DEPARTMENT OF CIVIL ENGINEERING

ANNA UNIVERSITY, CHENNAI

OUR VISION:

Department of Civil Engineering, Anna University, shall strive hard to develop and impart technical knowledge and professional skills required for Civil Engineering practice through excellence in teaching, research and consultancy to address sustainable infrastructure development needs at local, national and International levels.

OUR MISSION:

Department of Civil Engineering, Anna University shall contribute to technological and social development by

1. Providing a firm scientific and technological base in Civil Engineering to achieve self-reliance.
2. Providing quality education through innovation in teaching practices at par with global standards.
3. Nurturing leadership and entrepreneurship qualities with ethical values.
4. Developing and disseminating latest knowledge and technologies in emerging areas of Civil Engineering.
5. Sharing intellectual resources and infrastructure facilities through collaborative partnership.
6. Ensuring supporting conditions for enhancing the employability skills.

ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

M.E. ENVIRONMENTAL ENGINEERING

REGULATIONS – 2019

CHOICE BASED CREDIT SYSTEM

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

Graduates of the programme M E Environmental Engineering will

PEO1	Gain knowledge and skills in environmental engineering which will enable them to have a career and professional accomplishment in the public or private sector organisations
PEO2	Become consultants on complex real life Environmental Engineering problems related to water supply, sewerage, sewage treatment, solid waste management, air pollution control, environmental impact assessment, industrial pollution control.
PEO3	Become entrepreneurs and develop processes and technologies to meet desired environmental protection needs of society and formulate solutions that are technically sound, economically feasible, and socially acceptable.
PEO4	Perform investigation for solving environmental problems by conducting research using modern equipment and software tools.
PEO5	Function in multi-disciplinary teams and advocate policies, systems, processes and equipment for control and remediation of pollution.

PROGRAMME OUTCOMES

Graduates of the programme M E Environmental Engineering will be able to

PO1	Knowledge of Engineering Sciences	Apply the knowledge of mathematics, science and engineering fundamentals to the conceptualization of Environmental Engineering models
PO2	Problem analysis	Identify, formulate and solve Environmental Engineering problems
PO3	Design / development of solutions	Design solutions for complex Environmental Engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.
PO4	Investigation	Conduct investigations of Environmental problems including extract information pertinent to environmental engineering problems through literature survey, apply appropriate research methodologies, analysis and interpretation of data, and synthesis of information to provide valid conclusions
PO5	Modern Tool Usage	Create, select and apply appropriate techniques and modern engineering tools including prediction and modelling software, with due understanding of the limitations.
PO6	Individual and Team work	Function effectively as an individual and as a member or leader in diverse teams and in multi-disciplinary settings and demonstrating a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis.
PO7	Communication	Communicate effectively on Environmental Engineering issues with the engineering community and with society at large, and write reports and make effective presentations.
PO8	Engineer and Society	Demonstrate understanding of the societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to Environmental Engineering practice.

PO9	Ethics	Understand and commit to professional ethics and responsibilities of Environmental Engineers and to contribute to the society for sustainable development.
PO10	Environment and Sustainability	Understand the socio economic impact of Environmental Engineering solutions and demonstrate knowledge of sustainable development
PO11	Project Management and Finance	Demonstrate a knowledge and understanding of management and business practices, such as risk and change management, and understand their limitations
PO12	Life Long Learning	Develop ability to engage in independent and life-long learning to improve competence by critical examination of the outcomes of one's actions in addressing Environmental issues and learning from corrective and preventive measures.

PROGRAM SPECIFIC OUTCOMES (PSOs)

Graduates of the programme M E Environmental Engineering will be able to

PSO1	Knowledge of Environmental Engineering discipline	Demonstrate in-depth knowledge of Environmental Engineering discipline, with an ability to evaluate, analyze and synthesize existing and new knowledge.
PSO2	Critical analysis of Environmental problems and innovation	Critically analyze complex Environmental Engineering problems, apply independent judgment for synthesizing information and make innovative advances in a theoretical, practical and policy context.
PSO3	Conceptualization and evaluation of engineering solutions to Environmental Issues	Conceptualize and solve Environmental Engineering problems, evaluate potential solutions and arrive at technically feasible, economically viable and environmentally sound solutions with due consideration of health, safety, and socio cultural factors

1. PEO / PO Mapping:

PROGRAMME EDUCATIONAL OBJECTIVES	PROGRAMME OUTCOMES											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
I	H	H	H	H	H					H		L
II		H	H	H		H	H			H	H	M
III			H					H	H	H	M	M
IV	H	H	H	H	H	H	H			H		M
V						H	M	H	H	H		

L - Low; M-Medium; H-High

MAPPING OF COURSE OUTCOME AND PROGRAMME OUTCOME

		Course Name	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
YEAR I	SEMESTER I	Environmental Chemistry	H	H	H	H	M	M	M	M	M	M	M	
		Environmental Microbiology	M	M	H	M	M	M	L	M	M	M	M	L
		Design of physio- chemical treatment systems for water and Wastewater	H	M	M	H	L	M	M	H	H	H	M	H
		Statistical Methods for Engineers												
		Transport of water and wastewater	H	M	H	M	H	M	M	H	M	M	M	M
		Research Methodology and IPR	M	H	M	L	L	M	H	L	L	L	L	H
		Environmental Chemistry Laboratory	H	M	M	M	H	H	M	M	M	M	M	M
		Environmental Microbiology Laboratory	M	M	H	M	M	M	L	M	M	M	M	L
	SEMESTER II	Industrial wastewater pollution - prevention and control	H	M	H	M	L	M	H	H	H	H	M	H
		Design of Biological Treatment Systems	H	H	H	H	M	M	M	M	M	M	M	M
		Air Pollution Control	M	H	H	H	H	M	L	M	L	M	M	M
		Program Elective I												
		Program Elective II												
		Program Elective III												
		Audit Course –II												
		Environmental and Processes Monitoring Laboratory												
YEAR II	SEMESTER III	Program Elective IV												
		Program Elective V												
		Open Elective												
		Seminar												
		Dissertation I	H	M	M	M	M	H	M	M	M	M	M	H
	SEMESTER IV	Dissertation II	H	M	M	M	M	H	M	M	M	M	M	H

ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

M.E. ENVIRONMENTAL ENGINEERING

REGULATIONS - 2019

CHOICE BASED CREDIT SYSTEM

CURRICULA AND SYLLABI FOR I TO IV SEMESTERS

SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA5157	Statistical Methods for Engineers	FC	3	1	0	4	4
2.	EN5101	Environmental Chemistry	PCC	3	0	0	3	3
3.	EN5102	Environmental Microbiology	PCC	3	0	0	3	3
4.	EN5103	Design of Physico- Chemical Treatment systems for water and wastewater	PCC	3	0	0	3	3
5.	EN5104	Transport of water and wastewater	PCC	3	0	0	3	3
6.	RM5151	Research Methodology and IPR	RMC	2	0	0	2	2
7.		Audit Course I*	AC	2	0	0	2	0
PRACTICALS								
8.	EN5111	Environmental Chemistry Laboratory	PCC	0	0	4	4	2
9.	EN5112	Environmental Microbiology Laboratory	PCC	0	0	4	4	2
			TOTAL	**19**	**1**	**8**	**28**	**22**

* Audit Course is optional

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	EN5201	Design of Biological Treatment Systems	PCC	3	0	0	3	3
2.	EN5251	Air Pollution Control	PCC	3	0	0	3	3
3.	EN5252	Industrial Wastewater Pollution-Prevention and Control	PCC	3	0	0	3	3
4.		Program Elective I	PEC	3	0	0	3	3
5.		Program Elective II	PEC	3	0	0	3	3
6.		Program Elective III	PEC	3	0	0	3	3
7.		Audit Course II*	AC	2	0	0	2	0
PRACTICALS								
8.	EN5211	Environmental and Processes Monitoring Laboratory	PCC	0	0	6	6	3
			TOTAL	**20**	**0**	**6**	**26**	**21**

* Audit Course is optional

SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Program Elective IV	PEC	3	0	0	3	3
2.		Program Elective V	PEC	3	0	0	3	3
3.		Open Elective	OEC	3	0	0	3	3
PRACTICALS								
4.	EN5311	Seminar	EEC	0	0	2	2	1
5.	EN5312	Dissertation I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**14**	**23**	**16**

SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	EN5411	Dissertation II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS TO BE EARNED FOR AWARD OF THE DEGREE: 71

FOUNDATION COURSES (FC)

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	MA5157	Statistical Methods for Engineers	3	1	0	4	1

PROGRAMME CORE COURSES (PCC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	EN5101	Environmental Chemistry	3	0	0	3	I
2.	EN5102	Environmental Microbiology	3	0	0	3	I
3.	EN5103	Design of Physico- Chemical Treatment Systems for Water and Wastewater	3	0	0	3	I
4.	EN5104	Transport of Water and Wastewater	3	0	0	3	I
5.	EN5111	Environmental Chemistry Laboratory	0	0	4	2	I
6.	EN5112	Environmental Microbiology Laboratory	0	0	4	2	I
7.	EN5201	Design of Biological Treatment Systems	3	0	0	3	II
8.	EN5251	Air Pollution Control	3	0	3	3	II
9.	EN5211	Environmental and Processes Monitoring Laboratory	0	0	6	3	II
10.	EN5252	Industrial Wastewater Pollution-Prevention and Control	3	0	0	3	II
					TOTAL CREDITS	**28**	

PROGRAMME ELECTIVE COURSES [PEC]

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			C
			L	T	P	
1.	EN5001	Design of Environmental Engineering Structures	3	0	0	3
2.	EN5002	Natural Systems for Wastewater Treatment	3	0	0	3
3.	EN5003	Environmental Monitoring Instruments	3	0	0	3
4.	EN5004	Fate and remediation of Emerging Contaminants	3	0	0	3
5.	EN5005	Computing Techniques in Environmental Engineering	3	0	0	3
6.	EN5006	Air Quality Modeling	3	0	0	3
7.	EN5007	Water Quality Modeling	3	0	0	3
8.	EN5008	Environmental System Analysis	3	0	0	3
9.	EN5009	Advanced Oxidation Process	3	0	0	3
10.	EN5010	Environmental Reaction Engineering	3	0	0	3
11.	EN5071	Marine Pollution and Control	3	0	0	3
12.	EN5072	Membrane Separation for Water and Wastewater Treatment	3	0	0	3
13.	EM5071	Climate change and Modeling	3	0	0	3
14.	EM5072	Operation and Maintenance of Water and Wastewater Treatment Systems	3	0	0	3
15.	EM5073	Project formulation and implementation	3	0	0	3
16.	EM5251	Environmental impact Assessment	3	0	0	3
17.	EM5252	Solid and hazardous waste management	3	0	0	3

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	RM5151	Research Methodology and IPR	2	0	0	2	1
TOTAL CREDITS						**2**	

OPEN ELECTIVE COURSES [OEC]

*(Out of 6 Courses one Course must be selected)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	OE5091	Business Data Analytics	3	0	0	3	3
2.	OE5092	Industrial Safety	3	0	0	3	3
3.	OE5093	Operations Research	3	0	0	3	3
4.	OE5094	Cost Management of Engineering Projects	3	0	0	3	3
5.	OE5095	Composite Materials	3	0	0	3	3
6.	OE5096	Waste to Energy	3	0	0	3	3

AUDIT COURSES (AC)
Registration for any of these courses is optional to students

SL. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	AX5091	English for Research Paper Writing	2	0	0	0	1/2
2.	AX5092	Disaster Management	2	0	0	0	
3.	AX5093	Sanskrit for Technical Knowledge	2	0	0	0	
4.	AX5094	Value Education	2	0	0	0	
5.	AX5095	Constitution of India	2	0	0	0	
6.	AX5096	Pedagogy Studies	2	0	0	0	
7.	AX5097	Stress Management by Yoga	2	0	0	0	
8.	AX5098	Personality Development Through Life Enlightenment Skills	2	0	0	0	
9.	AX5099	Unnat Bharat Abhiyan	2	0	0	0	
					Total Credits	**0**	

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. No	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1	EN5311	Seminar	0	0	2	1	3
2	EN5312	Dissertation I	0	0	12	6	3
3	EN5411	Dissertation II	0	0	24	12	4
					TOTAL CREDITS	**19**	

Summary

	Name of the Programme: M.E. ENVIRONMENTAL ENGINEERING					
	SUBJECT AREA	CREDITS PER SEMESTER				CREDITS TOTAL
		I	II	III	IV	
1.	FC	4	00	00	00	4
2.	PCC	16	12	00	00	28
3.	PEC	00	09	06	00	15
4.	RMC	02	00	00	00	02
5.	OEC	00	00	03	00	03
6.	EEC	00	00	07	12	19
7.	Non Credit/Audit Course	✓	✓	00	00	
	TOTAL CREDIT	**22**	**21**	**16**	**12**	**71**

MA5157 STATISTICAL METHODS FOR ENGINEERS L T P C
3 1 0 4

OBJECTIVES:

- To enable them to estimate the value of the parameters involved in the specific distribution from a possible continuum of alternatives.
- To give an idea of testing the statistical hypothesis claimed based on a set of data points using suitable test statistics which follows standard sampling distributions.
- To establish a relationship that make it possible to predict one or more variable in terms of others using correlation and regression analysis.
- To introduce the various experimental designs and their corresponding analysis of variance which play vital role in many real time scenarios.
- To impart knowledge of handling random vectors which represent random variables in multi-dimensional space.

UNIT I ESTIMATION THEORY 12

Estimators: Unbiasedness, Consistency, Efficiency and Sufficiency–Maximum Likelihood Estimation – Method of moments.

UNIT II TESTING OF HYPOTHESIS 12

Tests based on Normal, *t*, χ^2 and *F* distributions for testing of means, variance and proportions – Analysis of *r x c* tables – Goodness of fit.

UNIT III CORRELATION AND REGRESSION 12

Multiple and Partial Correlation - Method of Least Squares- Plane of Regression - Properties of Residuals - Coefficient of Multiple Correlation - Coefficient of Partial Correlation - Multiple Correlation with total and partial correlations - Regression and Partial correlations in terms of lower order coefficients.

UNIT IV DESIGN OF EXPERIMENTS 12

Analysis of variance – One-way and two-way classifications – Completely randomized design – Randomized block design – Latin square design.

UNIT V MULTIVARIATE ANALYSIS 12

Random vectors and Matrices – Mean vectors and Covariance matrices – Multivariate Normal density and its properties – Principal components: Population principal components – Principal components from standardized variables.

TOTAL: 60 PERIODS

OUTCOMES:

At the end of the course, students will be able to

- Obtain the value of the point estimators using the method of moments and method of maximum likelihood.
- Use various test statistics in hypothesis testing for mean and variances of large and small samples.
- Determine the regression line using the method of least square and also to calculate the partial and multiple correlation coefficient for the given set of data points.
- Test the hypothesis for several means using one way, two way or three way classifications.
- Get exposure to the principal component analysis of random vectors and matrices.

REFERENCES:

1. Devore, J.L., “Probability and Statistics for Engineering and the Sciences”, Thomson and Duxbury, Singapore, 6th Edition, Boston, 2004.
2. Gupta, S.C., and Kapoor, V.K., “Fundamentals of Mathematical Statistics”, Sultan Chand and Sons, Eleventh Edition, Reprint, New Delhi, 2019.

3. Johnson, R. A. and Gupta, C. B., “Miller & Freund’s Probability and Statistics for Engineers”, Pearson Education, Asia, Eighth Edition, New Delhi, 2015.
4. Johnson, R.A., and Wichern, D.W., “Applied Multivariate Statistical Analysis”, Pearson Education, Sixth Edition, New Delhi, 2013.
5. Spiegel, M.R. and Stephens, L.J.,” Schaum’s outlines on Statistics”, Tata McGraw-Hill, 6th Edition, New York, 2018.

