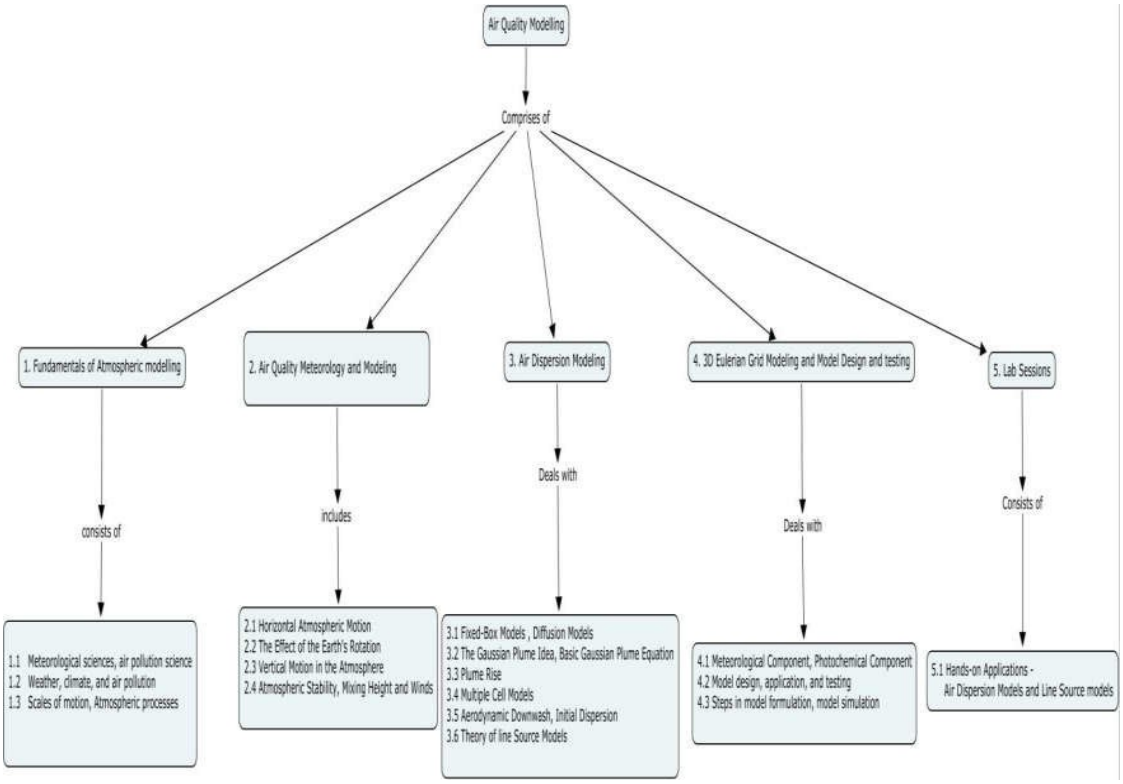
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	L	-	-	-	-	-	-	-	-	-	-	-	-
CO2	M	M	M	-	-	M	-	-	L	M	L	M	L
CO3	M	M	M	-	-	M	-	-	L	M	L	M	L
CO4	M	M	M	S	-	M	-	-	L	M	L	M	L
CO5	S	S	S	S	-	S	L	M	M	S	M	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	30	30	30	30
Apply	50	50	25	25
Analyse	-	-	25	25
Evaluate	-	-	-	-
Create	-	-	-	-

Concept Map



Syllabus

Fundamentals of Atmospheric Modeling: Brief history of meteorological sciences-Brief history of air-pollution science- The merging of air-pollution and meteorological sciences-Weather, climate, and air pollution-Scales of motion - Atmospheric processes **Air Quality Meteorology and Modeling:** The Atmosphere-Horizontal Atmospheric Motion -Equatorial Heating, Polar Cooling -The Effect of the Earth's Rotation-The Influence of the Ground and the Sea-Vertical Motion in the Atmosphere -Air Density Change with Temperature and Humidity -Air Density Change with Pressure -Atmospheric Stability-Mixing Height-Moisture -Winds -Velocities -Wind Direction. **Air Dispersion Modeling:** Fixed-Box Models -Diffusion Models -The Gaussian Plume Idea -

Gaussian Plume Derivation Some Modifications of the Basic Gaussian Plume Equation - Plume Rise -Long-Term Average Uses of Gaussian Plume Models -Pollutant Creation and Decay in the Atmosphere -Multiple Cell Models -Receptor-Oriented and Source-Oriented Air Pollution Models -Other Topics -Building Wakes -Aerodynamic Downwash -Transport Distances -Initial Dispersion EPA-Recommended Models-theory of line Source Models-BLP-CALINE3-CAL3 CTDMPLUS-OCD. **3D Eulerian Grid Modeling and Model Design and testing:** Meteorological Component - Photochemical Component- Application and Analysis.Model design, application, and testing: Steps in model formulation- Example model simulation. **Lab Sessions:** Hands-on Applications for real World Problems Using USEPA Air Dispersion Models and Line Source models-Literature survey/Case studies.

Course content and lecture schedule

S.No	Topic	No. of Lectures
	1. Fundamentals of Atmospheric Modeling	
1.1	Brief history of meteorological sciences, air pollution science	1
1.2	The merging of air-pollution and meteorological sciences-Weather, climate, and air pollution	1
1.3	Scales of motion, Atmospheric processes	1
	Tutorial	1
	2. Air Quality Meteorology and Modeling	
2.1	The Atmosphere, Horizontal Atmospheric Motion , Equatorial Heating, Polar Cooling	1
2.2	The Effect of the Earth's Rotation, The Influence of the Ground and the Sea	1
2.3	Vertical Motion in the Atmosphere , Air Density Change with Temperature, Humidity and Pressure	1
2.4	Atmospheric Stability, Mixing Height, Moisture, Winds Velocities Wind Direction.	1
	Tutorial	2
	3. Air Dispersion Modeling	
3.1	Fixed-Box Models , Diffusion Models	1
3.2	The Gaussian Plume Idea, Gaussian Plume Derivation Some Modifications of the Basic Gaussian Plume Equation	2
3.3	Plume Rise , Long-Term Average Uses of Gaussian Plume Models, Pollutant Creation and Decay in the Atmosphere	2
3.4	Multiple Cell Models, Receptor-Oriented and Source-Oriented Air Pollution Models, Other Topics, Building Wakes	2
3.5	Aerodynamic Downwash, Transport Distances, Initial Dispersion, EPA-Recommended Models	2
3.6	Theory of line Source Models-BLP-CALINE3-CAL3-CTDMPLUS-OCD.	2
	Tutorial	3

4. 3D Eulerian Grid Modeling and Model Design and testing		
4.1	Meteorological Component, Photochemical Component, Application and Analysis.	2
4.2	Model design, application, and testing	2
4.3	Steps in model formulation, Example model simulation	2
4.4	Tutorial Hands-on Applications for real World Problems Using US-EPA Air Dispersion Models and Line Source models.	6
Total		**36**

Reference Books

1. Mark Z. Jacobson, -Fundamental of Atmospheric Modeling‖ Gambridge University Press,2005
2. Noel de Nevers, — Air Pollution Control Engineering, 2nd ed.2000
3. Paolo Zannetti, EnviroComp/A&WMA, -Air Quality Modeling Vol.I-III

Course Designer

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18ENPN0 SUSTAINABLE MANAGEMENT OF URBAN ECOLOGY

Category	L	T	P	Credit
PE	3	0	0	3

Preamble

This course provides an overview of, and engagement with, various theoretical perspectives, debates and research practices in urban ecology, urban ecosystems, and urban sustainability. At the intersection of increasing urbanization and ecological crises, there has been an intense theoretical debate on how to understand and research urban nature and urban ecology in a sustainable manner. This course work covers the concept of sustainable management especially in the urban environment. It also explains the various environmental issues in an urban scenario and its impacts on ecology. It provides exposure to various issues in the management of urban water resources and wastewater. The future of Urban ecosystems and managing the climate change through the concept of future proofing is also addressed in the course work.

Prerequisite

Basic knowledge on Ecology, Environment, Water resources and wastewater engineering.