EN5101 ENVIRONMENTAL CHEMISTRY L T P C
3 0 0 3

OBJECTIVES:

- To educate the students in the area of water, air and soil chemistry
- To explain the theoretical basis and observational methods for study of contaminants and interactions in the environment

UNIT I FUNDAMENTALS 9

Stoichiometry and mass balance-Chemical equilibria, acid base, solubility product(Ksp) ,heavy metal precipitation, amphoteric hydroxides, CO_2 solubility in water and species distribution – Ocean acidification, Chemical kinetics , First order- 12 Principles of green chemistry.

UNIT II AQUATIC CHEMISTRY 11

Water and wastewater quality parameters- environmental significance and determination; Fate of chemicals in aquatic environment, volatilization, partitioning, hydrolysis, photochemical transformation– Degradation of synthetic chemicals - Metals, complex formation, oxidation and reduction , pE – pH diagrams, redox zones – sorption- Colloids, electrical properties, double layer theory, environmental significance of colloids, coagulation .

UNIT III ATMOSPHERIC CHEMISTRY 7

Atmospheric structure – chemical and photochemical reactions – photochemical smog. Ozone layer depletion – greenhouse gases and global warming, CO_2 capture and sequestration – acid rain- origin and composition of particulates. black carbon, air quality parameters determination.

UNIT IV SOIL CHEMISTRY 9

Nature and composition of soil - Clays- cation exchange capacity-acid base and ion-exchange reactions in soil – agricultural chemicals in soil-reclamation of contaminated land; salt by leaching-Heavy metals by electrokinetic remediation.

UNIT V EMERGING POLLUTANTS 9

Heavy metals-chemical speciation –Speciation of Hg & As- endocrine disturbing chemicals-Pesticides, Dioxins & Furan, PCBs , PAHs and Fluro compounds toxicity- Nano materials, CNT, titania, composites ,environmental applications.

TOTAL: 45 PERIODS

OUTCOMES:

CO1: Students will gain competency in solving environmental issues of chemicals based pollution
CO2: Ability to determine chemicals mobility in aquatic systems
CO3: Ability to identify contaminating chemicals in air and their fate
CO4: Understand the type of soil contaminants and provide remediation
CO5: Identify emerging environmental contaminants including speciation

REFERENCES:

1. Sawyer, C.N., Mac Carty, P.L. and Parkin, G.F., "Chemistry for Environmental Engineering and Science", Tata McGraw – Hill, Fifth edition, New Delhi 2003.
2. Colin Baird„ Environmental Chemistry, Freeman and company, New York, 5th Edition,2012.
3. Manahan, S.E., "Environmental Chemistry", Ninth Edition, CRC press, 2009.
4. Ronald A. Hites ,"Elements of Environmental Chemistry", Wiley, 2nd Edition,2012.

CO – PO Mapping- ENVIRONMENTAL CHEMISTRY

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	H	H	M	H	H
PO2	Problem analysis	M	M	H	L	M	M
PO3	Design / development of solutions				M	M	M
PO4	Investigation		M	M	L	M	M
PO5	Modern Tool Usage	H	M	H	H	H	H
PO6	Individual and Team work				H	H	H
PO7	Communication					M	M
PO8	Engineer and Society		M			M	M
PO9	Ethics						
PO10	Environment and Sustainability					M	M
PO11	Project Management and Finance		M			M	M
PO12	Life Long Learning	L				M	M
PSO1	Knowledge of Environmental Management discipline	M	M	M		M	M
PSO2	Environmental Performance Evaluation and coordination	M				M	M
PSO3	Conceptualization of Environmental Management Systems	M				M	M

EN5102 ENVIRONMENTAL MICROBIOLOGY L T P C
3 0 0 3

OBJECTIVES:

- The course provides a basic understanding on microbiology relevant to environmental engineering for candidates with little prior knowledge of the subject.
- The morphology, behaviour and biochemistry of bacteria, fungi, protozoa, viruses, and algae are outlined.
- The microbiology of wastewater, sewage sludge and solid waste treatment processes is also provided. Aspects on nutrient removal and the transmission of disease causing organisms are also covered.
- An exposure to toxicology due to industrial products and byproducts are also covered.

UNIT I FUNDAMENTALS OF MICROBIOLOGY 10

Classification of microorganisms – prokaryotic, eukaryotic, cell structure, characteristics, importance, introduction to water, soil and air borne pathogens and Parasites and their effects on human, animal and plant health, transmission of pathogens, transmissible diseases – bacterial, viral, protozoan, and helminths parasites, concentration and detection of virus. control of microorganisms preservation of microorganisms, DNA, RNA, replication, recombinant DNA technology, their potential applications and intellectual property rights.

UNIT II MICROBIAL DIVERSITY AND NUTRIENT TURNOVER 10

Distribution of microorganisms in different environments – diversity of microorganisms – fresh and marine, terrestrial – microbes in surface soil, air – outdoor and Indoor, aerosols, bio safety in laboratory – extreme environment – archae bacteria – occurrence in water supplies – problems and control. biogeochemical cycles-nitrogen, carbon, phosphorus, sulphur – Role of Microorganism in nutrient cycle.

UNIT III METABOLISM OF MICROORGANISMS 9

Nutrition and metabolism in microorganisms, growth phases, carbohydrate, protein, lipid metabolism – respiration, aerobic and anaerobic-fermentation, glycolysis, Kreb's cycle, hexose monophosphate pathway, electron transport system, oxidative phosphorylation, environmental factors, enzymes, bioenergetics, disruption in metabolism and disease. biodegradation of organic pollutants

UNIT IV MICROBIOLOGY OF WASTEWATER TREATMENT SYSTEMS 8

Microbiology of biological treatment processes – aerobic and anaerobic, **α**-oxidation, β-oxidation, nitrification and denitrification, eutrophication. nutrients removal – BOD, nitrogen, phosphate. microbiology of sewage sludge - indicator organisms of water – coliforms - total coliforms, E-coli, streptococcus, clostridium, Bioleaching

UNIT V TOXICOLOGY 8

Ecotoxicology – toxicants and toxicity, factors influencing toxicity. effects – acute, chronic, test organisms – toxicity testing-lab and field testing methods, bioconcentration – Bioaccumulation, biomagnification, bioassay, biomonitoring.

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1	Explain the basic importance and functional elements of environmental microbiology including the potential applications in the environment and intellectual property rights.
CO2	Understand and describe the type of microorganisms in the environment, their importance in water supplies and the role of microorganisms in the cycling of nutrients in an ecosystem.
CO3	Understand the metabolic processes on carbohydrates, protein and lipids, importance of enzymes, production of energy and the various additional metabolic processes.
CO4	Select and apply appropriate methods for assessing the water, air and soil borne pathogens, their health implications, importance of microbes in aerobic and anaerobic cycles and deterioration of water bodies.
CO5	Conduct testing and research on toxicology, understand the importance of test organisms, environmental applications such as biomagnifications, biomonitoring and in developing risk based standards.

REFERENCES:

1. Bhatia S.C. , "Hand Book of Environmental Microbiology", Part 1 and 2, Atlantic Publisher, 2008
2. Gabriel Bitton, Wastewater Microbiology, 2nd Edition, 3. Raina M. Maier, Ian L. Pepper, Charles P. Gerba, "Environmental Microbiology", Academic Press, 2000
4. Volodymyr Ivanov,Environmental Microbiology for Engineers 2nd Edition, CRC Press, 2015, ISBN 9781498702126
5. Nduka Okafor, Environmental Microbiology of Aquatic and Waste systems. Springer Publishers, 2011, ISBN 978-94-007-1459-5
6. Stanley E. Manahan, "Environmental Science and Technology", Lewis Publishers, 2008.
7. Hurst, C.J. Manual of "Environmental Microbiology". 2nd Ed. ASM PRESS, Washington, D.C. ISBN 1-55581 - 199 - X. 2002
8. Frank C. Lu and Sam Kacew, LU s Basic Toxicology, Taylor & Francis, London 4th Ed, 2002.

CO – PO Mapping- ENVIRONMENTAL MICROBIOLOGY

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	M	M	M	H	M	M
PO2	Problem analysis				M	M	M
PO3	Design / development of solutions	M		H	H	M	H
PO4	Investigation		M			M	M
PO5	Modern Tool Usage	M			M		M
PO6	Individual and Team work		M		M	M	M
PO7	Communication		M			L	L
PO8	Engineer and Society	M			M		M
PO9	Ethics	M					M
PO10	Environment and Sustainability	M			M		M
PO11	Project Management and Finance				M		M
PO12	Life Long Learning				M	L	L
PSO1	Knowledge of Environmental Management discipline	H		M	H	H	H
PSO2	Environmental Performance Evaluation and coordination	M	M	M	M	M	M
PSO3	Conceptualization of Environmental Management Systems			M	H	H	H

EN5103 DESIGN OF PHYSICO- CHEMICALTREATMENT SYSTEMS FOR WATER AND WASTEWATER **L T P C 3 0 0 3**

OBJECTIVE:

- To understand about the various pollutants present in water and wastewater and to choose the respective physico-chemical systems for effective treatment
- To apply the knowledge for municipal, industrial water and wastewater treatment plants and design suitable treatment schemes
- To advance knowledge on the emerging environmental issues on treatment systems and conduct research to identify most appropriate treatment schemes

UNIT I INTRODUCTION **5**

Pollutants in water and wastewater–characteristics, standards for performance- significance of physico-chemical treatment–Selection criteria-types of reactor-reactor selection-batch-continuous type-kinetics

UNIT II TREATMENT PRINCIPLES **10**

Physical treatment- screening –mixing, equalization –sedimentation – filtration – evaporation– incineration–gas transfer–mass transfer coefficient adsorption–isotherms–membrane separation, Reverse Osmosis, nanofiltration, ultrafiltration and electrodialysis, distillation– stripping and crystallization– recent advances.

Principles of Chemical treatment– Coagulation - flocculation–Precipitation – flotation - solidification and stabilization–Disinfection, Ion exchange, Electrolytic methods, Solvent extraction–advanced oxidation/reduction– recent trends

UNIT III DESIGN OF MUNICIPAL WATER TREATMENT PLANTS 10

Selection of treatment–design of municipal water treatment plant units–aerators–chemical feeding–flocculation–clarifier–tube settling–filters–rapid sand filters, slow sand filter, pressure filter, dual media filter – disinfection flow charts– layouts –hydraulic profile ,PID-construction and O&M aspects–case studies, residue management – upgradation of existing plants – recent trends.

UNIT IV DESIGN OF INDUSTRIAL WATER TREATMENT PLANTS 10

Design of industrial water treatment units-selection of process–design of softeners – demineralisers–Reverse osmosis plants–flow charts–layouts–hydraulic profile, PID-construction and O&M aspects–case studies, residue management–upgradation of existing plants –recent trends.

UNIT V DESIGN OF WASTEWATER TREATMENT PLANTS 10

Design of municipal wastewater treatment units-screens- grit chamber-settling tanks- sludge thickening - sludge dewatering systems - sludge drying beds - design of industrial wastewater treatment units - equalization - neutralization - chemical feeding devices – mixers - floatation units - oil skimmer - flowcharts – layouts – hydraulic profile, PID, construction and O&M aspects – case studies, retrofitting - residue management – upgradation of existing plants – recent trends.

TOTAL: 45 PERIODS

OUTCOME:

- On Completion of the course, the student is expected to be able to

CO1	Explain the significance of various pollutants present in water, wastewater and develop the kinetics for reactor design
CO2	Choose the relevant physico-chemical systems for effective water and wastewater treatment
CO3	Design the treatment scheme for municipal and industrial water, wastewater to meet the specific needs on residue management and up gradation of existing plants
CO4	Identify environmental issues in the society on wastewater treatment and formulate technical solutions that are economically feasible and socially acceptable
CO5	Conduct research to identify and design most appropriate treatment schemes for the emerging environmental issues on treatment systems in collaboration with municipalities, corporation, pollution control boards and industries

REFERENCES:

1. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017
2. Lee, C.C. and Shun dar Lin, "Handbook of Environmental Engineering Calculations", McGraw Hill, New York, 1999.
3. Qasim.S.R., Guang Zhu., “Wastewater Treatment and Reuse” – Volume 1& 2 2018.
4. CPHEEO manual – “Manual for sewerage and sewage treatment systems” – Part A,B,C, Ministry of Urban development, New Delhi,2013.
5. CPHEEO manual – “Manual for water supply and treatment” –Ministry of Urban development, New Delhi, 1999.

CO-PO Mapping- DESIGN OF PHYSICO- CHEMICALTREATMENT SYSTEMS FOR WATER AND WASTEWATER

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	H	H			H
PO2	Problem analysis		M	M	H	M	M
PO3	Design / development of solutions		M	M	M	M	M
PO4	Investigation				H	H	H

PO5	Modern Tool Usage			L			L
PO6	Individual and Team work					M	M
PO7	Communication					M	M
PO8	Engineer and Society				H	H	H
PO9	Ethics		H	H	H	H	H
PO10	Environment and Sustainability				H	H	H
PO11	Project Management and Finance				M	M	M
PO12	Life Long Learning					H	H
PSO1	Knowledge of Environmental Engineering discipline			M	M	M	M
PSO2	Critical analysis of environmental problems and innovation			M	M	M	M
PSO3	Conceptualization and evaluation of engineering solutions to Environmental Issues			H	H	H	H

EN5104 TRANSPORT OF WATER AND WASTEWATER L T P C
3 0 0 3

OBJECTIVE:

- To educate the students on economic design of water mains, distribution system and sewer networks

UNIT I GENERAL HYDRAULICS 8

Fluid properties; fluid flow – continuity principle, energy principle and momentum principle; frictional head loss in free and pressure flow, minor head losses, carrying capacity– flow measurement. need for transport of water and wastewater and types

UNIT II WATER TRANSMISSION MAINS 9

Planning of water system – design of storage reservoirs - water transmission main design-compound gravity and pumping main; selection of pumps and characteristics curve - economics; specials, jointing, laying and maintenance, water hammer analysis;

UNIT III WATER DISTRIBUTION 9

Service reservoirs-types and design. water distribution pipe networks design, analysis and optimization – appurtenances – corrosion prevention – minimization of water losses – leak detection. plumbing for water supply in high rise buildings. use of computer software in water transmission, water distribution design – EPANET 2.0, LOOP version 4.0, BRANCH,

UNIT IV WASTEWATER COLLECTION AND CONVEYANCE 10

Planning factors – design of sanitary sewer; partial flow in sewers, economics of sewer design; wastewater pumps and pumping stations- sewer appurtenances; material, construction, inspection and maintenance of sewers; design of sewer outfalls-mixing conditions; conveyance of corrosive wastewaters. plumbing for drains in high rise buildings

UNIT V STORM WATER DRAINAGE 9

Necessity- combined and separate system; estimation of storm water runoff - formulation of rainfall intensity duration and frequency relationships- rational methods. use of computer software in sewer design–sewer. SewerCAD, SewerGEMS

TOTAL: 45 PERIODS

OUTCOMES:

- On Completion of the Course the student will be able to

CO1	Understand general hydraulics and need for proper collection and conveyance of water and wastewater
CO2	Design economic diameters of gravity and pumping mains and storage reservoirs
CO3	Design and analysis of water distribution networks and apply computer softwares
CO4	Design sewer networks for various flow conditions
CO5	Design storm water drain and apply computer softwares for design of sewers.