Course Outcomes

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

	Course Outcome	Bloom's level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	Explain the concept of sustainable development in the urban perspective	Understand	80	A
CO2	Explain the concept of urban ecology and its framework	Understand	85	A
CO3	Apply the Urban water management tools and models	Apply	90	B
CO4	Explain the present scenario and introduce eco friendly techniques to manage the wastewater	Understand	85	B
CO5	Produce the future urban ecosystems keeping the climate change as a constraint	Apply	85	A

Mapping with Programme Outcomes

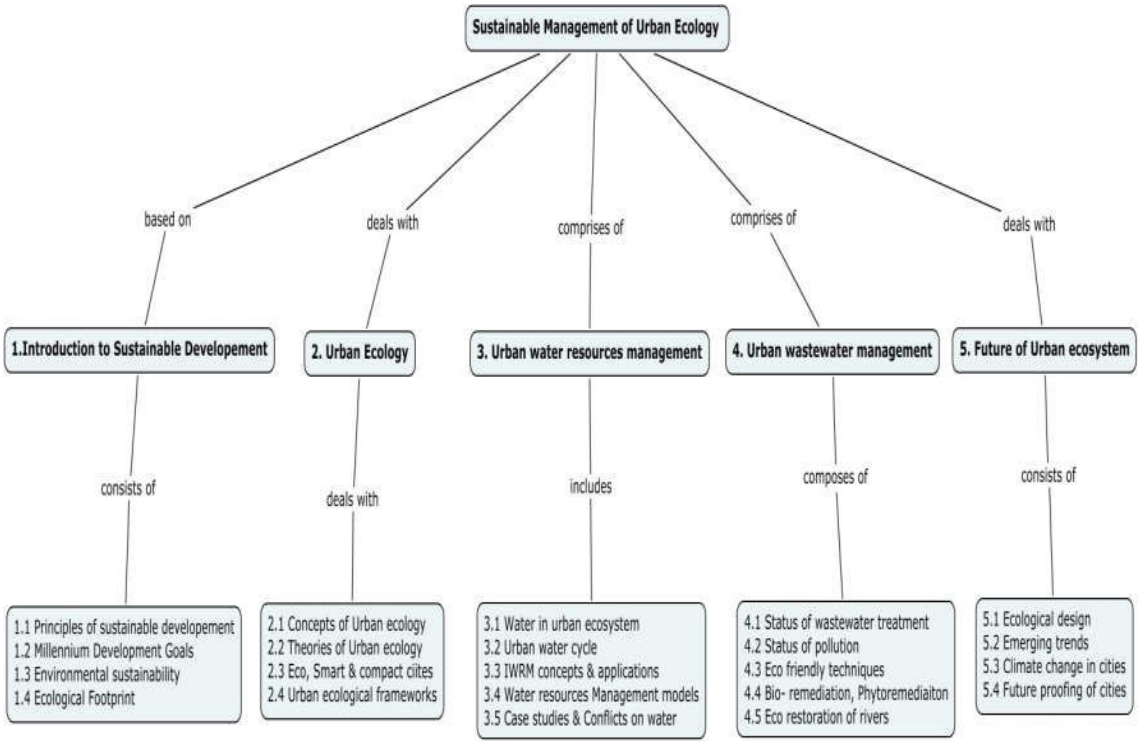
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	L	-	-	-	-	L	-	L	L	M	-	L	S
CO2	L	-	-	-	-	L	-	L	L	M	-	L	L
CO3	M	M	M	-	-	M	-	M	M	M	-	S	S
CO4	L	-	-	-	-	M	-	M	L	M	-	L	M
CO5	M	L	L	-	-	M	-	M	M	L	-	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	80	50	50	50
Apply	-	30	30	30
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Concept Map



Syllabus

Introduction to Sustainable Development: Definitions and principles of Sustainable Development –Environment and Development linkages –Millennium Development Goals **Environmental Sustainability:** Planning, Measuring Sustainability - Carrying Capacity and its limits - Social Capital and its limits- Urban sustainability, Social, Economic , Ecological dimensions, Concept of Ecological Foot print **Urban Ecosystem** Concepts and theories of urban ecology**-** Linkages with sustainable urbanism – Concepts of Eco cities, smart cities, compact cities- Urban Ecosystem Challenges and opportunities – Urban areas and ecological services, Urban Ecological Frameworks **Urban water resources management:** Water in urban ecosystem – Urban Water Cycle - storm water management practices – Water harvesting Structures – IWRM concepts, planning and applications to Urban Water management– Water Resources management models and Water policy of Developed

nations- National water Policy -Conflicts on water between Interstate and country – water Pricing – Case studies **Urban wastewater management:** Status of Wastewater treatment and disposal, pollution in India – Impacts on ecosystem, Eco friendly treatment systems-concept of decentralization – Bio remediation, Phytoremediation- Wastewater management policy and models of Developed nations– eco restoration of rivers – Case studies. **Futures of Urban Ecosystems** Scenario Planning and Adaptive Management, Ecological Design, Emerging Trends and Technologies, Integrated Models, Adaptation and mitigation measures to make cities resilient Future proofing of cities.

Course Contents and Lecture Schedule

S.No	Topics	No of Lectures
	1. Introduction to Sustainable Development	
1.1	Definitions and principles of Sustainable Development	1
1.2	History and emergence of the concept of Sustainable Development	1
1.3	Environment and Development linkages	1
1.4	Globalization and environment- Millennium Development Goals: Status (global and Indian)	1
1.5	Environmental Sustainability Planning Measuring Sustainability - Carrying Capacity And its Limits	1
1.6	Social Capital And its Limits	1
1.7	Introduction to urban sustainability	1
1.8	Social dimensions, Economic dimensions, Ecological dimensions	1
1.9	Physical aspects	1
1.10	Concept of Ecological Foot print.	1
	2. Urban ecology	
2.1	Concepts and theories of urban ecology and linkages with sustainable urbanism	1
2.2	Concepts of Eco cities, smart cities, compact cities etc.	1
2.3	Urban Ecosystem Challenges and opportunities of urban, rural and periurban growth,	1
2.4	Processes in human population growth, urbanization and implications for urban ecology	1
2.5	Urban areas and ecological ecosystem services	1
2.6	Urban Ecological Frameworks, the principles and frameworks of ecology	1
2.7	Environmental perspectives on Urban master plans	1
2.8	Institutions working on Water, Environment- National/International levels	1
	3. Urban water resources management	
3.1	Water in urban ecosystem and Urban Water Cycle	1
3.2	Urban water resources planning and organization aspects	1
3.3	Rainfall- runoff- Groundwater Recharge in urban regions	1
3.4	Storm water management practices storage capacity of urban components	1
3.5	Water harvesting Structures	1

3.6	IWRM – concepts and applications to Urban Water management and Distribution	1
3.7	Integrated urban water planning	1
3.8	Water Resources management models and Water policy of Developed nations	1
3.9	Case studies -Conflicts on water- Interstate/ country – water Pricing	1
4. Urban wastewater management		
4.1	Status of Wastewater treatment and disposal on India/ developed nations	1
4.2	Status of pollution	1
4.3	Eco friendly treatment systems-concept of decentralization	1
4.4	Bio remediation, Phytoremediation	1
4.5	Wastewater management policy and models of Developed nation and Case study on restoration of rivers	1
5. Futures of Urban Ecosystems		
5.1	Scenario Planning and Adaptive Management	1
5.2	Ecological Design, Emerging Trends and Technologies	1
5.3	Integrated Models, Climate modifications and managing climate change challenges in cities,	1
5.4	Adaptation and mitigation measures to make cities resilient Future proofing of cities	1
	Total periods	**36**

Reference Books

1. Neil S. Grigg., -Urban Water Infrastructure Planning – Management and Operations‖, John Wiley and Sons, 1986.
2. Philip James, Jari Niemelajurgen H . Breuste -Urban Ecology: Patterns, Processes and Applications‖, OUP Oxford, 2011.
3. Tracer Strange and Anne BAley ,-Sustainable Development –Linking economy,Society , environment‖, StatLink from OECD Publishing 2008.
4. UNU/IAS Report ,-Defining an Ecosystem Approach to Urban Management and Policy Development‖ March 2003 .
5. Zhifeng Yang -Eco- Cities: A Planning Guide (Applied Ecology and Environmental Management)‖ CRC Press, 2012.

Course Designer

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18ENPP0 **INDOOR AIR QUALITY MANAGEMENT**

Category	L	T	P	Credit
PE	3	0	0	3

Preamble

To impart knowledge on the principles of Indoor air quality and its effect on human health

Prerequisite

Nil

Course outcome

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

	Course Outcomes	Bloom's Level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1	Understand the basics of Indoor Air Quality management.	Understand	85	A
CO2	Investigate the behavior of air pollutants in indoor environment	Apply	75	B
CO3	Apply the concepts and tools for the management of Indoor Air pollutants	Apply	75	B
CO4	Examine the control technologies to address the Indoor Air Quality problems	Analyse	65	C
CO5	Understand the basics of indoor air pollution from outdoor sources	Understand	85	A
CO6	Investigate to extract pertinent information through literature survey for the scientific and technological control advancement of Indoor Air Pollution or case studies.	Analyse	65	C

Mapping with Programme Outcomes

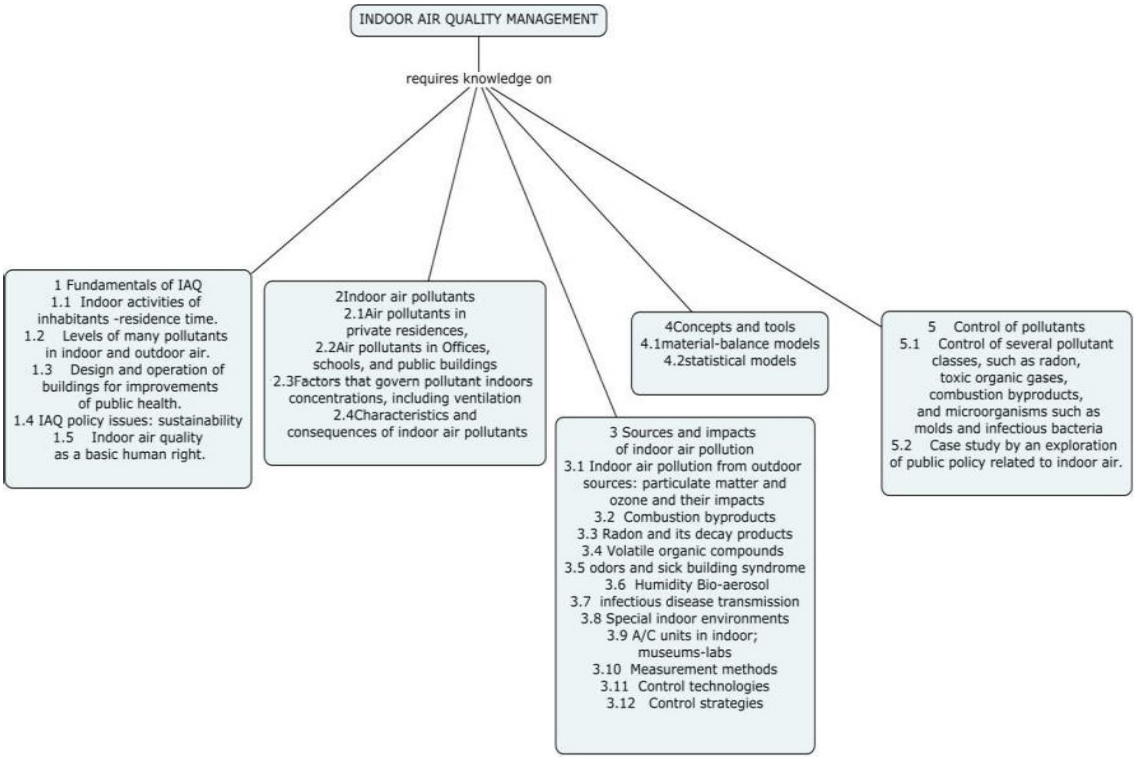
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	L	-	-	-	-	-	-	-	-	-	-	-	-
CO2	M	M	-	-	-	-	-	M	L	L	L	L	L
CO3	M	M	M	-	-	M	-	M	L	L	L	M	L
CO4	S	S	S	S	-	S	-	S	M	M	L	S	M
CO5	L	-	-	-	-	-			-	-	-	-	-
CO6	S	S	S	S	-	S		S	M	M	S	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	50	50	30	30
Apply	30	30	25	25
Analyse	-	-	25	25
Evaluate	-	-	-	-
Create	-	-	-	-

Concept Map



Syllabus

Fundamentals of IAQ: Indoor activities of inhabitants -residence time. Levels of many pollutants in indoor and outdoor air. Design and operation of buildings for improvements of public health. IAQ policy issues: sustainability; indoor air quality as a basic human right. **Indoor air pollutants:** Air pollutants in indoor environments, private residences, offices, schools, and public buildings, factors that govern pollutant indoors concentrations, including ventilation, Characteristics, Consequences.**Sources and impacts of indoor air pollution** 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; museums-labs; Measurement methods, Control

technologies, Control strategies. . **Concepts and tools:** exposure, material-balance models, statistical models Ventilation. **Control of pollutants -** Control of several pollutant classes, such as radon, toxic organic gases, combustion byproducts, and microorganisms such as molds and infectious bacteria **-** Case study by an exploration of public policy related to indoor air. **Survey of Literature -** Literature survey of Indoor Air Pollution and extraction of information

Course content and lecture schedule

Module No	Topics	No. of Lectures
	1 Fundamentals of IAQ	
1.1	Indoor activities of inhabitants -residence time.	1
1.2	Levels of many pollutants in indoor and outdoor air.	1
1.3	Design and operation of buildings for improvements of public health.	2
1.4	IAQ policy issues: sustainability	1
1.5	Indoor air quality as a basic human right.	1
	2 Indoor air pollutants	
2.1	Air pollutants in private residences,	1
2.2	Air pollutants in Offices, schools, and public buildings	1
2.3	Factors that govern pollutant indoors concentrations, including ventilation	1
2.4	Characteristics of indoor air pollutants	1
2.5	Case studies on Impact of indoor air pollutant on human health	2
	3 Sources and impacts of indoor air pollution	
3.1	Indoor air pollution from outdoor sources: particulate matter and ozone and their impacts	2
3.2	Combustion byproducts and its impacts	1
3.3	Radon and its decay products and its impacts	1
3.4	Volatile organic compounds and its impacts	1
3.5	odors and sick building syndrome and its impacts	1
3.6	Humidity Bio-aerosols and its impacts	1
3.7	infectious disease transmission and its impacts	1
3.8	Special indoor environments and its impacts	1
3.9	A/C units in indoor; museums-labs	1
3.10	Measurement methods	2
3.11	Control technologies	2
3.12	Control strategies	2
	4 Concepts and tools	

4.1	Material-balance models	2
4.2	Statistical models	2
	5 Control of pollutants	
5.1	Control of several pollutant classes, such as radon, toxic organic gases, combustion byproducts, and microorganisms such as molds and infectious bacteria	2
5.2	Case study by an exploration of public policy related to indoor air.	2
	6 Survey of Literature	
6.0	Literature survey of Indoor Air Pollution and extraction of information	
	TOTAL	**36**

Reference Books

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. Moroni Marco, Seifet Bernd and Lindrall Thomas, Indoor Air Quality: A Comprehensive Reference Book, Elsevier Science, Vol. 3, 1995

Course designers

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		Category	L	T	P	Credit
18ENPQ0	**SUSTAINABLE DEVELOPMENT AND ENVIRONMENT**	PE	3	0	0	3

Preamble

This coursework covers the concept of sustainable development in the context of various environmental components and its interaction with human development.

Course outcome

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

	Course Outcome	Bloom's level	Expected Attainment Percentage (%)	Expected Proficiency (Grade)
CO1	Explain the concept of Sustainable Development.	Understand	90	A
CO2	Explain the indicators towards attaining sustainability	Understand	80	B
CO3	Choose action plans for implementing sustainable development	Apply	85	B
CO4	Explain the concept of Sustainable measurements and Global commitments	Understand	90	A
CO5	Develop strategies to achieve sustainability.	Apply	80	B

Mapping with Programme Outcomes

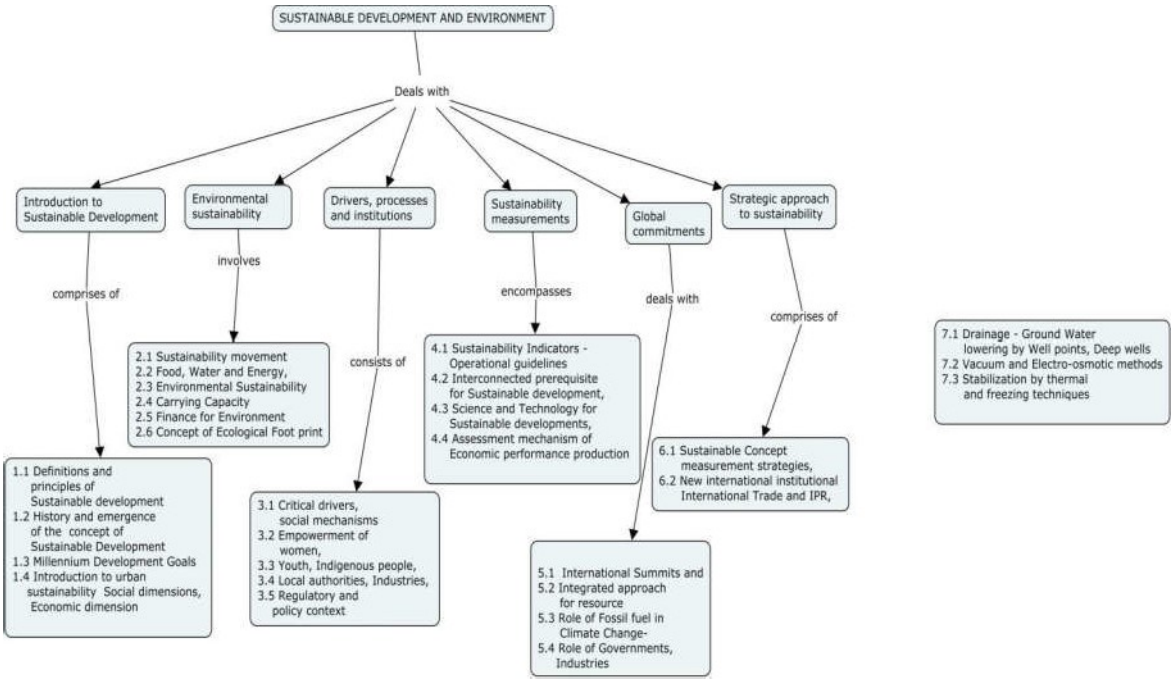
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	L	-	-	-	-	M	S	L	M	-	-	-	M
CO2	L	-	-	-	-	M	S	L	M	-	-	-	M
CO3	S	L	M	-	-	L	L	L	L	-	-	M	L
CO4	L	-	-	-	-	M	S	L	M	-	-	-	M
CO5	S	L	M	-	-	L	L	L	L	-	L	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	50	50	50	50
Apply	30	30	30	30
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Concept Map