REFERENCES:

1. Pramod R. Bhave, Rajesh Gupta. “Analysis of Water Distribution Networks”, Alpha Science International, 2006
2. Bajwa, G.S. "Practical Handbook on Public Health Engineering", Deep Publishers, Shimla, 2003
3. “Manual on water supply and Treatment”, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 1999.
4. “Manual on Sewerage and Sewage Treatment Part-A Engineering”, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2013

CO-PO Mapping- TRANSPORT OF WATER AND WASTEWATER

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H					H
PO2	Problem analysis	M		M			M
PO3	Design / development of solutions		H	H	H	H	H
PO4	Investigation	M	M				M
PO5	Modern Tool Usage		H	H	H	H	H
PO6	Individual and Team work	M	M	M	M	M	M
PO7	Communication	M					M
PO8	Engineer and Society	H	H	H	H	H	H
PO9	Ethics		M	M	M	M	M
PO10	Environment and Sustainability	H	M	M	M	M	M
PO11	Project Management and Finance		M				M
PO12	Life Long Learning	M					M
PSO1	Knowledge of Environmental Management discipline	M					M
PSO2	Environmental Performance Evaluation and coordination		M	M	M	M	M
PSO3	Conceptualization of Environmental Management Systems		M	M	M	M	M

RM5151 RESEARCH METHODOLOGY AND IPR L T P C
2 0 0 2

OBJECTIVES:

To impart knowledge and skills required for research and IPR:

- Problem formulation, analysis and solutions.
- Technical paper writing / presentation without violating professional ethics
- Patent drafting and filing patents.

UNIT I RESEARCH PROBLEM FORMULATION 6

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

UNIT II LITERATURE REVIEW 6

Effective literature studies approaches, analysis, plagiarism, and research ethics.

UNIT III TECHNICAL WRITING /PRESENTATION 6

Effective technical writing, how to write report, paper, developing a research proposal, format of research proposal, a presentation and assessment by a review committee.

UNIT IV INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS (IPR) 6

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.

UNIT V INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology.Patent information and databases.Geographical Indications. New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

TOTAL: 30 PERIODS

OUTCOMES:

1. Ability to formulate research problem
2. Ability to carry out research analysis
3. Ability to follow research ethics
4. Ability to understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity
5. Ability to understand about IPR and filing patents in R & D.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										
CO2	✓											
CO3	✓							✓				
CO4	✓				✓							
CO5	✓					✓						✓

REFERENCES:

1. Asimov, "Introduction to Design", Prentice Hall, 1962.
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
3. Mayall, "Industrial Design", McGraw Hill, 1992.
4. Niebel, "Product Design", McGraw Hill, 1974.
5. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners" 2010

EN5111 ENVIRONMENTAL CHEMISTRY LABORATORY L T P C
0 0 4 2

OBJECTIVES:

- To train in the analysis of physico-chemical parameters with hands on experience

1.	Good Laboratory Practices, Quality control, calibration of Glassware	8
2.	Sampling and Analysis of water (pH, alkalinity, hardness, chloride, Sulphate , turbidity EC, TDS,TS, nitrate, fluoride and Iron)	20
3.	Sampling and Wastewater analysis (BOD, COD, Phosphate, Ammonia, TKN, Oil & Grease, Surfactant and heavy metals)	20
4.	Sampling and characterization of soil (Moisture, EC, pH ,Na and K)	12

TOTAL: 60 PERIODS

OUTCOME:

CO1 : Ability to calibrate and standardize the equipments
CO2 : Abiltiy to collect proper sample for analysis
CO3 : The candidate ability to perform field oriented testing of water, wastewater and soil
CO4: Able to perform soil testing
CO5 Able to perform analysis of water and wastewater

REFERENCES:

1. APHA, "Standard Methods for the Examination of Water and Wastewater", 22nd Ed. Washington, 2012.
2. "Laboratory Manual for the Examination of water, wastewater soil Rump", H.H. and Krist, H. – Second Edition, VCH, Germany, 3rd Edition, 1999.
3. "Methods of air sampling & analysis", James P.Lodge Jr(Editor) 3rd Edition, Lewis publishers,Inc,USA,1989.

CO – PO Mapping- ENVIRONMENTAL CHEMISTRY LABORATORY

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	H	H	M	H	H
PO2	Problem analysis	M	M	H	L	M	M
PO3	Design / development of solutions				M	M	M
PO4	Investigation		M	M	L	M	M
PO5	Modern Tool Usage	H	M	H	H	H	H
PO6	Individual and Team work				H	H	H
PO7	Communication					M	M
PO8	Engineer and Society		M			M	M
PO9	Ethics						
PO10	Environment and Sustainability					M	M
PO11	Project Management and Finance		M			M	M
PO12	Life Long Learning	L				M	M
PSO1	Knowledge of Environmental Management discipline	M	M	M		M	M
PSO2	Environmental Performance Evaluation and coordination	M				M	M
PSO3	Conceptualization of Environmental Management Systems	M				M	M

EN5112 ENVIRONMENTAL MICROBIOLOGY LABORATORY L T P C
0 0 4 2

OBJECTIVE:

- To train the students in the analysis of various microbiological techniques, microbiological analysis, enzyme assay, pollutant analysis and operation of bioreactors.

EXPERIMENTS:

1. Preparation of culture media,
2. Isolation and culturing of microorganisms
3. Microscopical identification of Microorganisms (algae, bacteria and fungi)
4. Measurement of growth of microorganisms,
5. Analysis of air borne microorganisms,
6. Staining of bacteria.
7. Effect of pH, temperature on microbial growth
8. Bacteriological analysis of wastewater (Coliforms, *E.coli, Streptococcus*) – MPN
9. Bacteriological analysis of wastewater (Coliforms, *Streptococcus)* - MF techniques,
10. Effect of Heavy metals on microbial growth.
11. Detection of Anaerobic bacteria (*Clostridium* sp.)
12. Bioreactors (cultivation of microorganisms)

TOTAL: 60 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1	Explain the basic importance and functional elements of environmental microbiology including the types of microorganisms in air, water and soil.
CO2	Understand and describe the type of microorganisms in the environment, their importance and the method of culturing of microorganisms in the laboratory.
CO3	Understand the basic biochemical method of identification of microorganisms and to identify them using microscopial tool.
CO4	Select and apply appropriate methods for detection in the water, air and soil borne pathogens, their health implications, importance of microbes in our daily life.
CO5	Conduct testing and research on toxicology, the importance of test organisms, environmental applications of such microorganisms in toxicological studies and in developing risk based standards.

REFERENCES:

1. APHA, "Standard Methods for the Examination of Water and Wastewater", 22nd Ed. Washington, 2012.
2. Charles P. Gerba, "Environmental Microbiology: A laboratory manual", Elsevier Publications, 2012.
3. Christon J. Hurst, Ronald L. Crawford, Jay L. Garland, David A. Lipson, Aaron L. Mills, and Linda D. Stetzenbach, "Manual of Environmental Microbiology", 3rd Edition, ASM Press, 2007.

CO – PO Mapping- ENVIRONMENTAL MICROBIOLOGY LABORATORY

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	M	M	M	H	M	M
PO2	Problem analysis		H	M	M	M	M
PO3	Design / development of solutions	M	H	H	H	M	H
PO4	Investigation		M			M	M
PO5	Modern Tool Usage	M		M	M		M
PO6	Individual and Team work		M		M	M	M
PO7	Communication		M			L	L

PO8	Engineer and Society	M	M	M	M	M	M
PO9	Ethics	M					M
PO10	Environment and Sustainability	M		H	M	H	M
PO11	Project Management and Finance				M		M
PO12	Life Long Learning		M		M	L	L
PSO1	Knowledge of Environmental Management discipline	H		M		H	H
PSO2	Environmental Performance Evaluation and coordination	M	M	M	H	M	M
PSO3	Conceptualization of Environmental Management Systems		M		H	H	H

EN5201 DESIGN OF BIOLOGICAL TREATMENT SYSTEMS L T P C
3 0 0 3

OBJECTIVE:

- To understand the students on the principles and process designs of various treatment systems for wastewater
- To gain competency in the process employed in design of treatment systems and the components comprising such systems, leading to the selection of specific process.

UNIT I REACTION KINETICS AND BIO REACTORS 9

Objectives of biological treatment – significance – principles of aerobic and anaerobic treatment - kinetics of biological growth – factors affecting growth – attached and suspended growth - determination of kinetic coefficients for organics removal - enzyme kinetics biodegradability assessment - selection of process- reactors- biokinetics - batch reactor - continuous flow stirred tank reactor-plug flow reactor - flow charts, layout, PID, hydraulic profile

UNIT II CONVENTIONAL AEROBIC TREATMENT PROCESSES 9

Design of sewage treatment plant units –activated sludge process and variations - trickling filters- bio-tower- RBC- fluidized bed reactors, aerated lagoons, waste stabilization ponds – natural treatment systems, constructed wetland – nutrient removal systems- disposal options – reclamation and reuse – recent trends.

UNIT III ADVANCED AEROBIC TREATMENT PROCESSES OF WASTEWATER 9

Sequencing batch reactors- moving bed biofilm reactors- membrane bioreactor- reclamation and reuse of wastewater-design of tertiary treatment units-application of membrane separation technologies in reuse of sewage -nutrient removal systems-case studies

UNIT IV ANAEROBIC TREATMENT OF WASTEWATER 9

Attached and suspended growth process - design of units – UASB – post treatment systems for UASB reactor-anaerobic filters – expanded bed and fluidized bed anaerobic systems - septic tank and soil disposal system - anaerobic baffled reactor – design of nutrient removal systems - anaerobic ammonium oxidation process - recent trends.

UNIT V SLUDGE TREATMENT, OPERATION AND MAINTENANCE 9

Sources and its characteristics-design of sludge management facilities, sludge thickening- sludge digestion - biogas generation- sludge dewatering- mechanical – ultimate residue disposal – recent advances-construction and operational maintenance problems in STPs– trouble shooting – planning, organizing and controlling of plant operations – capacity building - retrofitting case studies

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1	Understand the microbial process and its kinetics
CO2	Design and size the different components of conventional aerobic treatment systems.
CO3	Design and size the different components of advanced aerobic treatment systems.
CO4	Understand in detail about the anaerobic treatment of wastewater which includes the design of attached and suspended growth processes.
CO5	Design the different elements of sludge treatment systems and understand the importance O&M issues pertaining to biological treatment systems

REFERENCES:

1. Arceivala S.J., and Asolekar S.R "Wastewater Treatment for Pollution Control and reuse "McGraw Hill , third Edition, New Delhi, 2007.
2. Manual for “Sewerage and Sewage Treatment Systems” CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2013.
3. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017
4. Qasim, S. R. and Guang Zhu "Wastewater Treatment and Reuse. Theory and Design Examples", CRC Press, New York, 2018.
5. F.R. Spellman, "Hand Book of Water and Wastewater Treatment Plant operations", CRC Press, New York 2009.
6. David Hendricks, "Fundamentals of Water Treatment Process", CRC Press, New York 2011.

CO – PO Mapping- DESIGN OF BIOLOGICAL TREATMENT SYSTEMS

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H		H			H
PO2	Problem analysis	M	H	H	M		H
PO3	Design / development of solutions	M	H	H	H	M	H
PO4	Investigation		M		H		H
PO5	Modern Tool Usage			M	M		M
PO6	Individual and Team work				M		M
PO7	Communication			M			M
PO8	Engineer and Society		M			M	M
PO9	Ethics					M	M
PO10	Environment and Sustainability	M			M		M
PO11	Project Management and Finance			M			M
PO12	Life Long Learning						
PSO1	Knowledge of Environmental Management discipline						
PSO2	Environmental Performance Evaluation and coordination	H	M	M			M
PSO3	Conceptualization of Environmental Management Systems	M				L	M

EN5251 **AIR POLLUTION CONTROL** **L T P C**
3 0 0 3

OBJECTIVE:

- To impart knowledge on types and sources of air pollution, its effects and design of control methods

UNIT I INTRODUCTION **8**

Structure and composition of atmosphere – sources and classification of air pollutants – effects of air pollutants on human health, vegetation & animals, Materials & Structures – effects of air pollutants on the atmosphere, soil & water bodies – Longterm effects– global climate change, Ozone Holes – ambient air quality and emission standards – air pollution indices – emission inventories.

UNIT II AIR POLLUTION MONITORING AND MODELLING **8**

Ambient and stack sampling and analysis of particulate and gaseous pollutants -effects of meteorology on air pollution - fundamentals, atmospheric stability, inversion, wind profiles and stack plume patterns- transport & dispersion of air pollutants – modelling techniques – Air Pollution climatology.

UNIT III CONTROL OF PARTICULATE POLLUTANTS **10**

Factors affecting selection of control equipment; gas particle interaction, – working principle, design and performance equations of gravity separators, cyclones, Fabric filters, particulate scrubbers, electrostatic precipitators – operational considerations - costing of APC equipment – recent advances

UNIT IV CONTROL OF GASEOUS POLLUTANTS **10**

Factors affecting selection of control equipment -working principle, design and performance equations of absorption, adsorption, condensation, incineration, bio-scrubbers, bio-filters –control technologies-SO_2,NO_x CO, H_2S; process control and monitoring - operational considerations - costing of APC equipment –emerging trends,

UNIT V AUTOMOBILE AND NOISE POLLUTION **9**

Vehicular Pollution: Automobile emission- types of emissions- prevention and control of vehicular pollution.

Noise Pollution: Sources and effects of noise pollution – measurement – standards –control and preventive measures.

Indoor Air Pollution: Sources and effects –control and preventive measures

TOTAL: 45 PERIODS

OUTCOMES:

After completion of this course, the student is expected to be able to understand:

CO1	Various types and sources of air pollution and its effects
CO2	Methods of source and ambient monitoring and dispersion of pollutants and their modeling
CO3	The principles and design of control of particulate pollutants
CO4	The principles and design of control of gaseous pollutant
CO5	Sources, effects and control of vehicular, indoor air and noise pollution

REFERENCES:

1. Noel de Nevers, "Air Pollution Control Engg", McGraw Hill, New York, 2016.
2. Daniel Vallero “Fundamentals of Air Pollution”, Fourth Edition, 2008.
3. Arthur C.Stern, “Air Pollution (Vol.I – Vol.VIII)”, Academic Press, 2006.
4. Lawrence K. Wang, Norman C. Parelra, Yung Tse Hung, "Air Pollution Control Engineering", Tokyo, 2004.
5. David H.F. Liu, Bela G. Liptak, “Air Pollution”, Lweis Publishers, 2000.
6. Wayne T.Davis, “Air Pollution Engineering Manual”, John Wiley & Sons, Inc., 2000.

CO – PO Mapping- AIR POLLUTION CONTROL

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	M	M	M	H	M
PO2	Problem analysis					H	H
PO3	Design / development of solutions			H	H	M	H
PO4	Investigation		H			H	H
PO5	Modern Tool Usage	H		H	H	M	H
PO6	Individual and Team work		M			M	M
PO7	Communication			L	L		L
PO8	Engineer and Society	M					M
PO9	Ethics	L					L
PO10	Environment and Sustainability	M				M	M
PO11	Project Management and Finance			M	M		M
PO12	Life Long Learning		M				M
PSO1	Knowledge of Environmental Management discipline	M	L	M	M	M	M
PSO2	Environmental Performance Evaluation and coordination		M	M	M		M
PSO3	Conceptualization of Environmental Management Systems		M	M	M		M

EN5252 INDUSTRIAL WASTEWATER POLLUTION - PREVENTION AND CONTROL **L T P C 3 0 0 3**

OBJECTIVES:

- To understand the principle of various processes applicable to industrial wastewater treatment
- To impart knowledge on the concept and application of Industrial pollution prevention, cleaner technologies, industrial wastewater treatment and residue management.
- To identify the best applicable technologies for wastewater treatment from the perspective of yield production.