Syllabus

Introduction to Sustainable Development: Definitions and principles of Sustainable development, History and emergence of the concept of Sustainable Development, Environment and Development linkages, Globalization and environment-Millennium Development Goals: Status (global and Indian), Evolving conceptions - causes and consequences, Social Capital And its Limits, Introduction to urban sustainability, Social dimensions, Economic dimensions, Ecological dimensions **Environmental sustainability:** Sustainability movement towards Land, Food, Water and Energy, Environmental Sustainability Planning Measuring Sustainability - Carrying Capacity And its Limits, Finance for Environment-Sustainable development, Concept of Ecological Foot print, **Drivers, processes and institutions** Critical drivers, social mechanisms and cognitive factors, Empowerment of women, Children, Youth, Indigenous people, Empowerment of NGOs, Local authorities, Industries, Role of Corporate Social Responsibility, Regulatory and policy context of Sustainability. **Sustainability measurements** Sustainability Indicators - Operational guidelines - Interconnected prerequisite for Sustainable development, Science and Technology for Sustainable developments, Performance indicators of Sustainability, Assessment mechanism of Economic performance - production and consumption, Constraints and barriers for sustainable development. **Global commitments** International Summits and Trans boundary issues, Integrated approach for resource protection and management, Role of Fossil fuel in Climate Change- future use of renewable energy, Role of Governments, Industries and Individuals - International agreement and Protocols. **Strategic approach to sustainability-**Sustainable Concept measurement strategies, From sustainability 'Problems' to 'Solution' strategies, New international institutional contexts, International Trade and IPR, Global Accord

Lecture schedule

Module No	Topics	No of Lectures
	1.0 Introduction to Sustainable Development	
1.1	Definitions and principles of Sustainable Development	1
1.2	History and emergence of the concept of Sustainable Development	1
1.3	Environment and Development linkages	1
1.4	Globalization and environment- Millennium Development Goals: Status (global and Indian)	1
1.5	Evolving conceptions - causes and consequences	1
1.6	Social Capital And its Limits	1
1.7	Introduction to urban sustainability	1
1.8	Social dimensions, Economic dimensions, Ecological dimensions	1
	2.0 Environmental Sustainability	
2.1	Sustainability movement towards Land, Food, Water and Energy	1
2.2	Environmental Sustainability Planning Measuring Sustainability - Carrying Capacity And its Limits	1
2.3	Moving towards Sustainability-Possible ways	1
2.4	Finance for Environment-Sustainable development	1
2.5	Concept of Ecological Foot print,	1
	3.0 Drivers, processes and institutions	
3.1	Critical drivers, social mechanisms and cognitive factors	1
3.2	Empowerment of women, Children, Youth, Indigenous people	1
3.3	Empowerment of NGOs, Local authorities, Industries	1
3.4	Role of Corporate Social Responsibility	1
3.5	Regulatory and policy context of Sustainability	1
	4.0 Sustainability Measurements	
4.1	Sustainability Indicators - Operational guidelines	1
4.2	Interconnected prerequisite for Sustainable development	1
4.3	Science and Technology for Sustainable developments	1
4.4	Performance indicators of Sustainability	1
4.5	Assessment mechanism	1
4.6	Economic performance - production and consumption	1
4.7	Constraints and barriers for sustainable development.	1
	5.0 Global Commitments	
5.1	International Summits and Trans boundary issues	1
5.2	Integrated approach for resource protection and management	1
5.3	Role of Fossil fuel in Climate Change- future use of renewable energy	1
5.4	Role of Governments, Industries and Individuals	1
5.5	International agreement and Protocols	1
	6.0 Strategic approach to sustainability	
6.1	Sustainable Concept measurement strategies	1
6.2	From sustainability 'Problems' to 'Solution' strategies	1
6.3	New international institutional contexts	1
6.4	International Trade and IPR	2

6.5	Global Accord	1
	Total periods	**36**

Reference Book

1. -Achieving Broad-Based Sustainable Development: Governance, Environment, and Growth with Equity James H. Weaver, Michael T. Rock, Kenneth Kustere. Kumarian Press, West Hartford, CT. Publication Year: 1997
2. -Sustainable development Kirkby. J, O'Keefe P. and Timberlake, Earth Scan Publication, London, 1996.
3. Sustainable Environmental Management: Principles and Practice by R. Kerry Turner. 292 pgs. Publisher: Belhaven Press, ISBN:1852930039.
4. Environmental Concerns and Sustainable development: Some perspectives from India,Editors: Ganesha Somayaji and Sakarama Somayaji, publisher TERI Press, ISBN 8179932249.
5. -Introduction to Sustainability, N. Munier ,Springer 2005

Course designers

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		Category	L	T	P	Credit
18ENPR0	**ENVIRONMENTAL GEOTECHNOLOGY**	PE	3	0	0	3

Preamble

This course is an interdisciplinary course covering topics from geotechnical engineering and environmental engineering to develop environmentally sound solutions to geotechnical problems.

Course Outcomes

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

	Course Outcomes	Bloom's level	Expected Attainment level (%)	Expected Proficiency (grade)
CO1.	Solve the environmental engineering problems specific to different soil and subsurface conditions.	Apply	80	B
CO2.	Ilustrate the chemical interaction with the soil and the transport mechanism of the contaminants in the soil	Apply	80	B
CO3.	Identify and illustrate soil characterisation Techniques	Apply	80	B
CO4.	Choose appropriate techniques for the waste containment.	Apply	80	B
CO5.	Illustrate the remediation techniques for waste contaminated sites	Apply	80	B

Mapping with Programme Outcomes

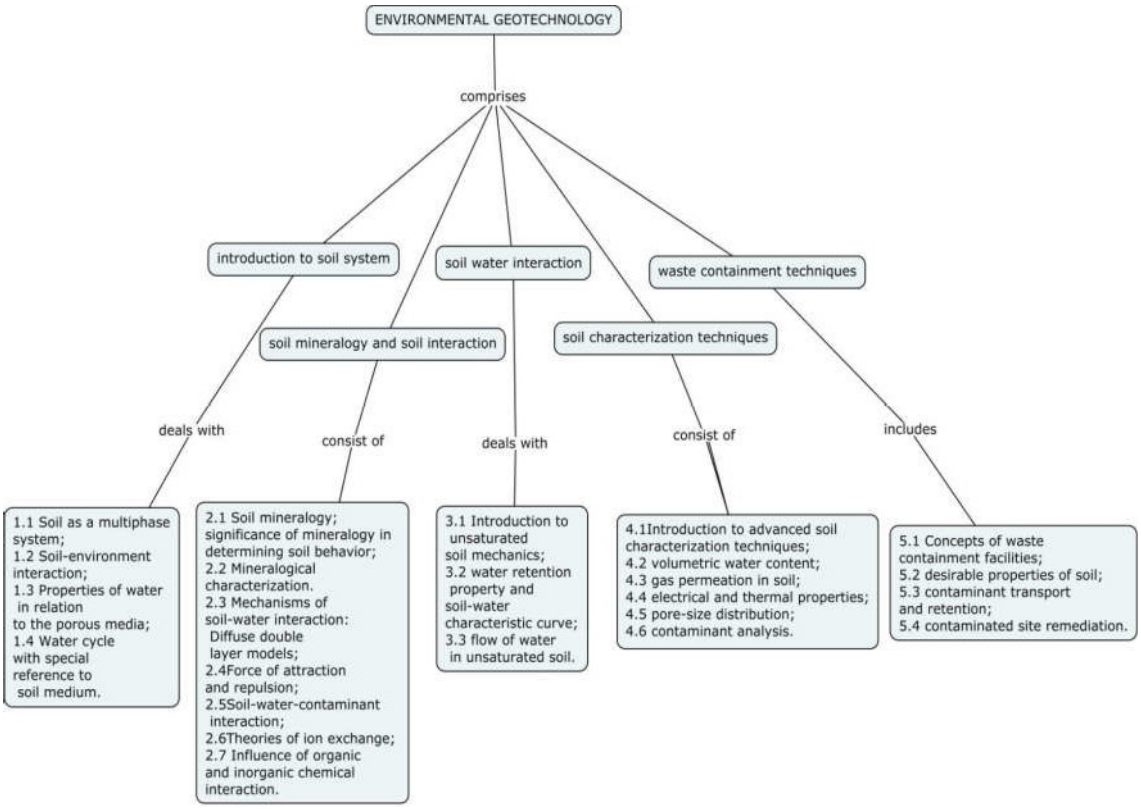
COS	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO 1	PSO 2
CO1	M	M	-	-	-	M	-	L	M	M	-	M	M
CO2	M	M	-	-	-	M	-	L	M	L	-	M	M
CO3	M	M	M	M	-	M	-	M	M	M	-	M	M
CO4	M	M	M	M	-	M	-	M	L	M	-	M	M
CO5	M	M	M	M	-	M	-	M	L	M	-	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	40	40	40	40
Apply	40	40	40	40
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Concept Map



Syllabus

Introduction to soil system 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 and Soil interaction: soil mineralogy; significance of mineralogy in determining soil behaviour; Mineralogical characterization; Mechanisms of soil-water interaction: Diffuse double layer models; Force of attraction and repulsion; Soil-water-contaminant interaction; Theories of ion exchange; Influence of organic and inorganic chemical interaction.

Soil-water interaction: Introduction to unsaturated soil mechanics; water retention property and soil-water characteristic curve; flow of water in unsaturated soil.