UNIT I INTRODUCTION **8**

Industrial scenario in India– industrial activity and environment - uses of water by industry – sources and types of industrial wastewater – nature and origin of pollutants - industrial wastewater and environmental impacts – regulatory requirements for treatment of industrial wastewater – industrial waste survey – industrial wastewater monitoring and sampling - generation rates, characterization and variables – toxicity of industrial effluents and bioassay tests – major issues on water quality management.

UNIT II INDUSTRIAL POLLUTION PREVENTION & WASTE MINIMISATION **8**

Prevention vis a vis control of industrial pollution – benefits and barriers – waste management Hierarchy - source reduction techniques – periodic waste minimisation assessments – evaluation of pollution prevention options – cost benefit analysis – pay-back period – implementing & promoting pollution prevention programs in industries.

UNIT III INDUSTRIAL WASTEWATER TREATMENT 10

Flow and load equalisation – solids separation – removal of fats, oil & grease- neutralisation-removal of inorganic constituents – precipitation, heavy METAL removal, nitrogen & phosphorous removal, Ion exchange, adsorption, membrane filtration, electro dialysis & evaporation – removal of organic constituents – biological treatment processes, chemical oxidation processes, advanced oxidation processes – treatability studies.

UNIT IV WASTEWATER REUSE AND RESIDUAL MANAGEMENT 9

Individual and common effluent treatment plants – Joint treatment of industrial and domestic wastewater - zero effluent discharge systems - quality requirements for wastewater reuse industrial reuse , present status and issues - disposal on water and land – residuals of industrial wastewater treatment – quantification and characteristics of sludge – thickening, digestion, conditioning, dewatering and disposal of sludge – management of RO rejects.

UNIT V CASE STUDIES 10

Industrial manufacturing process description, wastewater characteristics, source reduction options and waste treatment flow sheet for textiles – tanneries – pulp and paper – metal finishing – Oil refining–pharmaceuticals–sugar and distilleries

TOTAL: 45 PERIODS

OUTCOME:

- On Completion of the course, the student is expected to be able to

CO1	Explain the source and types of industrial wastewater and their environmental impacts and choose the regulatory laws pertaining to environmental protection
CO2	Identify industrial wastewater pollution and implement pollution prevention, waste minimization in industries
CO3	Apply knowledge and skills to design industrial wastewater treatment schemes
CO4	Audit and analyze environmental performance of industries to internal, external client, regulatory bodies and design water reuse management techniques
CO5	Conduct research to develop effective management systems for industrial wastewater that are technically sound, economically feasible and socially acceptable

REFERENCES:

1. "Industrial wastewater management, treatment & disposal, Water Environment" Federation Alexandria Virginia, Third Edition, 2008.
2. Lawrance K. Wang, Yung Tse Hung, Howard H.Lo and Constantine Yapijakis “handlook of Industrial and Hazardous waste Treatment”, Second Edition, 2004.
3. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017
4. Nelson Leonard Nemerow, “ industrial waste Treatment”, Elsevier, 2007.
5. Wesley Eckenfelder W., “ Industrial Water Pollution Control”, Second Edition, Mc Graw Hill, 2000.
6. Paul L. Bishop, Pollution Prevention: - Fundamentals and Practice, Mc-Graw Hill International, Boston, 2000.
7. Waste water Treatment for pollution control and reuse by Soli. J. Arceivala, Shyam. R. Asolekar, Tata Mcgraw Hill, 2007

CO-PO Mapping- INDUSTRIAL WASTEWATER POLLUTION - PREVENTION AND CONTROL

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H				H	H
PO2	Problem analysis		M	M	M	H	M
PO3	Design / development of solutions					H	H
PO4	Investigation		M		M	H	M

PO5	Modern Tool Usage				L		L
PO6	Individual and Team work		M		H	M	M
PO7	Communication			H	H	M	H
PO8	Engineer and Society				H	H	H
PO9	Ethics	H		H	H	H	H
PO10	Environment and Sustainability				H	H	H
PO11	Project Management and Finance				M		M
PO12	Life Long Learning		H	H		H	H
PSO1	Knowledge of Environmental Engineering discipline	H				H	H
PSO2	Critical analysis of environmental problems and innovation		M	M		M	M
PSO3	Conceptualization and evaluation of engineering solutions to Environmental Issues		M		H	H	H

EN5211 ENVIRONMENTAL AND PROCESSES MONITORING LABORATORY L T P C
0 0 6 3

OBJECTIVE:

- To develop the skill for conducting treatability studies of water and wastewater and monitoring of ambient air and noise quality

Sl. No.	**Name of Experiment**	**Hours**
1.	Coagulation and Flocculation	6
2.	Batch studies on settling	6
3.	Studies on Filtration- Characteristics of Filter media	6
4.	Water softening	6
5.	Adsorption studies/Kinetics	6
6.	Langelier Saturation Index and Silt Density Index- For Membrane Filtration	6
7.	Kinetics of suspended growth process (activated sludge process)-and Sludge volume Index	12
8.	Sludge Filterability Test	6
9.	Anaerobic Reactor systems / kinetics (Demonstration)	6
10.	Advanced Oxidation Processes – (Photo catalysis)	6
11.	Disinfection for Drinking water (Chlorination)	6
12.	Ambient Air Sampling-Determination of PM10, PM2.5, SO_2 and NO_2	12
13.	Noise Monitoring-Determination of Equivalent Noise Level	6
	TOTAL PERIODS	**90**

OUTCOME:

After the completion of the course the students will be able

CO1	To conduct treatability studies on water and wastewater treatment
CO2	To determine the removal / degradation of pollutants from water and wastewater and arrive at kinetics
CO3	To design scaled up reactors for treatment of water and wastewater treatment based on laboratory studies
CO4	To determine ambient air quality of given study area in terms of Particulate and Gaseous Pollutants
CO5	To determine Equivalent Noise Level by noise monitoring

REFERENCES:

1. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017
2. Lee, C.C. and Shundar Lin. "Handbook of Environmental Engineering Calculations", Mc Graw Hill, New York, 1999.
3. AEESP Environmental Processes Laboratory Manual, Association of Environmental Engineering and Science Professors Foundation, Washington, 2002.
4. Aery N C., “Manual of Environmental Analysis”, Ane Books Pvt. Ltd. New Delhi, 2014
5. CPCB, Guidelines for the Measurement of Ambient Air Pollutants, Volume I, Central Pollution Control Board, Ministry of Environment and Forests, Government of India, 2001

CO-PO Mapping- ENVIRONMENTAL AND PROCESSES MONITORING LABORATORY

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	H	H	M	M	H
PO2	Problem analysis	H			H		H
PO3	Design / development of solutions	H	L	H	L	L	M
PO4	Investigation	M	M		M	M	M
PO5	Modern Tool Usage	L	H	H	M	M	M
PO6	Individual and Team work	H	H	H	H	H	H
PO7	Communication	M	H		H	H	M
PO8	Engineer and Society	H	H	H	H	H	H
PO9	Ethics	H	H	H	H	H	H
PO10	Environment and Sustainability	H	H	H	H	H	H
PO11	Project Management and Finance			M			M
PO12	Life Long Learning			H			H
PSO1	Knowledge of Environmental Management discipline	H	H	H	H	H	H
PSO2	Environmental Performance Evaluation and coordination	H	H	H	H	H	H
PSO3	Conceptualization of Environmental Management Systems	H	H	H	H	H	H

EN5001 DESIGN OF ENVIRONMENTAL ENGINEERING STRUCTURES L T P C
3 0 0 3

OBJECTIVES:

- To gain knowledge and skills on structural design principles of water and wastewater retaining structures used in environmental engineering

UNIT I INTRODUCTION AND DESIGN OF PIPES 9

Environmental engineering structures - Introduction - concept of elastic method, ultimate load method and limit state method – advantages of limit state method over other methods – limit state philosophy as detailed in current IS Code. structural design of - concrete, prestressed concrete pipes - anchorage for pipes - massive outfalls, advances in the manufacture of pipes.

UNIT II DESIGN OF WATER TANKS 9

IS Codes for the design of water retaining structures - design of concrete roofing systems – cylindrical, spherical and conical shapes - design of circular, rectangular, spherical and INTZE type water tanks

UNIT III DESIGN OF WATER TREATMENT PLANT STRUCTURES 9

Structural design of screen chamber, settling tank, clariflocculators, filters and service reservoirs.

UNIT IV DESIGN OF WASTEWATER TREATMENT PLANT STRUCTURES 9

Structural design of wastewater treatment units - grit chamber, aeration tank, sludge digester, UASBR, sludge thickener, sludge drying beds.

UNIT V SPECIAL STRUCTURES 9

Design of masonry walls, columns and footings as per NBC and IS Codes - swimming pools, intake towers – design of cyclone separator – scrubber.

TOTAL : 45 PERIODS

OUTCOMES:

- On completion of the course, the students are able to

CO1	Apply the principle of limit state design for concrete pipe design
CO2	Do structural design of Water tanks
CO3	Design the water treatment plant Structures.
CO4	Design the components of wastewater treatment plant structures.
CO5	Apply the knowledge of structural design to various environmental engineering structures.

REFERENCES:

1. "Prestressed Concrete" by Krishna Raju, Tata McGraw Hill Publishing Co 2017.
2. "Reinforced Concrete" by N.C.Sinha & S.K.Roy - S.Chand and Co. 2017
3. Ramaswamy, G.S., “Design and Construction of Concrete shell roofs", CBS Publishers, India, 1986.
4. Green, J.K. and Perkins, P.H., “Concrete liquid retaining structures", Applied Science Publishers, 1981.
5. Rajagopalan K.,"Storage structures", Tata McGraw Hill, New Delhi, 2016.
6. Krishna Raju N., "Advanced Reinforced Concrete Design", CBS Publishers and Distributors, New Delhi, 2016.

CO – PO Mapping- DESIGN OF ENVIRONMENTAL ENGINEERING STRUCTURES

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H					H
PO2	Problem analysis		H	H			H
PO3	Design / development of solutions	H	H		M		H
PO4	Investigation		M	L	M	L	M
PO5	Modern Tool Usage	M				M	M
PO6	Individual and Team work		H		M		H
PO7	Communication			M			M
PO8	Engineer and Society		M		M	M	M
PO9	Ethics			M			M
PO10	Environment and Sustainability				M	H	H
PO11	Project Management and Finance			M	M		M
PO12	Life Long Learning	M					M
PSO1	Knowledge of Environmental Management discipline			M	M		M
PSO2	Environmental Performance Evaluation and coordination			M		H	H
PSO3	Conceptualization of Environmental Management Systems			M	M		M

EN5002 NATURAL SYSTEMS FOR WASTEWATER TREATMENT L T P C
3 0 0 3

OBJECTIVE

- To gain knowledge and understanding of wetlands on types of wetland, constructed wetland - application, design, method of treatment of both domestic and industrial wastewaters and case studies.
- To gain knowledge on design, construction and operation of waste stabilization pond and sludge disposal.

UNIT I INTRODUCTION TO WETLAND TREATMENT SYSTEM 9

Definition and concept of wetland - types of wetland. Wetland - ecology, flora and fauna, ecological aspects, human health and wetland, onsite applications. introduction to constructed wetland-types-free water surface, subsurface wetland-horizontal and vertical flow- wastewaters and their application in wetland - constructed wetland plants-media – in constructed wetland.

UNIT II CONSTRUCTED WETLAND AND REMOVAL MECHANISMS 9

Site identification- construction and design of constructed wetland, startup, operation and maintenance of wetland system-wetland hydrology- hydraulics. Treatment of domestic wastewater and its performance, mechanisms of pollutant removal- suspended solids, organic matter, nitrogen, phosphorus, pathogen and other contaminants. Reuse of treated wastewater and its applications-limitation of constructed wetland system.

UNITIII CASE STUDIES ON CONSTRUCTED WETLAND SYSTEM 8

Constructed wetland- treatment of domestic wastewater- greywater - landfill leachate – treatment of industrial wastewaters- textile wastewater – dairy wastewater and its performance. Removal of specific pollutants such as heavy metals, aromatics and emerging contaminants etc. Use of amendments in wetland construction, and its performance. Capital and maintenance costs.

UNITIV DESIGN OF WASTEWATER POND SYSTEMS. 10

Introduction- facultative -partial -mix aerated- ponds -complete -mix aerated pond systems - anaerobic ponds -nitrogen removal in lagoons. Modified high -performance aerated pond systems for nitrification and denitrification - nitrogen removal in ponds coupled with wetlands and gravel bed nitrification filters -Control of algae and design of settling basins. Hydraulic control of ponds - removal of phosphorous -removal of pharmaceuticals and personal care products and antibiotic resistant genes.

UNIT V SLUDGE MANAGEMENT AND TREATMENT 9

Sludge quantity and characteristics - stabilization and dewatering -sludge freezing -reed beds - vermi stabilization -comparison of bed type operations -composting land application and surface disposal of bio solids onsite wastewater systems -effluent disposal and reuse. Sludge quantity and characteristics-stabilization and dewatering-sludge freezing reed beds-vermi stabilization-Comparison of bed-type operations-composting land application and surface disposal of biosolids-on-site wastewater systems- effluent disposal and reuse.

TOTAL : 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1	Explain the various aspects of wetland system, its function and its application in the treatment of wastewaters
CO2	Apply the knowledge of science and engineering fundamentals to know the types of wetlands, construction and operation of wetlands, wetland hydraulics and design of wetland and its performance Understand the process of treatment of domestic waste in the removal of solids, organic matter, phosphate, nitrogen, pathogens and its reuse
CO3	Understand the process of treatment of industrial wastewater in the removal of solids, organic matter, phosphate, nitrogen, heavy metals, phenolics and feasibility for reuse
CO4	Understand the various pond system available for wastewater treatment. design of pond system -removal mechanism
CO5	Manage and dispose the sludge naturally and economically.

REFERENCES:

1. EPA- Design Manual on constructed wetland and aquatic plant system for municipal wastewater treatment system
2. Treatment wetlands by Robert .H.Kadlec, Scott Wallace , CRC press published July 22, 2008
3. Natural Wastewater Treatment Systems, Ronald W. Crites, E. Joe Middlebrooks, Robert K. Bastia, 2nd Edition, CRC PressPublished March 14, 2014
4. Waste water treatment in constructed wetlands with horizontal sub- surface flow by Jan Vyamazal and Lenka Kropfelova, Springer 2010.
5. Constructed wetlands for industrial wastewater treatment system by Alexandros I.Stefanakis (editor), Wiley black well.2018

CO – PO Mapping- NATURAL SYSTEMS FOR WASTEWATER TREATMENT

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences		H	M			H
PO2	Problem analysis	H	M		M	M	M
PO3	Design / development of solutions			H			H
PO4	Investigation		M			M	M
PO5	Modern Tool Usage		M		M		M
PO6	Individual and Team work		M	M			M
PO7	Communication					L	L
PO8	Engineer and Society	M			M		M
PO9	Ethics				M		M
PO10	Environment and Sustainability	M			M		M
PO11	Project Management and Finance				M		M
PO12	Life Long Learning					L	L
PSO1	Knowledge of Environmental Management discipline	H	M	H	H		H
PSO2	Environmental Performance Evaluation and coordination	M	M	M	M	M	M
PSO3	Conceptualization of Environmental Management Systems			H	H		H

EN5003 ENVIRONMENTAL MONITORING INSTRUMENTS L T P C

3 0 0 3

OBJECTIVES:

- . To educate the students on various instrumental methods of monitoring the quality of air, water and soil.