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

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

Course Contents and Lecture Schedule

S. No	Topics	Periods
	1.0 Introduction to soil system	
1.1	Soil as a multiphase system	2
1.2	Soil-environment interaction	1
1.3	Properties of water in relation to the porous media	1
1.4	Water cycle with special reference to soil medium.	2

2.0 Soil mineralogy and Soil interaction		
2.1	Soil mineralogy	2
2.2	Significance of mineralogy in determining soil behaviour	1
2.3	Mineralogical characterization	2
2.4	Mechanisms of soil-water interaction: Diffuse double layer models	1
2.5	Force of attraction and repulsion	1
2.6	Soil-water-contaminant interaction	1
2.7	Theories of ion exchange	1
2.8	Influence of organic and inorganic chemical interaction.	2
3.0 Soil-water interaction		
3.1	Introduction to unsaturated soil mechanics	2
3.2	Water retention property and soil-water characteristic curve	2
3.3	Flow of water in unsaturated soil.	1
4.0 Soil characterization techniques		
4.1	Introduction to advanced soil characterization techniques	2
4.2	Volumetric water content	1
4.3	Gas permeation in soil	1
4.4	Electrical and thermal properties of soil	2
4.5	Pore-size distribution	1
4.6	Soil contaminant analysis	1
5.0 Waste containment techniques		
5.1	Concepts of waste containment facilities	2
5.2	Desirable properties of soil	1
5.3	Contaminant transport and retention	2
5.4	Contaminated site remediation.	1
	TOTAL	**36**

Reference Books

1. Mitchell, J. K and Soga, K Fundamentals of Soil Behavior, John Wiley and Sons Inc., 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

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18ENPS0	BIODEGRADATION AND BIOREMEDIATION TECHNIQUES	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

Bioremediation approach is currently applied to contain contaminants in soil, groundwater, surface water, and sediments including air .This technology includes phytoremediation (plants) and rhizoremediation (plant and microbe interaction).
Rhizoremediation, which is the most evolved process of bioremediation, involves the removal of specific contaminants from contaminated sites by mutual interaction of plant roots and suitable microbial flora. These technologies have become attractive alternatives to conventional cleanup technologies due to relatively low capital costs and their inherently aesthetic nature.

Pre-requisite

Solid waste management

Course Outcomes

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

	Course outcome	Bloom's level	Expected Attainment Level (%)	Expected Proficiency (grade)
CO1.	Understand the basic knowledge about biodegradation and bioremediation	Understand	90	A
CO2.	Understand the fate and transport of contaminants in soil and water	Understand	80	B
CO3.	Evaluate the benefit of microorganisms in degrading organic contaminants	Understand	90	A
CO4.	Choose suitable microorganism for biodegradation of selected compound bodies	Apply	80	B
CO5.	Select suitable assessment methods forbioremediation	Apply	90	A
CO6.	Understand the role of different strains and protein in the enhanced biodegradation	Apply	80	B

Mapping with Programme Outcomes

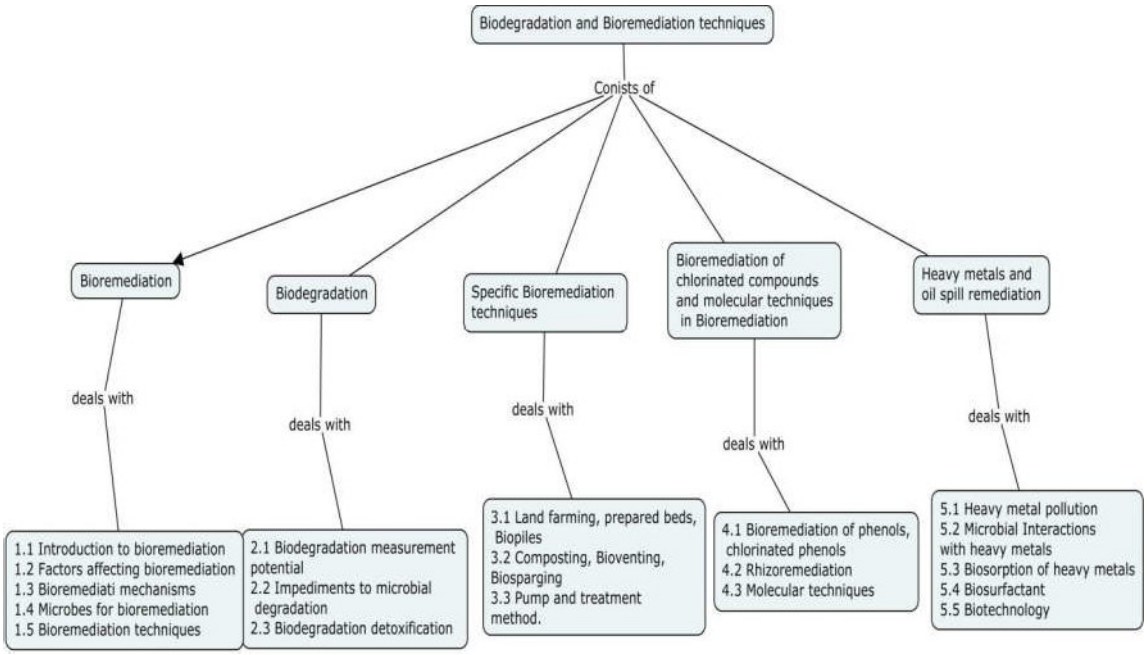
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	S	M	L	S	-	M	-	-	L	L	-	S	M
CO2	S	S	S	S	-	-	-	-	-	-	-	M	M
CO3	S	S	S	S	-	-	-	-	-	-	-	S	M
CO4	S	S	S	S	-	-	-	-	-	-	-	S	M
CO5	M	M	M	M	-	-	-	-	-	-	-	M	M
CO6	M	M	M	M	-	-	-	-	-	-	-	M	M

trong;M-Medium;L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	50	50	40	40
Apply	30	30	40	30
Analyze	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Concept Map



Syllabus

Bioremediation : Introduction to Bioremediation- Types of Bioremediation, Factors affecting Bioremediation -Bioremediation Mechanisms-Limitations of Bioremediations- Microbes for Bioremediation - Essential Characteristics of Microbes for Bioremediation, Microbial Adaptation for Adverse conditions. Microbes involved in Bioremediation. Metabolic process involved in bioremediation. Bioremediation Techniques :Insitu&Exsitu bioremediation techniques. **Biodegradation:** 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. **Specific Bioremediation Technologies**: Application, specific advantages and disadvantages of specific bioremediation technologies - land farming, prepared beds, biopiles, composting, bioventing, biosparging, pump and treat method, constructed wet lands, use of bioreactors for bioremediation. Use of microbes (bacteria and fungi) and plants in biodegradation and

Biotransformation; Phytoremediation: Waste water treatment using aquatic plants; Root zone treatment. **Bioremediation of Chlorinated Compounds and Molecular Techniques in Bioremediation**: Bioremediation of phenols, chlorinated phenols, chlorinated aliphatic compounds, heterocyclic compounds, cyanides, dyes; Rhizoremediation: a beneficial plant-microbe interaction; Molecular techniques in bioremediation- Enhanced biodegradation through pathway engineering; Biodegradation of polyhalogenated compounds by genetically engineered bacteria. **Heavy Metal and Oil Spill Bioremediation** : Heavy metal pollution & sources; Microbial interactions with heavy metals - resistance &t tolerance;Microbial transformation; Accumulation and concentration of metals. Biosorption of heavy metals by microbial biomass and secondary metabolites – Biosurfactants. Advantages of biosurfactants over chemical surfactants.; Biotechnology and oil spills; Improved oil recovery.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
	1.Bioremediation	
1.1	Introduction to Bioremediation- Types of Bioremediation, Factors affecting Bioremediation	**1**
1.2	Bioremediation Mechanisms, Limitations of Bioremediations, Microbes for Bioremediation	**2**
1.3	Essential Chararcteristics of Microbes for Bioremediation	**1**
1.4	Microbial Adapadation for Adverse conditions. Microbes involved in Bioremediation	**1**
1.4.1	Metabolic process involved in bioremediation. Bioremediation Techniques : Insitu & Exsitu bioremediation techniques.	**2**
	2.Biodegradation	
2.1	Biodegradation Measurement Potential . Impediments to Microbial Biodegradation	**1**
2.2	Biodegradation Detoxication Reactions - Principles of Biodegradation. Biodegradation Kinetics	**2**
2.3	Effect of Pollutant Chemical Structure on Biodegradation. Fate and Transport of Contaminants in Soils and Water Bodies	**3**
2.4	Requirements of Biodegradation - Nutritional Factors - Chemical Structure	**2**
2.5	Environmental Factors - Biological Factors - Bioavailability and Aging	**1**
	3. Specific Bioremediation Technologies	
3.1	Application, specific advantages and disadvantages of specific bioremediation technologies - Land farming, Prepared beds, Biopiles, Composting, Bioventing, Biosparging	**2**
3.1.1	Pump and treat method, Constructed wet lands	**1**
3.1.2	Use of bioreactors for bioremediation, Use of microbes (bacteria and fungi) and plants in biodegradation and Biotransformation	**1**
3.1.3	Phytoremediation- Waste water treatment using aquatic plants; Root zone treatment	**1**

4. Bioremediation of Chlorinated compounds and Molecular techniques in Bioremediation		
4.1	Bioremediation of phenols, Chlorinated Phenols	**2**
4.1.1	Chlorinated Aliphatic compounds, Heterocyclic compounds, Cyanides and Dyes	**1**
4.1.2	Rhizoremediation: a beneficial plant-microbe interaction	**1**
4.2	Molecular Techniques in bioremediation	**1**
4.3	Enhanced biodegradation through pathway engineering	**1**
4.4	Biodegradation of Polyhalogenated compounds by genetically engineered bacteria.	**1**
5. Heavy Metal and Oil spill Bioremediation		
5.1	Heavy metal pollution & sources. Microbial interactions with heavy metals - resistance &tolerance	**2**
5.2	Microbial transformation; Accumulation and concentration of metals.	**1**
5.2.1	Biosorption of heavy metals by microbial biomass and secondary metabolites	**2**
5.3	Biosurfactants. Advantages of biosurfactants over chemical surfactants	**2**
5.4	Biotechnology and oil spills; Improved oil recovery.	**1**
	Total	**36**

References Books

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, 2 nd Edition, Academic Press, 1993.
3. Bruce E. Rittmann, Perry L. McCarty, -Environmental Biotechnology: Principles and Applications‖ McGraw-Hill, 2001.
4. Phillip L. Buckingham , Jeffrey C. Evans,‖ Hazardous Waste Management‖ Waveland PrInc; Reissue edition 1, 2010.
5. S. K. Agarwal, -Environmental Biotechnology‖, APH Publishing, 2000
6. Martin Alexander, -Biodegradation & Bioremediation‖, Academic press, 1999. 6 Karrely D., Chakrabarty K., Omen G.S, -Biotechnology and Biodegradation‖, Portfolio Pub. Co., 1990.
7. P. Rajendran, P. Guansekaran, -Microbial Bioremediation‖, Mjp Publishers, 2011.
8. Jeff Kuo, -Practical design calculations for groundwater and soil remediation– CRCPress;Second edition 2014.

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18ENPT0 **COMPUTATIONAL INTELLIGENCE FOR HYDROSYSTEMS**

Category	L	T	P	Credit
PE	3	0	0	3

Preamble

To develop skills of the students in the software application for simulation in Water resources management. To enable the students to understand application of the latest Information Technology tools available in water resources engineering .

Course Outcomes

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

	Course Outcome	Bloom's level	Expected Attainment level (%)	Expected Proficiency (Grade)
CO1	To introduce the computational knowledge in the field of water resources systems.	Understand	90	A
CO2	To comprehend Optimization concepts for water resource system planning and management	Understand	85	B
CO3	To apply Decision support system in water resource system planning and management	Apply	85	A
CO4	Understand better data management and analysis concept	Understand	85	B
CO5	Understand role of IT in water resource management and use the latest intelligent technology and algorithms.	Understand	85	A
CO6	To apply the simulation models in water resource management	Apply	85	B

Mapping with Programme Outcomes

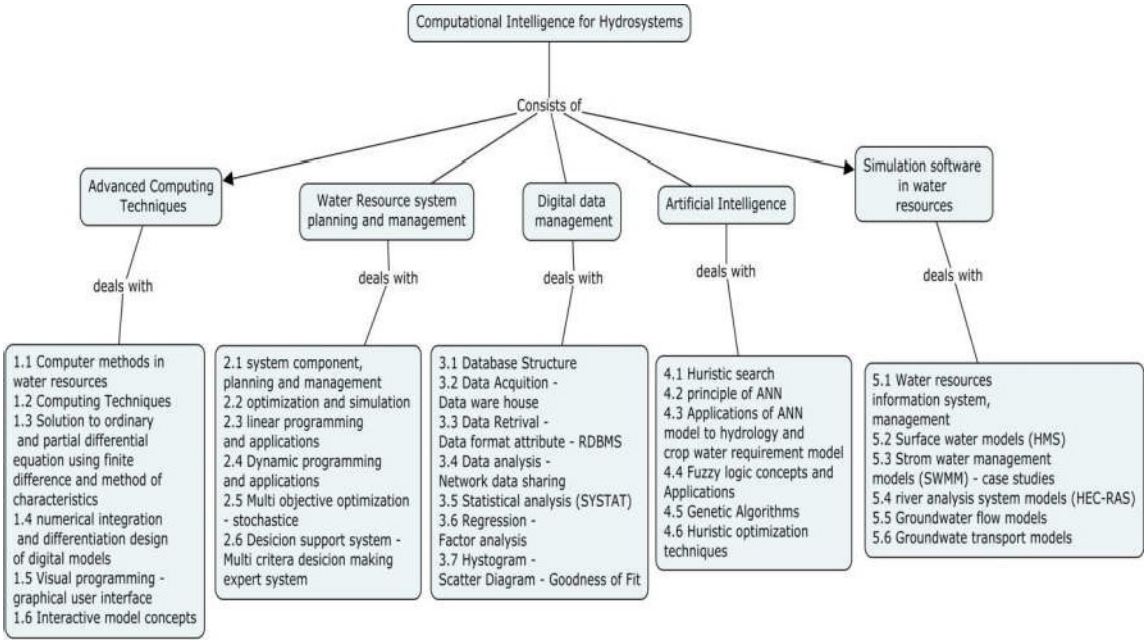
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	S	L	L	L	S	-	M	S	S	-	-	S	-
CO2	S	M	L	M	-	M	S	S	S	-	M	S	-
CO3	S	S	S	M	S	S	M	-	S	-	L	-	S
CO4	S	-	L	L	S	-	M	S	S	-	-	S	-
CO5	S	L	M	L	S	-	M	S	S	-	L	-	S
CO6	S	S	S	S	S	S	S	S	S	S	S	-	S

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	50	50	50	50
Apply	40	40	40	40
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Concept Map



Syllabus

Advanced computing techniques : Computer methods in water resources – Computing techniques - Solution to ordinary and partial differential equation using Finite difference and Method of Characteristics- Numerical integration and differentiation Design of digital models - Visual programming - Graphical user interface - Interactive model concepts. **Water resource system planning and mangement**: System component, planning and management-Optimisation and Simulation-Linear programing and applications-Dynamic programming and applications- multi objective optimization- stochastic optimization - Decision Support System- multicriteria decision making- expert system. **Digital data management** Data base structure - Data acquisition - Data warehouse - Data Retrieval-Data Format Attribute - RDBMS - Data analysis - Network data sharing - Statistical Analysis (SYSTAT) - Regression - factor analysis - histogram - scatter diagram - Goodness of fit. **Artificial intelligence** Heuristic search - Principle of Artificial Neural Network (ANN) - Application of ANN Model to Hydrology and Crop Water Requirement model. Fuzzy Logic concepts and Applications – Genetic Algorithms-Heuristic Optimization techniques.

Simulation software in water resources: Water Resources Information System, Management Information System- Surface water models (HMS) - Storm Water Management Models (SWMM)- - Case studies- River Analysis system models (HEC-RAS)-Ground Water Flow models – Groundwater transport models.

Course Contents and Lecture Schedule

S.No	Topics	No. of Lectures
	1. Advanced computing techniques	
1.1	Computer methods in water resources	1
1.2	Computing techniques	1
1.3	Solution to ordinary and partial differential equation using Finite difference and Method of Characteristics	2
1.4	Numerical integration and differentiation Design of digital models	2
1.5	Visual programming - Graphical user interface	1
1.6	Interactive model concepts	1
	2. Water resource system planning and management	
2.1	System component, planning and management	1
2.2	Optimisation and Stimulation	1
2.3	Linear programing and applications	1
2.4	Dynamic programming and applications	1
2.5	multi objective optimization- stochastic optimization	1
2.6	decision support system- multicriteria decision making- expert system.	2
	3. Digital data management	
3.1	Data base structure	1
3.2	Data acquisition- Data warehouse	1
3.3	Data retrieval-Data format Attribute – RDBMS	1
3.4	Data analysis - Network data sharing	1
3.5	Statistical Analysis (SYSTAT)	1
3.6	Regression - factor analysis	1
3.7	histogram - scatter diagram - Goodness of fit.	1
	4. Artificial intelligence	
4.1	Heuristic search	1
4.2	Principle of Artificial Neural Network (ANN)	1
4.3	Application of ANN Model to Hydrology model.	1
4.4	Fuzzy Logic concepts and Applications	2
4.5	Genetic Algorithms	1
4.6	Heuristic Optimization techniques	1
	5. Simulation software in water resources	
5.1	Water Resources Information System, Management Information System.	1
5.2	Surface water models (HMS)	1
5.3	Storm Water Management Models (SWMM)- Case studies	2
5.5	River Analysis system models (HEC-RAS)	1
5.6	Ground Water Flow models – Groundwater transport models.	2
	Total	**36**

References Books

1. Aliev R. A, and Aliev Rashad "Soft Computing and its Applications World Scientific Publications" Co. Pte. Ltd. Singapore, 2001.
2. Janusz Kacprzyk "Applied Decision with Soft Computing" Springer, 2003
3. Carlos A. Coello Coello, David A Van Veldhuizen, Gary B Lamont, "Evolutionary Algorithms for Solving Multi-objective problems", Springer, 2002.
4. Tayfur Gökmen "Soft computing in water resources engineering", WIT Press, Great Britain,UK,20124.
5. John E. Gribbin, "Introduction to hydraulics and hydrology with applications for Storm water Management". DELMAR, Thomson Learning, USA,2002.
6. Remson I, Hornberger G.M. and Moiz F.J., "Numerical methods in Sub- Surface Hydrology". Wiley Inter Science, 1985

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18ENPU0	TRANSPORT OFWATER AND WASTEWATER	Category	L	T	P	Credit
		PE	2	2	0	3

Preamble

Transportation of water from the source / treatment plant to the city premises and distributing it through a network of pipes to the doorsteps of consumers at adequate pressure is a most important operation to fulfil the various water demands of the general public. Estimation and collection of storm drainage generated from the township / city areas as well as the wastewater generated by the people and conveying through a well-planned sewer network to the treatment plant is also equally important to maintain the health and hygienic conditions in the urban areas.