UNIT I FUNDAMENTALS 9

Wet chemistry methods and their limitations-instrumental methods, selection of method- precision and accuracy, error in measuring signals- quality control & assurance- sample preservation, sample preparation and analyte isolation.

UNIT II SPECTROSCOPIC METHODS 12

Principles, techniques and applications of spectrophotometry, fluorimetry, nephelometry and turbidimetry, Atomic Absorption Spectrometry (Flame, graphite furnace, cold vapour and hydride generation), Atomic Emission Spectrometry (AES), flame photometry and Inducted Coupled Plasma (ICP) – TOC Analyzer

UNIT III CHROMATROGRAPHIC METHODS 8

Principles, techniques and applications of GC, GC-MS, high performance liquid chromatography (HPLC) and Ion Chromatography (IC)-hyphenated techniques for environmental contaminant (trace organics) analysis, ICP-MS

UNIT IV ELECTRO AND RADIO ANALYTICAL METHODS 8

Principles, techniques and applications of conductometry, potentiometry, coulometry, AOX Analyzer. amperometry, polarography, electro-capillary analysis, Neutron Activation Analysis (NAA), X-ray Fluorescence (XRF) and X-ray Diffraction (XRD) methods.

UNIT V CONTINUOUS MONITORING INSTRUMENTS 8

Principles, techniques and applications of NDIR analyzer for CO, chemiluminescent analyzer for NOx, fluorescent analyzer for SO_2- particulates analysis- auto analyzer for water quality using flow injection analysis. LIMS.

TOTAL: 45 PERIODS

OUTCOMES:

CO1: Able to select appropriate instrumental method for chemical analysis
CO2: Understand spectroscopic methods of analysis of pollutants
CO3: Select correct method for toxic organics estimation using chromatography methods
CO4: Understand electro and nondestructive methods of analysis
CO5: Familiar with online analyzers

REFERENCES:

1. Willard H. Merritt, L. Dean, D.A. and Settle, F.A. 'Instrumental methods of analysis Edn. Words Worth, New York, 2004.
2. Paul R. Loconto Trace Environmental Quantitative Analysis: Principles, Techniques, and Applications**,** Marcel Dekker; 2nd Edition , 2005,
3. Ewing Instrumental Methods of Chemical Analysis, 5th Edition, McGraw Hill, New York.1985
4. Reeve, R.N., "Introduction to Environmental Analysis", Analytical Techniques in the Sciences, John Wiley & Sons, Chichester, UK, 2002.
5. Barcelo, D.(editor), "Environmental analysis. Techniques, Applications and Quality Assurance", Elsevier, The Netherlands, 1996

CO – PO Mapping- ENVIRONMENTAL MONITORING INSTRUMENTS

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	H	H	M	H	H
PO2	Problem analysis	M	M	H	L	M	M
PO3	Design / development of solutions				M	M	M
PO4	Investigation		M	M	L	M	M
PO5	Modern Tool Usage	H	M	H	H	H	H
PO6	Individual and Team work				H	H	H
PO7	Communication					M	M
PO8	Engineer and Society		M			M	M
PO9	Ethics						
PO10	Environment and Sustainability					M	M
PO11	Project Management and Finance		M			M	M
PO12	Life Long Learning	L				M	M
PSO1	Knowledge of Environmental Management discipline	M	M	M		M	M
PSO2	Environmental Performance Evaluation and coordination	M				M	M
PSO3	Conceptualization of Environmental Management Systems	M				M	M

EN5004 FATE AND REMEDIATION OF EMERGING CONTAMINANTS L T P C
3 0 0 3

OBJECTIVE:

- To impart knowledge on the priority list of emerging contaminants and improve understanding of their sources, occurrence, distribution, existing regulations/policies, analysis and screening techniques, environmental fate, transport, underlying mechanisms, modelling frameworks, ecotoxicity, risk assessment tools and remediation technologies.

UNIT I SOURCES, OCCURRENCE AND REGULATORY REQUIREMENTS 9

Definition - Priority *vs.* emerging contaminants - recent concerns - major groups - examples - properties - sources - occurrence - distribution in soils, groundwater, industrial and municipal wastewaters, aquaculture effluents, freshwater and marine ecosystems, air, food, plants, animals and human blood - existing global regulatory frameworks and policies

UNIT II CHARACTERIZATION AND INSTRUMENTATION 7

Sampling – sample preparation methods – analytical protocols for detection of pharmaceuticals, personal care products, antimicrobials and antibiotics, hormones, phthalate plasticizers and degradation products, surfactants, brominated fire retardants, pesticides and nanoparticles – analytical instruments

UNIT III ENVIRONMENTAL FATE AND TRANSPORT 9

Sorption - leaching - runoff - erosion - volatilization - plant/animal uptake - degradation and transformation - human health and ecological risks - environmental fate modelling frameworks - risk assessment tools - challenges - biomonitoring and biosensors

UNIT IV REMEDIATION TECHNOLOGIES 13

Incineration - sonolysis - multi-phase extraction - permeable reactive barrier - advanced oxidation processes - membrane based separation - nanofiltration - Reverse osmosis - biosorption - bioaugmentation - combined treatment options - remediation endpoints - challenges - opportunities

UNIT V CASE STUDIES 7

Occurrence in different environmental compartments - environmental fate and transport - potential and known risks to human health and the environment - effective technological and policy approaches to prevent, control and remove emerging pollutants in the environment

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to:

CO1	Explain about the different kinds of emerging contaminants, their sources, occurrence, distribution in different environmental compartments and existing regulations/policies
CO2	Explain about the analytical techniques for the detection of emerging contaminants in environment
CO3	Explain about the environmental fate, behaviour, underlying mechanisms, human health and ecological risks of emerging contaminants, and will be able to monitor and assess the degree of environmental contamination by emerging pollutants
CO4	Select an appropriate single and/or integrated physical, chemical and/or biological clean-up option for environments contaminated with different classes of emerging pollutants in order to achieve the target remedial endpoints
CO5	Conduct independent research in the future pertinent to emerging contaminant pollution and remediation

REFERENCES:

1. Alok Bhandari, Rao Y. Surampalli, Craig D. Adams, Pascale Champagne, Say Kee Ong, R. D. Tyagi and Tian Zhang, Contaminants of Emerging Environmental Concern, American Society of Civil Engineers, US, 2009.
2. Caitlin H. Bell, Margaret Gentile, Erica Kalve, Ia Ross, John Horst and Suthan Suthersan, Emerging Contaminants Handbook, CRC Press, US, First edition, 2018.

3. Damia Barcelo and Mira Petrovic, Emerging Contaminants from Industrial and Municipal Waste Removal Technologies, Springer, Germany, 2012.
4. Damia Barcelo, Emerging Organic Contaminants and Human Health, Springer, Germany, 2012.
5. Francisco G, Calvo-Flores, Joaquin Isac-Garcia, Jose A. Dobado, Emerging Pollutants: Origin, Structure and Properties, Wiley & Sons, US, 2018.
6. Giusy Lofrano, Emerging Compounds Removal from Wastewater Natural and Solar Based Treatments, Springer, Germany, 2012

CO – PO MAPPING: FATE AND REMEDIATION OF EMERGING CONTAMINANTS

PO/PSO		Course outcome					Overall correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of engineering sciences	M	M	M	M	M	M
PO2	Problem analysis	M		M		M	M
PO3	Design/development of solutions				H	M	H
PO4	Investigation	H	M		M	M	M
PO5	Modern tool usage		M	M			M
PO6	Individual and team work				M		M
PO7	Communication	M	M	M	M	M	M
PO8	Engineer and society	M				M	M
PO9	Ethics	M					M
PO10	Environment and sustainability	M			H	M	M
PO11	Project management and finance					L	L
PO12	Life long learning	H	M	M	H	M	M
PSO1	Knowledge of environmental management discipline	H	M	H	H	M	H
PSO2	Environmental performance evaluation and coordination			M	M	M	M
PSO3	Conceptualization of environmental management systems				M	M	M

EN5005 COMPUTING TECHNIQUES IN ENVIRONMENTAL ENGINEERING L T P C
3 0 0 3

OBJECTIVES:

- To educate the students to know about the computing techniques used in environmental engineering, and explain the artificial intelligence like ANN, Fuzzy logic and genetic algorithm applications in environmental engineering.

UNIT I SOFT COMPUTING PRINCIPLES 9

Introduction to computing techniques – algorithms and flowcharts, numerical methods - solution to ordinary and partial differential equation using finite difference, finite element and finite volume methods, numerical integration and differentiation.

UNIT II ARTIFICIAL INTELLIGENCE 9

Knowledge based expert system concepts - principle of Artificial Neural Network (ANN) – perceptron learning rule, neural network structure – neural network operations – ANN Algorithm - Application of ANN Model to environmental field – genetic algorithms

UNIT III FUZZY LOGIC 9

Fuzzy logic principles - fuzzy logic and the theory of uncertainty - fuzzy set theory- fuzzy membership function, fuzzy relations, fuzzy rule, and applications of the fuzzy set theory to inference and control, clustering, and image processing.

UNIT IV DIGITAL DATA MANAGEMENT 9

Data base structure - data acquisition - data warehouse - DBMS - RDBMS - data analysis - network data sharing - Statistical Analysis (SYSTAT) - regression - factor analysis - histogram - scatter diagram - goodness of fit – big data analysis.

UNIT V ENVIRONMENTAL MODELING SOFTWARE 9

Introduction to MATLAB Software – MATLAB applications in environmental – pollutants transport, decay and degradation modeling using MIKE 21 – MODFLOW - case studies.

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the students are able to

CO1	Understand the various computing techniques available for environmental engineering.
CO2	Apply the principles of ANN and GA for solving environmental problems
CO3	Apply the principles of Fuzzy logic and for solving environmental problems.
CO4	Work in the statistical analysis software SYSTAT.
CO5	Employ modern advanced computing tool MATLAB software in environmental studies

REFERENCES:

1. Aliev R. A, and Aliev Rashad, "Soft Computing and its Applications", World Scientific Publications Co. Pte. Ltd. Singapore, 2017.
2. Chepra S. C. and Canele R. P., "Numerical Methods for Engineers", McGraw-Hill, a business unit of The McGraw-Hill Companies, Inc., 1221 Avenue of the Americas, New York, NY 10020. 6th Edition 2018.
3. Data-Driven Modeling: Using MATLAB in Water Resources and Environmental Engineering, Springer; 2014 edition.
4. Mathews J. H. and Fink K.D. "Numerical methods using MATLAB", Pearson Education 2018.

CO – PO Mapping- COMPUTING TECHNIQUES IN ENVIRONMENTAL ENGINEERING

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H			M		H
PO2	Problem analysis		H	H	M		H
PO3	Design / development of solutions		M	M			M
PO4	Investigation		M				M
PO5	Modern Tool Usage		H				H
PO6	Individual and Team work			M		L	M
PO7	Communication				M	M	M
PO8	Engineer and Society		M	M	M		M
PO9	Ethics					M	M
PO10	Environment and Sustainability		H	M		M	M
PO11	Project Management and Finance				H		H
PO12	Life Long Learning		H	H			H
PSO1	Knowledge of Environmental Management discipline	H			M	H	H
PSO2	Environmental Performance Evaluation and coordination					H	H
PSO3	Conceptualization of Environmental Management Systems				M	M	M

EN5006 **AIR QUALITY MODELLING** **L T P C**
3 0 0 3

OBJECTIVES:

- To introduce the theory of dispersion of air pollution in the atmosphere and major approaches for air pollution modelling and to demonstrate the features of most widely used commercial and freely available air quality models

UNIT I MODELLING AND MODELS 8

Overview of different types of models-deterministic and stochastic approach- steps in model development- numerical and simulations models- calibration and validation of models- limitations-transport phenomena- mass balance analysis-model development and decision making. Types of air quality models-classification

UNIT II METEOROLOGY AND DISPERSION 11

Chemistry of air Pollutants - atmospheric reactions, sinks for air pollution –transport of air pollutants - meteorological factors for dispersal of air pollutants – meteorological modelling-developing wind rose and pollutant rose diagrams-vertical structure of temperature and stability, mixing height; tall stacks-transport and diffusion of stack emissions –plume segments–flare stack–plume rise equations-Holland's and Brigg's models.

UNIT III EMISSION AND SOURCE DISPERSION MODELS 10

modeling for reactive and nonreactive pollutants, point source-single and multiple sources- area sources, line source models, fixed box models- diffusion models – Gaussian plume derivation-modifications of Gaussian plume equation- Gaussian puff model- emission models-emission factors-long term average-multiple cell model-accuracy and utilization-limitations-air quality mapping

UNIT IV RECEPTOR MODELS AND INDOOR AIR QUALITY MODELS 8

Receptor models- source apportionment studies- CMB model- PMF models; environmental wind tunnel models; indoor air pollutants –mass balance-single compartment-multiple compartments calculation of deposition velocity and Position of Particles-Aerosol-Odours and sick building syndrome-Integrated Models.

UNIT V SOFTWARE PACKAGE APPLICATIONS 8

Commercial air quality models - ADMS, AERMOD, CALINE, CALPUFF, DEGADIS, HYROAD, INDUSTRIAL SOURCE COMPLEX, SCREEN, HYSPLIT, INDEX

TOTAL: 45 PERIODS

OUTCOMES:

- At the end of the course the student will be to

CO1	Concepts and types of models, model development, their applicability and limitations.
CO2	Understand the physicochemical transformation of air pollutants in the atmosphere along with the meteorological influence in dispersion of pollutants.
CO3	Identifies emission source and applies suitable modeling tools to estimate the impact of the pollutants.
CO4	Fetch knowledge on source inventories, model prediction efficiency and potential risk assessment..
CO5	Understand the application of models to predicts the air quality scenarios for different conditions and find suitable mitigation measures.

REFERENCES:

1. Noel de Nevers, "Air Pollution Control Engg"., Mc Graw Hill, New York, 2016.
2. Arthur C.Stern, "Air Pollution (Vol.I – Vol.VIII)", Academic Press, 2006.
3. Lawrence K. Wang, Norman C. Parelra, Yung Tse Hung, "Air Pollution Control Engineering", Tokyo, 2004
4. John H. Seinfeld and Spyros N. Pandis Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, 2 nd Edition, , 2006,
5. Mark Z. Jacobson Fundamentals of Atmospheric Modeling, 2 nd Edition, 2005,
6. Deaton and Wine Brake, "Dynamic Modeling of Environmental Systems", Wiley & Sons, 2002.

CO – PO Mapping- AIR QUALITY MODELLING

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	M		M		M
PO2	Problem analysis	L	M	H	M	M	M
PO3	Design / development of solutions			H		M	H
PO4	Investigation		M	M	H	M	M
PO5	Modern Tool Usage	H		H		H	H
PO6	Individual and Team work			M	M		M
PO7	Communication	M			M	M	M
PO8	Engineer and Society	M		M		M	M
PO9	Ethics			M			M
PO10	Environment and Sustainability		M				M
PO11	Project Management and Finance					M	
PO12	Life Long Learning	M					M
PSO1	Knowledge of Environmental Management discipline	L			L		L
PSO2	Environmental Performance Evaluation and coordination		M	M	M	M	M
PSO3	Conceptualization of Environmental Management Systems			M	M	M	M

EN5007 WATER QUALITY MODELLING L T P C
3 0 0 3

OBJECTIVES:

- To understand the fundamentals of mathematical models and their importance in water quality modelling, and to impart the skills to use water quality modelling software for surface and groundwater quality modelling.