Prerequisite

Knowledge on Pipe flow and open channel flow.

Course Outcomes

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

	Course Outcomes	Bloom's Level	Expected Attainment level (%)	Expected Proficiency Level in grade
CO1	Apply the principle of hydraulics in water transportation and distribution and wastewater collection and conveyance.	Apply	80	B
CO2	Produce water supply mains taking into account all the design parameters.	Apply	80	B
CO3	Analyze a water supply distribution network.	Analyze	80	B
CO4	Examine appropriate pipe material, necessary pipe appurtenances for construction and investigate the leaking mains of the water distribution system	Analyze	80	B
CO5	Produce a proper storm drainage for speedy draining of storm water from the city area.	Apply	80	B
CO6	Produce a sewer network for the proper disposal of the sewage generated from the city limits to treatment plant	Apply	80	B

Mapping with Programme Outcomes

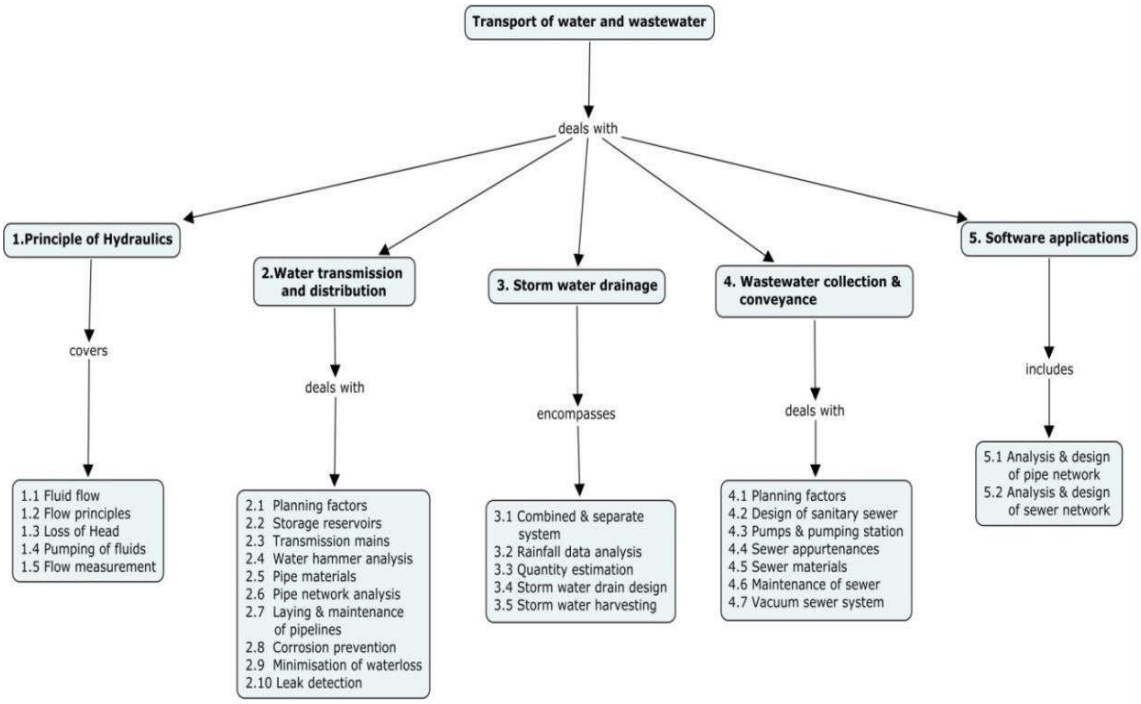
Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	M	L	L	-	-	-	-	-	-	-	-	M	M
CO2	M	L	L	-	-	-	L	-	-	-	-	M	M
CO3	M	M	M	-	-	-	L	-	-	-	-	M	M
CO4	M	M	M	-	-	-	L	-	-	-	-	M	M
CO5	M	L	L	-	-	-	L	L	-	-	-	M	M
CO6	M	L	L	-	-	-	L	L	-	-	-	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	-	-	-	-
Understand	50	30	30	30
Apply	50	50	50	50
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	20	20	20

Concept Map



Syllabus

Principles of hydraulics - fluid flow, continuity principle, energy principle. Loss of head-Tutorials – major loss - minor losses - Tutorials -pumping of fluids - types of pumps, selection of pumps - flow measurement - pipe flow, open channel flow- Tutorials. **Water transmission and distribution**- planning factors-transmission mains - Tutorials – design & Economizing of transmission mains – water hammer analysis- Tutorials - Upsurge and Down surge – pipe materials-water distribution pipe network-analysis, - Tutorials design of network & optimization - Tutorials - Laying and maintenance of pipelines. Pipe appurtenances – corrosion prevention – minimization of water losses and leak detection. **Storm water drainage** –combined and separate system, quantity estimation - Tutorials – rainfall data analysis – storm water drain design - Tutorials – storm water harvesting and roof water harvesting. **Wastewater collection and conveyance** – planning factors – design of sanitary

sewer - Tutorials – economics of sewer design-- Tutorials - Pumps and Pumping stations – sewer appurtenances – material, construction, inspection and maintenance of sewer, recent trends - Vacuum sewer system. **Software applications-** Water distribution- LOOP, BRANCH and EPANET- Sewer design – SEWER.

Course Contents and Lecture Schedule

S.No	Topic	No. of Lectures
	1. Principles of hydraulics	
1.1	Principles of hydraulics- fluid properties- Continuity principle and energy principle	1
1.1.1	Problems in Bernoulli's theorem-Tutorial	1
1.2	Loss of head – major loss-minor losses- estimation of losses	1
1.2.1	Problems in loss of head-Tutorial	1
1.3	Flow measurement-pipe flow-open channel flow	1
1.3.1	Problems in flow measurements	2
	2. Water transmission and distribution	
2.1	Planning factors- Storage reservoirs- need and capacity fixing	1
2.1.1	Problems in Storage capacity-Tutorial	1
2.2	Water hammer analysis – Upsurge and Down surge	1
2.2.1	Problems in Water hammer analysis-Tutorial	1
2.3	Pipe materials- Pumping of fluids-types of pumps-selection of pumps	1
2.4	Water distribution network analysis-optimization of pipe network system	2
2.4.1	Problems in Water Distribution Analysis-Tutorial	2
2.5	Laying and maintenance of pipelines - Pipe appurtenances	2
2.6	Corrosion of pipelines, prevention of corrosion	1
2.7	Minimization of water losses - Leak detection	1
	3. Storm water drainage	
3.1	Combined and separate system	1
3.2	Rainfall data analysis- Quantity estimation	1
3.2.1	Problems in storm water quantity estimation-Tutorial	1
3.3	Storm water drain design	1
3.3.1	Problems in Strom water drain deign -Tutorial	1
3.4	Storm water harvesting and roof water harvesting	0.5
	4. Wastewater collection and conveyance	
4.1	Planning factors	0.5
4.2	Design of sanitary sewer	1
4.2.1	Problems in Design of Sanitary Sewer-Tutorial	2
4.3	Pumps and pumping station- Sewer appurtenances	1
4.4	Sewer materials and laying of sewer- Vacuum sewer system- Introduction	1
4.5	Inspection and maintenance of sewer – recent trends	1

5. Software applications		
5.1	Analysis of pipe network using - LOOP, BRANCH & EPANET and optimization	2
5.2	Design of sewer network using SEWER	2
Total		**36**

Reference Books

1. Bhave P. R , "Analysis of flow in water distribution Networks", Technomic publishing co,U.S.A.,1991.
2. "Manual on sewerage and sewage treatment", CPHEEO, Ministry of urban affairs and employment GOI, New Delhi,2001.
3. -Manual on water supply and treatment", CPHEEO, Ministry of urban affairs and Employment GOI, New Delhi,2001.
4. -Manual on water supply maintenance and management CPHEEO, Ministry of urban affairs and Employment GOI, New Delhi.
5. Ven Te Chow, David R Maidment, Larry W Mays "Applied hydrology", Mcgraw hill book co. 1988.

Course Designers:

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18OEXX0	PROJECT MANAGEMENT	Category	L	T	P	Credit
		OE	1	1	0	2

Preamble

Complex research and development projects can be managed effectively if the project managers have the means to plan and control the schedules and costs of the work required to achieve their technical performance objectives. When planning of a project is undertaken, aspects such as resources needed for its accomplishment, its cost, its duration should be determined. The answers to all these questions can be found by adopting the modern techniques of project management.

Prerequisite

Nil

Course Outcomes:

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

(CO1) Explain the concept of projects, its process, objectives and functions of project management	Understand
(CO2) Analyze and Manage time in projects through Gantt charts, CPM and PERT techniques	Apply
(CO3) Balance resource requirements of projects so as to avoid idling of resources	Apply
(CO4) Update projects and determine revised schedule of activities and critical path if any	Apply
(CO5) Crash projects to determine its optimum time- minimum cost relationships	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO5.	M	---	---	---	---	M	S	S	---	M	---
CO6.	S	S	S	M	M	M	---	---	---	---	---
CO3	S	S	S	M	M	M	---	---	---	---	---
CO4	S	S	S	M	M	M	---	---	---	---	---
CO5	S	S	S	M	M	M	---	---	---	---	---

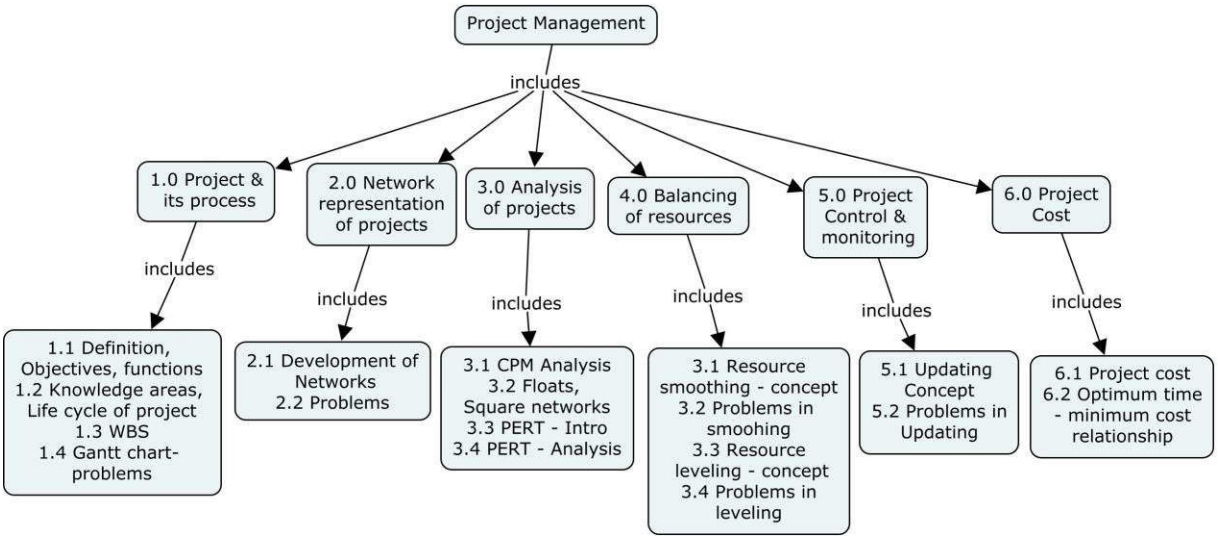
S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	10	10	10
Understand	30	40	30	30
Apply	50	50	60	60

Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Concept Map



Syllabus

Project and its process- Define project and process, Objectives and functions of Project management, project life cycle- influencing factors. - Case study. **Project Time Management:** Work break down structure- Activity/ Task- Events- Case study. Gantt Charts, Milestone chart. Project Network- Fulkerson‘s rules – A-O-A and A-O-N networks. Analyze project time- Critical path method (deterministic approach- activity oriented network analysis- 80-20 rule- Case study. Square network diagram. Project updating and monitoring- Case study. Estimate time- Program Evaluation & Review Technique (Probabilistic Approach)- Event oriented network analysis- Optimistic, Pessimistic and Most likely time, Degree of variability in average time, Probabilistic estimate, % utilization of resources. **Resource Management:** Types of resource- Time, Men, Material, Machinery, Money, Space. Balancing of resource- Resource Smoothing technique- Time constraint. Resource leveling technique- Resource constraint- Case study. **Resource optimization:** Types of cost – Direct, Indirect and Total Cost. Variation of Cost with time. CPM Cost model.

References

1. "A Guide to the Project Management Body of Knowledge (PMBOK Guide) - Fourth Edition, An American National Standard, ANSI/PMI 990001-2008"
2. Gene Dixon, -Service Learning and Integrated Collaborative Project Management‖, Project Management Journal, DOI:10.1002/pmi, February 2011, pp.42-58
3. Jerome D. Wiest and Ferdinand K. Levy, -A Management Guide to PERT/CPM‖, Prentice Hall of India Publishers Ltd., New Delhi, 2009.
4. Punmia B. C. and Khandelwal K.K., -Project Planning and Control with PERT/CPM‖, Laxmi publications, New Delhi, 2005

5. Srinath L.S., -PERT & CPM- Principles and Applicationsǁ, Affiliated East West Press Pvt., Ltd., New Delhi, 2008
6. https://nptel.ac.in/courses/105106149/ Project Planning and Control - Prof. Koshy Varghese, IITM, Chennai.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1.0	**Introduction to Project Management**	
1.1	Define project and process, objectives, Functions of management	2
1.2	Project knowledge area, project integration- project life cycle-influencing factors, Case study	1
1.3	Work break down structure (WBS), time estimate	1
1.4	Traditional management systems – Gantt approach, progress-chart, Bar-chart- Merits and limitations. Problems in Bar-chart	2
	Tutorial	2
2.0	**Project Programming**	
2.1	Introduction to modern management concepts, uni-dimensional management techniques- Development of network based on Fulkerson‘s rules	2
2.2	Problems in development of network	1
	Tutorial	2
3.0	**Network Techniques**	
3.1	Critical Path Method (CPM) for management, CPM network analysis	2
3.2	Identification of critical path, floats, square network diagrams-problems	2
3.3	Programme Evaluation and Review Technique (PERT) network-introduction to theory of probability and statistics, probabilistic time estimation for activities	2
3.4	Analysis of PERT network – problems	
	Tutorial	2
4.0	**Resource Balancing**	
4.1	Resource balancing- objectives, resource smoothing technique – concept and procedure	1
4.2	Problems using resource smoothing technique	2
4.3	Resource Levelling technique - concept and procedure	
4.4	Problems using Resource Levelling technique	2
	Tutorial	2
5.0	**Project Control and Monitoring**	
5.1	Project programming, Reviewing, updating and monitoring – concept	1
5.2	Problems in updating of projects – determination of revised critical	

	path	
	Tutorial	2
6.0	**Project Cost**	
6.1	Introduction to two-dimensional network analysis – activity cost information, cost –time relationship - cost slope, project direct and indirect cost	1
6.2	Crashed programmes- optimum time –minimum cost solution- Problems	2
	Tutorial	2
	Total Periods	**36**

Course Designers:

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18PGAA0	PROFESSIONAL AUTHORING	Category	L	T	P	Credit
		AC	2	0	0	2

Preamble

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

1. Explain how to improve your writing skills and level of readability
2. Write each section of research paper
3. Write good quality technical paper

Syllabus

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

Key skills for writing a Title, writing an Abstract, writing an Introduction, writing a Review of the Literature,

Skills for Writing the Methods, Results, Discussion and Conclusions
Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

Assessment Pattern

Abstract	:	10
Introduction	:	10
Literature Review	:	10
Research Question	:	10
Methods	:	10
Results and Discussion	:	10
Conclusions	:	10
Appropriateness of Title	:	05
Quality of the Paper and Plagiarism	:	25

References

1. Goldbort R, ‗Writing for Science', Yale University Press, 2006
2. Day R, ‗How to Write and Publish a Scientific Paper', Cambridge University Press, 2006
3. Highman N, ‗Handbook of Writing for the Mathematical Sciences, SIAM Highman's book, 1998
4. Adrian Wallwork, ‗English for Writing Research Papers', Springer New York Dordrecht Heidelberg London, 2011

		Category	L	T	P	Credit
18PGAB0	**VALUE EDUCATION**	AC	2	0	0	2

Preamble

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

1. Experience self-development
2. Explain the importance of Human values
3. Develop the overall personality

Syllabus

Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non- moral valuation. Standards and principles, Value judgements

Importance of cultivation of values, Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness, Honesty, Humanity, Power of faith, National Unity, Patriotism, Love for nature, Discipline

Personality and Behavior Development, Soul and Scientific attitude, Positive Thinking. Integrity and discipline, Punctuality, Love and Kindness, Avoid fault Thinking, Free from anger, Dignity of labour, Universal brotherhood and religious tolerance, True friendship, Happiness Vs suffering, love for truth.

Aware of self-destructive habits, Association and Cooperation, Doing best for saving nature

Character and Competence –Holy books vs Blind faith, Self-management and Good health, Science of reincarnation, Equality, Nonviolence , Humility, Role of Women, All religions and same message, Mind your Mind, Self-control, Honesty, Studying effectively

Assessment Pattern

Bloom's Category	Continuous Assessment Test	Terminal Examination
Remember	20	20
Understand	40	40
Apply	40	40
Analyse	0	0
Evaluate	0	0
Create	0	0

References

1. Chakroborty, S.K. -Values and Ethics for organizations Theory and practicell, OxforUniversity Press, New Delhi