UNIT I MODELLING INSIGHTS 9

Engineers and Mathematical models-Water quality models – historical development - different types of models-- steps in model development - importance of model building.- calibration and verification of models- finite element, finite difference and finite volume methods.

UNIT II POLLUTANT TRANSPORT‘ 9

Transport phenomena – advection, diffusion, dispersion- contamination transport in surface and subsurface water - Simple transport models –steady state and time variable solutions- conservation of mass, momentum and energy balance, governing equation for contaminant fate and transport

UNIT III SURFACE WATER QUALITY MODELLING 10

Water quality modeling of streams, lakes and estuaries – water quality– model sensitivity – assessing model performance; Models for dissolved oxygen, pathogens and BOD-Streeter Phelp’s model for point and distributed sources - modified streeter Phelp’s equations. Tropic status assessment.

UNIT IV GROUNDWATER QUALITY MODELLING 9

Groundwater flow and mass transport of solutes – groundwater quality modelling using numerical methods - degradation of organic compounds in sub surface - prediction of contaminant transport and particle tracking -seawater intrusion – basic concepts and modelling.

UNIT V WATER QUALITY MODELLING SOFTWARE 8

Exposure to surface water and groundwater quality modelling software's – MIKE 21, WASP, QUAL2E and MODFLOW – demonstration - case studies.

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the students are able to

CO1	Know about the principles of water quality modelling.
CO2	Understand the pollutant transport phenomena in surface and groundwater.
CO3	Apply the knowledge of surface water quality modelling to predict the water quality of rivers, lakes and estuary.
CO4	Predict the groundwater contamination transport.
CO5	Predict water quality of surface and sub surface water using numerical solution.

REFERENCES:

1. Steven C. Chapra, "Surface Water Quality Modelling", Tata McGraw-Hill Companies, Inc., New Delhi 2018.
2. "Water Quality Modelling for Rivers and Streams" Authors: Benedini, Marcello, Tsakiris, George, Springer Netherlands 2017.
3. **"**Hydrodynamics and Water Quality**:** Modelling Rivers, Lakes, and Estuaries", Zhen-Gang Ji, John Wiley & Sons, 2018.
4. "Modelling Groundwater Flow and Contaminant Transport By Jacob Bear, A. H.-D. Cheng, Springer Science & Business Media, 2010.
5. "Mathematical Modelling of Groundwater Pollution" Ne-Zheng Sun, Alexander Sun, Springer New York, 2012

CO – PO Mapping- WATER QUALITY MODELLING

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	H				H
PO2	Problem analysis				M	H	H
PO3	Design / development of solutions			H	H	M	H
PO4	Investigation		H	M	H		H
PO5	Modern Tool Usage				H	M	H
PO6	Individual and Team work					M	M
PO7	Communication				M		M
PO8	Engineer and Society			M	H	H	H
PO9	Ethics			M	M		M
PO10	Environment and Sustainability				H	H	H
PO11	Project Management and Finance			M	M	M	M
PO12	Life Long Learning	H	M			H	H
PSO1	Knowledge of Environmental Management discipline					H	H
PSO2	Environmental Performance Evaluation and coordination				H	M	H
PSO3	Conceptualization of Environmental Management Systems		M	H			H

EN5008 ENVIRONMENTAL SYSTEM ANALYSIS L T P C
3 0 0 3

OBJECTIVES:

- To introduce the modelling concept in various environmental field like ecological modelling, CSTR modelling and the kinetics of reaction
- To gain knowledge on river and stream water modelling and soft computing techniques.

UNIT I ECOLOGICAL SYSTEM 9

Basic concepts in ecology and ecological modelling, population dynamics: birth and death processes. Single species growth, prey-predator models: Lotka-Volterra, Rosenzweig-MacArther, Kolmogorov models. multi-species modeling - structural analysis and stability of complex ecosystems.

UNIT II REACTOR MODELLING 9

CSTR, plug-flow, dispersion. A case study of a tubular reactor with axial dispersion, parameter calibration: search algorithms for nonlinear dynamical models, variance of estimated parameters. application to Monod and Haldane kinetics.

UNIT III WATER QUALITY MODELLING 9

Rivers and streams water quality modeling -dispersion and mixing- water quality modelling process- model sensitivity-assessing model performance; models for dissolved oxygen and pathogens- pollutant and nutrient dynamics -dissolved oxygen dynamics -groundwater quality modeling.

UNIT IV MICROBIAL DYNAMICS AND ENERGETICS 9

Requirements for carbon and nutrient removal. Activated sludge: process schemes: completely mixed, plug-flow, SBR, nutrient removal. Anaerobic digestion: process dynamics, operational control of wastewater treatment processes.

UNIT V COMPUTER BASED SOLUTIONS 9

Formulation of linear optimization models. linear programming. sensitivity testing and duality. Solution techniques and computer programming; Formulation of linear optimization models. Application of models- simulation, parameter estimation and experimental design.

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the students are able to

CO1	Apply the principle of system modeling
CO2	Do reactor modeling
CO3	Develop water quality models.
CO4	Model microbial dynamics
CO5	Apply the knowledge of numerical techniques to environmental system modeling

REFERENCES:

1. Deaton, M.L and Winebrake, J.J., "Dynamic Modeling of Environmental Systems", Springer-Verlag, 2000
2. Orhon, D and Artan, N., "Modeling of Activated Sludge Systems, Technomic" Publ. Co., 1994.
3. Steven C. Chapra, “Surface Water Quality Modelling”, Tata McGraw-Hill Companies,Inc., New Delhi 2018.

CO – PO Mapping- ENVIRONMENTAL SYSTEM ANALYSIS

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H		H	M		H
PO2	Problem analysis		M	M			M
PO3	Design / development of solutions				H	M	H
PO4	Investigation				M	M	M
PO5	Modern Tool Usage			H	H		H
PO6	Individual and Team work		M	H		H	H
PO7	Communication				M	M	M
PO8	Engineer and Society				M		M
PO9	Ethics			M			M

PO10	Environment and Sustainability				M	H	H
PO11	Project Management and Finance				H	H	H
PO12	Life Long Learning	H		H		M	H
PSO1	Knowledge of Environmental Management discipline				H	M	H
PSO2	Environmental Performance Evaluation and coordination				M	M	M
PSO3	Conceptualization of Environmental Management Systems			H		M	H

EN5009 ADVANCED OXIDATION PROCESS L T P C
3 0 0 3

OBJECTIVES:

- To identify the most critical issues and challenges that limit the use of conventional treatment processes in planning, design and operation of modern water and wastewater treatment facilities
- To understand the fundamentals of advanced oxidation processes (AOPs), photochemistry, ozone chemistry, and its application to AOPs for the detoxification of contaminated water
- To develop in-depth knowledge that can be used to devise and design effective AOP treatment systems to meet not only current but also anticipated regulatory requirements, and to enhance independent learning and critical thinking skills.

UNIT I INTRODUCTION TO AOPs 8

Introduction to AOPs for water and wastewater treatment – mechanism – photooxidation reactions photocatalytic reactions, photo initiated oxidation – UV- H_2O_2 / ozonation, fenton / photofenton – photocatalysis – light source choice – used in AOPs and their spectral distributions.

UNIT II HOMOGENOUS AOPs 8

Ozone, electro-chemical oxidation, ultrasonication, UV – photolysis, hydrogen peroxide and ultraviolet radiation (H_2O_2 /UV), Fenton and Photo Fenton's oxidation, chemical and non-chemical AOPs, advantages and disadvantages of homogeneous processes.

UNIT III HETEROGENEOUS PROCESS 10

Introduction to nano & heterogeneous photocatalysis effect of system composition and process. Identification of degradation products, photoreactors (liquid phase/ gas phase) – solar/ artificial light photo reactors – operation of pilot plants – comparing reactor efficiencies – system design – solar collectors – technology issues – slurry, supported catalyst – reuse – novel photocatalysts, synthesis methods – bulk, chemical approaches, physical approaches, nanoporous materials – physic chemical methods for characterization of nanomaterials.

UNIT IV AOP ENHANCEMENT TECHNIQUES 9

Non-thermal plasma-electron hydraulic cavitation and sonolysis- super water oxidation – γ rays-electron beams, Quantum yield improvement by additional oxidants – hydrogen peroxide persulphate– catalyst modification. case studies and applications semiconductor photolysis. process fundamentals, applications and commercial process.

UNIT V INDUSTRIAL APPLICATIONS AND ECONOMIC ASSESSMENT OF AOPs 10

Application of AOPs for textile, petroleum, pharmaceutical and petrochemical industries - ground water decontamination – drinking water treatment – pilot & land fill photochemical - cost calculation–economic analysis.

TOTAL: 45 PERIODS

OUTCOME:

On Completion of the course, the student is expected to be able to

CO1	Comprehend the basic principles of advanced water treatment processes, capabilities / constraints of their application in water and wastewater treatment
CO2	Apply technical knowledge and skills on the design and operation of AOPs for the water and wastewater treatment
CO3	Design suitable pre-treatment and post treatment schemes, and cleaning protocols for AOPs
CO4	Conduct economic assessment on AOTs for water and wastewater treatment
CO5	Select appropriate AOPs to solve emerging environmental wastewater issues in the society, that are technically sound, economically feasible and socially acceptable

REFERENCES:

1. Cao G., "Nanostructures & Nanomaterials: Synthesis, Properties & Applications", Imperial College Press, 2004.
2. Rose R. M., Shepard L. A.and Wulff J., “The Structure and Properties of Materials”, Wiley Eastern Ltd,
3. Simon Parsons, "Advanced oxidation processes for water and wastewater treatment", IWA Publishing, 2004
4. Thomas Oppenländer, "Photochemical Purification of Water and Air: Advanced Oxidation Processes (AOPs): Principles, Reaction Mechanisms, Reactor Concepts", Wiley-VCH Publishing, Published by, 2003
5. Marta.I.Litter, RobertsJ.Candal,J.Martin Meichtry, "Advanced Oxidation Technologies: Sustainable Solution for Environmental Trearment , CRC,Press, 2014.
6. R.M.Rose, L.A.Shepard and J.Wulff, “The Structure and Properties of Materials”, Wiley Eastern Ltd, 1996.

CO-PO Mapping- ADVANCED OXIDATION PROCESS

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	M	M		M	M
PO2	Problem analysis		M	M		M	M
PO3	Design / development of solutions			M		M	M
PO4	Investigation		M		M	H	M
PO5	Modern Tool Usage			L			L
PO6	Individual and Team work				M		M
PO7	Communication			M			M
PO8	Engineer and Society					H	H
PO9	Ethics		M	M	M		M
PO10	Environment and Sustainability					H	H
PO11	Project Management and Finance			M	H	H	H
PO12	Life Long Learning					M	M
PSO1	Knowledge of Environmental Engineering discipline	M		M			M
PSO2	Critical analysis of environmental problems and innovation		M	H		H	H
PSO3	Conceptualization and evaluation of engineering solutions to Environmental Issues		M	M	M	H	M

EN5010 ENVIRONMENTAL REACTION ENGINEERING L T P C
3 0 0 3

OBJECTIVES:

- Gain an understanding of the fundamentals of chemical reaction engineering with a focus on chemical reaction rates and reaction mechanisms. The course will cover mole balances, rate laws, chemical kinetics, and reactor design. These principles can be applied to any environmental system where chemical transformations must be described.

UNIT I PRINCIPLES OF REACTION ENGINEERING 9

Classification of reactions, reaction rate, variables affecting reaction rate, speed of chemical reactions. Reaction engineering principles of chemical treatment – chemical reactions in major treatment technologies, incineration, selective catalytic reduction. wet- gas scrubbing - H_2S

UNIT II KINETICS OF HOMOGENOUS REACTIONS 9

Simple reactor types, the rate equation, concentration dependent term of rate equation. Molecularity and order of reaction. Rate constant k, representation of an elementary and nonelementary reaction. Kinetic models for nonelementary reactions. Testing kinetic models. temperature dependant term of rate equations from Arrhenius theory and comparison with collision and transition state theory. Activation energy and temperature dependency.

UNIT III REACTOR ANALYSIS 8

Reactor concepts, ideal reactors, reaction rate measurements, sequencing batch reactor, reactors in series and reactors in recycle. non-ideal reactor behaviour, RTD analysis

UNIT IV MASS TRANSFER AND ITS APPLICATIONS 8

Principles of diffusion and mass transfer between phases, gas absorption, humidification operations, leaching and extraction, drying of solids, fixed-bed separation, membrane separation process- adsorption.

UNIT V BIOLOGICAL REACTION ENGINEERING 10

Kinetics of cell growth and enzymes. cell growth kinetics; substrate uptake and product formation in microbial growth; enzyme kinetics, Michaelis-Menten rate form.-biological kinetics, aerobic processes-anaerobic processes - anaerobic digestion, anaerobic filters, Up flow anaerobic sludge blanket reactor. bio concentration, bioaccumulation, biomagnification, bioassay, bio monitoring. bioscrubbers, biotrickling filters and their applications. vermi technology, methane production, root zone treatment, membrane technology.

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1	Successfully apply advanced concepts of reaction engineering to identify, formulate, and solve complex environmental engineering problems
CO2	Understand interaction of pollutants in environment
CO3	Understand reactor behavior and transformation of contaminants
CO4	Conceptualize mass transport phenomina
CO5	Apply reaction engineering concept in biological treatment system

REFERENCES:

1. Weber, W.J and Di Giano, F.A., "Process Dynamics in Environmental systems", John Wiley sons Inc, 1996.
2. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017
3. Dunn I.J, Elmar Heinzle, John Ingham, Prenosil J.E, " Biological reaction engineering", Wiley inter science, 2005.
4. The Engineering of Chemical reactions by Lanny.D.Schmidt,Oxford University Press , 1997.

CO-PO Mapping- ENVIRONMENTAL REACTION ENGINEERING

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	M	M		M	M	M
PO2	Problem analysis	H		H	M	M	H
PO3	Design / development of solutions	H		H	H	H	H
PO4	Investigation	H	M	M	H	H	H
PO5	Modern Tool Usage		M	M		M	M
PO6	Individual and Team work						
PO7	Communication	M	M				M
PO8	Engineer and Society		H			M	H
PO9	Ethics		M		M		M
PO10	Environment and Sustainability		H				H
PO11	Project Management and Finance						
PO12	Life Long Learning	M		M	M		M
PSO1	Knowledge of Environmental Engineering discipline		M				M
PSO2	Critical analysis of environmental problems and innovation	M	M		H	L	M
PSO3	Conceptualization and evaluation of engineering solutions to Environmental Issues	M		M			M

EN5071 MARINE POLLUTION AND CONTROL L T P C
3 0 0 3

OBJECTIVES:

- To impart the knowledge about marine and coastal environment, oceanography, and sources, effects and monitoring of marine pollutants.

UNIT I MARINE AND COASTAL ENVIRONMENT 9

Seas and oceans, continental area, coastal zone, properties of sea water, principles of marine geology, coastal features – beaches, estuaries, lagoons, salt marshes, mangroves and sand dunes–the oceans and climate, coastal zone regulation in india- national and international treaties.

UNIT II OCEAN HYDRODYNAMICS 9

Wave theory, waves in shallow waters – refraction, diffraction and shoaling, approximations for deep and shallow water conditions – tidal classification - general circulation of ocean waters - ocean currents - coastal sediment transport - onshore offshore sediment transport - beach formation and coastal processes - Tsunamis, storm surge, El Nino effect.

UNIT III MARINE POLLUTION 9

Sources of marine pollution – point and non-point sources, pollution caused by effluent discharge, oil exploration, dredging, offshore mining, port and harbour activities, power plants, agriculture runoff, plastic waste, marine debris and marine litter - effects of marine pollution on marine water quality and coastal ecosystems.

UNIT IV MARINE POLLUTION MONITORING 9

Basic measurements - sounding boat, echo sounders – current meters - tide gauge - use of GPS – measurement of coastal water characteristics – sea bed sampling – modelling of pollutant transport and dispersion - oil spill models - ocean monitoring satellites – applications of remote sensing and GIS in monitoring marine pollution – online marine pollution monitoring,

UNIT V MARINE POLLUTION CONTROL MEASURES 9

Marine discharges and effluent standards, pollution control strategies – marine outfall design-selection of optimal marine outfall locations - Total Maximum Daily Load (TMDL) applications – protocols in marine pollution control– Integrated Coastal Zone Management (ICZM) and sustainable development.

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the students are able to

CO1	Know about the different components of marine environment.
CO2	Understand physical concepts lying behind the tides, waves, and oceanic currents and natural processes of various activities happening over the marine environment
CO3	Identify and measure the marine pollution levels and effects
CO4	Apply the knowledge of remote sensing and GIS for monitoring marine environment water quality.,
CO5	Develop marine pollution control measures.

REFERENCES:

1. "Marine Pollution R.B. Clark, C. Frid and M Atttrill, Oxford Science Publications, 5th Edition, 2017.
2. Marine Pollution: New Research - Tobias N. Hofer, Nova Publishers, 2018,
3. Laws, E.A., "Aquatic pollution", an introductory text. John Wiley and Sons, Inc., New York, 2000.
4. Practical Handbook of Estuarine and Marine Pollution, Michael J. Kennish, Volume 10 of CRC Marine Science, CRC Press, 1996.

CO – PO Mapping- MARINE POLLUTION AND CONTROL

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	H		M		H
PO2	Problem analysis			H	M	H	H
PO3	Design / development of solutions					M	M
PO4	Investigation				H	H	H
PO5	Modern Tool Usage				H	M	H
PO6	Individual and Team work			M		M	M
PO7	Communication				M	H	H
PO8	Engineer and Society				H	H	H
PO9	Ethics				M	M	M
PO10	Environment and Sustainability					M	M
PO11	Project Management and Finance				M	M	M
PO12	Life Long Learning	M	M				M
PSO1	Knowledge of Environmental Management discipline					H	H
PSO2	Environmental Performance Evaluation and coordination				H	M	H
PSO3	Conceptualization of Environmental Management Systems		M	M			M

EN5072 MEMBRANE SEPARATION FOR WATER AND WASTEWATER TREATMENT **L T P C 3 0 0 3**

OBJECTIVE

- To introduce the principles and design of different membrane separation technologies including microfiltration, ultrafiltration, nanofiltration, reverse osmosis, electrodialysis and membrane bioreactor processes for water and wastewater treatment.

UNIT I MEMBRANE FILTRATION PROCESSES **10**

Membrane filtration for solid Liquid separation - cross flow filtration - theory of membrane separation – mass transport characteristics - concentration polarisation – membrane flux and trans membrane pressure -types and choice of membranes- porous, nonporous, symmetric and assymmetric – membrane structures and materials - plate and frame, spiral wound and hollow fibre membranes –membrane performance factors and considerations - membrane manufacturing process.

UNIT II MEMBRANE SYSTEMS **10**

Membrane module/element designs – membrane system components – design of membrane systems - design of modules, assembly, plant process control and applications - design and applications of low pressure membrane technology systems-microfiltration and ultrafiltration-design and applications of diffusive membrane technologies- nanofiltration and reverse osmosis - – electro dialysis : Ion exchange membranes, process design- design of membrane systems - pump types and pump selection – plant operations – economics of membrane systems

UNIT III MEMBRANE BIOREACTORS **8**

Historical perspective of MBRs- biotreatment fundamentals- MBR principles and fundamentals-MBR design principles, design assignment, alternative MBR configurations - commercial technologies- fouling and fouling control- case studies

UNIT IV PRETREATMENT AND POST TREATMENT SYSTEMS **8**

Membrane fouling – source water quality characterization- particulate membrane foulants - mineral membrane-scaling foulants - natural organic foulants- microbial foulants- parameters and measurement methods- Langlier index, silt density index -combined impacts of various types of foulants- control of fouling -pretreatment methods and strategies –source water screening and conditioning- pretreatment by sand and membrane filtration- monitoring of pretreatment –chemical cleaning systems- biofoulant control – post treatment systems

UNIT V CASE STUDIES **9**

Case studies on the design of membrane based water and wastewater treatment systems – zero liquid effluent discharge plants – desalination of brackish water and seawater – project implementation and project economics – environmental issues –reject management -energy recovery systems

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1	Explain the various main membrane processes, principles, separation mechanisms, and applications
CO2	Apply the knowledge of science and engineering fundamentals to analyse the mechanisms of membrane filtration
CO3	Design of membrane systems involving microfiltration, ultrafiltration, nanofiltration, reverse osmosis, electrodialysis and membrane bioreactor processes
CO4	Select appropriate membrane technologies for water and wastewater treatment taking into account the impact of the solutions in a sustainability context
CO5	Conduct research pertinent to membrane technology applications to water and wastewater treatment and communicate effectively to different stakeholders as well as engage in independent life-long learning

REFERENCES:

1. Mihir K. Purkait, Randeep Singh, Membrane Technology in Separation Science, CRC Press, 2018
2. Anthony Wachinski, Membrane Processes for water reuse, McGraw-Hill, Newyork, 2013
3. Nikolay Voutchkov, Desalination Engineering-Planning and Design, McGraw-Hill, Newyork, 2013
4. Symon Jud, MBR Book – "Principles and application of MBR in water and wastewater treatment", Elservier, 2010.
5. A.F. Ismail, Takeshi Matsuura, Membrane Technology for Water and Wastewater Treatment, Energy and Environment, CRC Press, 2016
6. Kaustubha Mohanty, Mihir K. Purkait, Membrane Technologies and Applications, CRC Press, 2011
7. Baker, R.W., "Membrane technology and applications", 2nd ., John Wiley 2012
8. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse fourth Edition, McGraw-Hill, 2017

CO – PO Mapping - MEMBRANE SEPARATION FOR WATER AND WASTEWATER TREATMENT

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences		H				H
PO2	Problem analysis	H	M		M	M	M
PO3	Design / development of solutions			H			H
PO4	Investigation		L			L	L
PO5	Modern Tool Usage		M		M		M
PO6	Individual and Team work		M	M			M
PO7	Communication					L	L
PO8	Engineer and Society	M			M		M
PO9	Ethics				M		M
PO10	Environment and Sustainability	M			M		M
PO11	Project Management and Finance				M		M
PO12	Life Long Learning					L	L
PSO1	Knowledge of Environmental Engineering discipline	H	M	H	H		H
PSO2	Critical analysis of Environmental problems and innovation	M	M	M	M	M	M
PSO3	Conceptualization and evaluation of engineering solutions to Environmental Issues			H	H		H

EM5071 CLIMATE CHANGE AND MODELLING L T P C
3 0 0 3

OBJECTIVES:

- To introduce the emerging concepts of climate modelling and projecting future climate change, understand data analysis and application.

UNIT I CLIMATE CHANGE AND CLIMATE VARIABILITY 9

Introduction- atmosphere - weather and climate - climate parameters (Temperature, Rainfall, Humidity, Wind etc.,) Equations governing the atmosphere - numerical weather prediction models - introduction to GCMs - applications in climate change projections

UNIT II IPCC CLIMATE SCENARIOS 9

Intergovernmental PANEL on Climate Change (IPCC) - an overview - key assumptions – Representative Concentration Pathways (RCP 2.6, 4.5, 6.0, 8.5)

UNIT III GLOBAL CLIMATE MODEL AND REGIONAL CLIMATE MODEL 9

Climate model – types of model- General Circulation Models (GCM) - Issues with GCMs - Introduction to RCMs and LAMs - RCMs modellers -advantages and disadvantages of GCMs and RCMs

UNIT IV DOWNSCALING GLOBAL CLIMATE MODEL - AN OVERVIEW 9

Need for downscaling - selection of GCMs for regional climate change studies - ensemble theory selection of ensembles, model domain (Spatial domain and temporal domain), Resolution and climate variables - lateral boundary conditions - methods of downscaling (Statistical and Dynamical) - examples from each and their limitations.

UNIT V ANALYSIS AND POST PROCESSING 9

Model validation and calibration- evaluating model performance- post processing - introduction to analysis tools - Ferret, R, Grads, IDL, SPSS, ArcGIS - climate change impact - vulnerability assessment-case studies-Adaptation strategies

TOTAL: 45 PERIODS

OUTCOMES

- On completion of the course, the student is expected to be able to

CO1: Understand the basics of climate change and variability
CO2: Comprehend the latest IPCC climate scenarios
CO3: Gain in-depth knowledge on climate models
CO4: Downscale of climate scenarios through different modelling techniques, and validate climate models
CO5: Post process the model outputs for climate impact assessment, know about adaptation strategies

REFERENCES:

1. IPCC Fifth Assessment Report, Cambridge University Press, Cambridge, UK, 2013
2. Neelin David J, “Climate Change and Climate Modelling”, Cambridge University Press 2011
3. Kendal McGuffie, Ann Henderson, “A Climate Modelling” Primer 3rd Edition, John Wiley & Sons, Ltd, Chichester, UK 2005
4. Thomas Stocker, “Introduction to Climate Modelling”, Advances in Geophysical and Environmental Mechanics and Mathematics. Springer Publication, 2011
5. David Archer, ‘Global warming-Understanding the forecast’, Blackwell publishing, 2007

CO – PO Mapping- CLIMATE CHANGE AND MODELLING

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences			M	M		M
PO2	Problem analysis	H		H		H	H
PO3	Design / development of solutions				M		M
PO4	Investigation			M	M		M
PO5	Modern Tool Usage			H	H	H	H
PO6	Individual and Team work				H	H	H
PO7	Communication	L				M	L
PO8	Engineer and Society		M			M	M
PO9	Ethics						
PO10	Environment and Sustainability		H				H
PO11	Project Management and Finance					H	H
PO12	Life Long Learning	M		H		M	M

PSO1	Knowledge of Environmental Engineering discipline		M				M
PSO2	Environmental Performance Evaluation and coordination					M	M
PSO3	Conceptualization of Environmental Engineering Systems		H			H	H

EM5072 OPERATION AND MAINTENANCE OF WATER AND WASTEWATER TREATMENT SYSTEMS **L T P C 3 0 0 3**

OBJECTIVE:

- To educate the student on the various operation & maintenance aspects of water treatment systems, sewer systems, sewage treatment plants and effluent treatment plants.

UNIT I ELEMENTS OF OPERATION AND MAINTENANCE 9

Strategy for good operation and maintenance- preventive and corrective maintenance scheduling - operation and maintenance Plan - proper and adequate tools, spare units and parts - training requirements- laboratory control- records and reports- housekeeping –sampling procedure- analytical techniques- code of practice for analytical laboratories- measurement of flows, pressures and Levels -safety in O&M operations - management information system - measures for conservation of energy

UNIT II OPERATION AND MAINTENANCE OF WATER SUPPLY SYSTEMS 9

Operational problems, O&M practices and records of operation of reservoir and intakes - causes of failure of wells- rehabilitation of tube wells & bore wells- prevention of incrustation and corrosion - problems in transmission mains- maintenance of pipelines and leakage control- repair method for different types of pipes- preventive and corrective maintenance of water pumps - problems in the water distribution system and remedies- water quality monitoring and surveillance

UNIT III OPERATION AND MAINTENANCE OF SEWERAGE SYSTEMS 9

Components and functions of sewerage system – maintenance of collection system – operational problems– clogging of pipes – hazards – precautions against gas hazards – precautions against infections – devices for cleaning the conduits – preventive and corrective maintenance of sewage pumps –operation and maintenance of sewage pumping stations- maintenance hazards and operator protection –SOP-case studies

UNIT IV OPERATION AND MAINTENANCE OF PHYSICO-CHEMICAL TREATMENT UNITS 9

Operation and maintenance in screen chamber, grit chamber and clarifiers- operation issues, trouble shooting guidelines and record keeping requirements for clarifier, equalization basins, neutralization unit - chemical storage and mixing equipment - chemical metering equipment - flash mixer –filters, thickeners and centrifuges- filter press - start-up and maintenance inspection - motors and pumps - hazards in chemical handling – jar test - chlorination equipment - membrane process systems- SDI and LSI determination- process chemistry and chemical dosage calculations- SOP-case studies

UNIT V OPERATION AND MAINTENANCE OF BIOLOGICAL TREATMENT UNITS 9

Construction, operation and maintenance aspects of activated sludge process, trickling filters, anaerobic digester, SBR, UASBR, MBRs- startup and shutdown procedures-DO, MLSS and SVI monitoring- trouble shooting guidelines –planning, organizing and controlling of plant operations – capacity building, case studies of retrofitting- SOP-case studies

TOTAL: 45 PERIODS

OUTCOMES:

On completion of the course, the student is expected to be able to

CO1	Understand the O&M issues pertaining to STP and WTP
CO2	Understand operation and maintenance of water intakes and supply systems
CO3	Recognize the O&M issues relevant to sewerage system
CO4	Understand operation and maintenance of physico-chemical treatment units
CO5	Understand operation and maintenance of biological treatment units

REFERENCES:

1. CPHEEO , Manual on operation and maintenance of water supply systems, Central Public Health and Environmental Engineering Organisation, Ministry of Urban Development, Government of India 2013
2. Ministry of Drinking Water and Sanitation, operation and maintenance manual for rural water supplies, Government of India, 2013
3. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017
4. Ananth S Kodavasal, The STP Guide-Design, Operation and maintenance, Karnataka State Pollution Control Board, Bangalore,2011
5. Frik Schutte, handbook for the operation of water Treatment Works,The Water Research Commission, The Water Institute of Southern Africa, TT265/06, 2006.
6. Michael D. Nelson, Chair, Operation of municipal waste water treatment plants, Water environment federation, vol.2 liquid process, 2007.
7. Michael D. Nelson, Chair, Operation of municipal waste water treatment plants, Water environment federation,vol.1 Management and support systems, sixth edition, 2007.

CO – PO Mapping- OPERATION AND MAINTENANCE OF WATER AND WASTEWATER TREATMENT SYSTEMS

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	M	M	M	H	
PO2	Problem analysis	M		H		M	
PO3	Design / development of solutions	M	H	H	H	H	
PO4	Investigation	H	H	H	M	M	
PO5	Modern Tool Usage	M			M	L	
PO6	Individual and Team work	M		M		L	
PO7	Communication	M	M		M		
PO8	Engineer and Society			M		M	
PO9	Ethics		M		M		
PO10	Environment and Sustainability	M		M			
PO11	Project Management and Finance		M				
PO12	Life Long Learning	M		M		M	
PSO1	Knowledge of Environmental Management discipline	M			M		
PSO2	Environmental Performance Evaluation and coordination		M		M	M	
PSO3	Conceptualization of Environmental Management Systems	M		M			

EM5073 PROJECT FORMULATION AND IMPLEMENTATION L T P C
3 0 0 3

OBJECTIVES:

- To examine the techniques and procedures relevant for project planning and implementation in developing countries, especially infrastructure projects pertaining to environmental sector
- To enable the students to understand about project identification, feasibility analysis, design, financing, implementation, monitoring and evaluation

UNIT I INTRODUCTION TO PROJECT FORMULATION 9

Overview of the project cycle – planning process and project planning – search for project ideas – strategies in capital allocation – key elements in project formulation – methods and tools for project formulation – project identification and selection – preparation of feasibility reports as per government policies (AMRUT / JnNURM)

UNIT II PROJECT ANALYSIS 8

Capital cost estimation – market demand analysis – technical analysis – environmental analysis – financial and economic analysis – cash flow generation

UNIT III PROJECT APPRAISAL 10

Time and value of money – investment criteria – internal rate of return – net present value, cost benefit analysis, and social cost benefit analysis – project risk analysis – appraisal of marketing strategy – pricing and credit worthiness and management capabilities

UNIT IV PROJECT FINACING AND IMPLEMENTATION 10

Funding options for urban and rural development projects – tender procedure – transparency in government tender rules – organizational aspects in project management – network techniques for project management – resource management - risk management

UNIT V PROJECT MONITORING AND EVALUATION 8

Need and techniques for monitoring – service Level benchmark performance and process monitoring – monitoring Schedules – Penalty and Bonus points

TOTAL: 45 PERIODS

OUTCOMES:

On completion of the course, the student is expected to be able to

CO1	Understand the project cycle, key elements in project formulation, methods and tools for project formulation
CO2	Understand capital cost estimation, market and demand analysis, technical, environmental, financial and economic analysis
CO3	Understand time and value of money, investment criteria, internal rate of return, cost benefit analysis, project risk analysis and appraisal of marketing strategy
CO4	Have knowledge on funding options for urban and rural development projects, tender procedure, transparency, resource management & risk management
CO5	Understand need and techniques for monitoring project performance

REFERENCES:

1. Clifford F Gray, Erik W Larson , “Project Management-The Managerial Process” Tata Mcgraw-Hill Publishing Co Ltd
2. Jack Meredith, Samuel J. Mantel Jr. “Project Management- A Managerial Approach” John Wiley and Sons
3. John M Nicholas “Project Management for Business and Technology” Prentice Hall Of India Pvt Ltd
4. James P Lewis “ Project Planning ,Scheduling And Control” Tata McGraw-Hill.
5. Detailed Project Report: Preparation Toolkit (Sub-mission for Urban Infrastructure and Governance), Government of India
6. www.india.gov.in national portal for India

CO – PO Mapping- PROJECT FORMULATION AND IMPLEMENTATION

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences	H	H	H	H	H	
PO2	Problem analysis		H	M	M	M	
PO3	Design / development of solutions						
PO4	Investigation		M	M	M	M	
PO5	Modern Tool Usage						
PO6	Individual and Team work		M		M	M	
PO7	Communication						
PO8	Engineer and Society			H	H	H	
PO9	Ethics		L	L	L	L	
PO10	Environment and Sustainability		M	M	M	M	
PO11	Project Management and Finance			L		L	
PO12	Life Long Learning	L					
PSO1	Knowledge of Environmental Management discipline	H	M	M	M	H	
PSO2	Environmental Performance Evaluation and coordination			M	M	M	
PSO3	Conceptualization of Environmental Management Systems		H	M	M	M	

EM5251 ENVIRONMENTAL IMPACT ASSESSMENT L T P C
3 0 0 3

OBJECTIVES:

- To make the students to understand environmental clearance, its legal requirements and to provide knowledge on overall methodology of EIA, prediction tools and models, environmental management plan and case studies.

UNIT I INTRODUCTION 9

Historical development of Environmental Impact Assessment (EIA). Environmental Clearance- EIA in project cycle. legal and regulatory aspects in India – types and limitations of EIA –EIA process-screening – scoping - terms of reference in EIA- setting – analysis – mitigation. Cross sectoral issues –public hearing in EIA- EIA consultant accreditation.

UNIT II IMPACT INDENTIFICATION AND PREDICTION 10

Matrices – networks – checklists – cost benefit analysis – analysis of alternatives – expert systems in EIA. prediction tools for EIA – mathematical modeling for impact prediction – assessment of impacts – air – water – soil – noise – biological — cumulative impact assessment

UNIT III SOCIO-ECONOMIC IMPACT ASSESSMENT 8

Socio-economic impact assessment - relationship between social impacts and change in community and institutional arrangements. factors and methodologies- individual and family level impacts. communities in transition-rehabilitation

UNIT IV EIA DOCUMENTATION AND ENVIRONMENTAL MANAGEMENT PLAN 9

Environmental management plan - preparation, implementation and review – mitigation and rehabilitation plans – policy and guidelines for planning and monitoring programmes – post project audit – documentation of EIA findings – ethical and quality aspects of environmental impact assessment

UNIT V CASE STUDIES **9**

Mining, power plants, cement plants, highways, petroleum refining industry, storage & handling of hazardous chemicals, common hazardous waste facilities, CETPs, CMSWMF, building and construction projects

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1	Understand need for environmental clearance, its legal procedure, need of EIA, its types, stakeholders and their roles
CO2	Understand various impact identification methodologies, prediction techniques and model of impacts on various environments
CO3	Understand relationship between social impacts and change in community due to development activities and rehabilitation methods
CO4	Document the EIA findings and prepare environmental management and monitoring plan
CO5	Identify, predict and assess impacts of similar projects based on case studies

REFERENCES:

1. EIA Notification 2006 including recent amendments, by Ministry of Environment, Forest and Climate Change, Government of India
2. Sectoral Guidelines under EIA Notification by Ministry of Environment, Forest and Climate Change, Government of India
3. Canter, L.W., Environmental Impact Assessment, McGraw Hill, New York. 1996
4. Lawrence, D.P., Environmental Impact Assessment – Practical solutions to recurrent problems, Wiley-Interscience, New Jersey. 2003
5. Lee N. and George C. 2000. Environmental Assessment in Developing and Transitional Countries. Chichester: Willey
6. World Bank –Source book on EIA ,1999
7. Sam Mannan, Lees' Loss Prevention in the Process Industries, Hazard Identification Assessment and Control, 4th Edition, Butterworth Heineman, 2012.

CO – PO Mapping- ENVIRONMENTAL IMPACT ASSESSMENT

PO/PSO		Course Outcome					Overall Correlation of COs to Pos
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences		H			H	H
PO2	Problem analysis		M	M			M
PO3	Design / development of solutions		H	H	H		H
PO4	Investigation		M	M		M	M
PO5	Modern Tool Usage		M	M	H		M
PO6	Individual and Team work		M	M	M		M
PO7	Communication				L		L
PO8	Engineer and Society	M			M		M
PO9	Ethics	H	H	H	M	M	H
PO10	Environment and Sustainability	H			M		M
PO11	Project Management and Finance				L		L
PO12	Life Long Learning		L	L			L
PSO1	Knowledge of Environmental Engineering discipline	M					M
PSO2	Environmental Performance Evaluation and coordination		M	M	M		M
PSO3	Conceptualization of Environmental Engineering Systems		M		M		M

EM5252 SOLID AND HAZARDOUS WASTE MANAGEMENT L T P C
3 0 0 3

OBJECTIVE

- To impart knowledge and skills relevant to minimization, storage, collection, transport, recycling, processing and disposal of solid and hazardous wastes including the related regulations, engineering principles, design criteria, methods and equipment.

UNIT I WASTE CLASSIFICATION AND REGULATORY REQUIREMENTS 9

Sources and types of solid and hazardous wastes - need for solid and hazardous waste management – salient features of latest Indian legislations on management and handling of solid wastes, hazardous wastes, biomedical wastes, electronic wastes, construction and demolition wastes, plastics and discarded lead acid batteries – elements of integrated waste management and roles of stakeholders - seven elements and seven step approach to integrated solid waste management planning.

UNIT II WASTE CHARACTERIZATION, SOURCE REDUCTION AND RECYCLING 9

Waste sampling and characterization plan - waste generation rates and variation – physical composition, chemical and biological properties – hazardous characteristics – ignitability, corrosivity and TCLP tests –source reduction, segregation and onsite storage of wastes – waste exchange - extended producer responsibility - recycling of plastics, C&D wastes and E wastes.

UNIT III WASTE COLLECTION, TRANSPORT AND MATERIAL RECOVERY 9

Door to door collection of segregated solid wastes - analysis of hauled container and stationery container collection systems - compatibility, storage, labeling and handling of hazardous wastes –- principles and design of transfer and transport facilities - hazardous waste transport and manifests - mechanical processing and material separation technologies – Size reduction – size separation - density separation - magenetic separation – compaction – principles and design of material recovery facilities – physico chemical treatment of hazardous wastes - solidification and stabilization – case studies on waste collection and material recovery

UNIT IV BIOLOGICAL AND THERMAL PROCESSING OF WASTES 9

Biological and thermo chemical conversion technologies – composting – biomethanation – incineration – pyrolysis- plasma arc gasification –principles and design of biological and thermal treatment facilities - MSW processes to energy with high-value products and specialty BY-Products - operation of facilities and environmental controls - treatment of biomedical wastes – case studies and emerging waste processing technologies.

UNIT V WASTE DISPOSAL 9

Sanitary and secure landfills - components and configuration– site selection - liner and cover systems - geo synthetic clay liners and geo membranes - design of sanitary landfills and secure landfills- leachate collection, treatment and landfill gas management – landfill construction and operational controls - landfill closure and environmental monitoring – landfill bioreactors – rehabilitation of open dumps and biomining of dumpsites-remediation of contaminated sites- Case studies

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1	Explain the various functional elements of solid and hazardous waste management including the associated legal, health, safety, and cultural issues as well as responsibilities of different stakeholders
CO2	Apply the knowledge of science and engineering fundamentals to characterize different types of solid and hazardous wastes, assess the factors affecting variation and assess performance of waste treatment and disposal systems

CO3	Design of systems and processes to meet specified needs of waste minimization, storage, collection, transport, recycling, processing and disposal.
CO4	Select appropriate methods for processing and disposal of solid and hazardous wastes, taking into account the impact of the solutions in a sustainability context
CO5	Conduct research pertinent to solid and hazardous waste management and communicate effectively to different stakeholders as well as engage in independent life-long learning

REFERENCES:

1. George Tchobanoglous, Hilary Theisen and Samuel A, Vigil, "Integrated Solid Waste Management, Mc-Graw Hill India, First edition, 2015.
2. CPHEEO, "Manual on Municipal Solid waste management,Vol I, II and III, Central Public Health and Environmental Engineering Organisation , Government of India, New Delhi, 2016.
3. William A. Worrell, P. Aarne Vesilind, Christian Ludwig, Solid Waste Engineering - A Global Perspective, 3rd Edition, Cengage Learning, 2017.
4. Michael D. LaGrega, Philip L Buckingham, Jeffrey C. E vans and "Environmental Resources Management, Hazardous waste Management", Mc-Graw Hill International edition, New York,2010.
5. John Pitchtel,Waste Management Practices, CRC Press,Taylor and Francis Group,2014.
6. Gary C. Young, Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons, Wiley, 2010
7. Cherry P M, Solid and Hazardous Waste Management, CBS publishers and distributors Pvt Ltd, 2018
8. Rao M.N, Razia Sultana, Sri Harsha Kota, solid and hazardous waste management – Science and Engineering , Butterworth-Heinemann, 2016

CO – PO Mapping –Solid and Hazardous Waste Management

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PO1	Knowledge of Engineering Sciences		H				H
PO2	Problem analysis	H	M		M	M	M
PO3	Design / development of solutions			H			H
PO4	Investigation		M			M	M
PO5	Modern Tool Usage		M		M		M
PO6	Individual and Team work		M	M			M
PO7	Communication					L	L
PO8	Engineer and Society	M			M		M
PO9	Ethics				M		M
PO10	Environment and Sustainability	M			M		M
PO11	Project Management and Finance				M		M
PO12	Life Long Learning					L	L
PSO1	Knowledge of Environmental Management discipline	H	M	H	H		H
PSO2	Environmental Performance Evaluation and coordination	M	M	M	M	M	M
PSO3	Conceptualization of Environmental Management Systems			H	H		H

OPEN ELECTIVE COURSES (OEC)

OE5091 BUSINESS DATA ANALYTICS L T P C
3 0 0 3

OBJECTIVES:

- To understand the basics of business analytics and its life cycle.
- To gain knowledge about fundamental business analytics.
- To learn modeling for uncertainty and statistical inference.
- To understand analytics using Hadoop and Map Reduce frameworks.
- To acquire insight on other analytical frameworks.

UNIT I OVERVIEW OF BUSINESS ANALYTICS 9

Introduction – Drivers for Business Analytics – Applications of Business Analytics: Marketing and Sales, Human Resource, Healthcare, Product Design, Service Design, Customer Service and Support – Skills Required for a Business Analyst – Framework for Business Analytics Life Cycle for Business Analytics Process.

Suggested Activities:

- Case studies on applications involving business analytics.
- Converting real time decision making problems into hypothesis.
- Group discussion on entrepreneurial opportunities in Business Analytics.

Suggested Evaluation Methods:

- Assignment on business scenario and business analytical life cycle process.
- Group presentation on big data applications with societal need.
- Quiz on case studies.

UNIT II ESSENTIALS OF BUSINESS ANALYTICS 9

Descriptive Statistics – Using Data – Types of Data – Data Distribution Metrics: Frequency, Mean, Median, Mode, Range, Variance, Standard Deviation, Percentile, Quartile, z-Score, Covariance, Correlation – Data Visualization: Tables, Charts, Line Charts, Bar and Column Chart, Bubble Chart, Heat Map – Data Dashboards.

Suggested Activities:

- Solve numerical problems on basic statistics.
- Explore chart wizard in MS Excel Case using sample real time data for data visualization.
- Use R tool for data visualization.

Suggested Evaluation Methods:

- Assignment on descriptive analytics using benchmark data.
- Quiz on data visualization for univariate, bivariate data.

UNIT III MODELING UNCERTAINTY AND STATISTICAL INFERENCE 9

Modeling Uncertainty: Events and Probabilities – Conditional Probability – Random Variables – Discrete Probability Distributions – Continuous Probability Distribution – Statistical Inference: Data Sampling – Selecting a Sample – Point Estimation – Sampling Distributions – Interval Estimation – Hypothesis Testing.

Suggested Activities:

- Solving numerical problems in sampling, probability, probability distributions and hypothesis testing.
- Converting real time decision making problems into hypothesis.

Suggested Evaluation Methods:

- Assignments on hypothesis testing.
- Group presentation on real time applications involving data sampling and hypothesis testing.
- Quizzes on topics like sampling and probability.

UNIT IV ANALYTICS USING HADOOP AND MAPREDUCE FRAMEWORK 9

Introducing Hadoop – RDBMS versus Hadoop – Hadoop Overview – HDFS (Hadoop Distributed File System) – Processing Data with Hadoop – Introduction to MapReduce – Features of MapReduce – Algorithms Using Map-Reduce: Matrix-Vector Multiplication, Relational Algebra Operations, Grouping and Aggregation – Extensions to MapReduce.

Suggested Activities:

- Practical – Install and configure Hadoop.
- Practical – Use web based tools to monitor Hadoop setup.
- Practical – Design and develop MapReduce tasks for word count, searching involving text corpus etc.

Suggested Evaluation Methods:

- Evaluation of the practical implementations.
- Quizzes on topics like HDFS and extensions to MapReduce.

UNIT V OTHER DATA ANALYTICAL FRAMEWORKS 9

Overview of Application development Languages for Hadoop – PigLatin – Hive – Hive Query Language (HQL) – Introduction to Pentaho, JAQL – Introduction to Apache: Sqoop, Drill and Spark, Cloudera Impala – Introduction to NoSQL Databases – Hbase and MongoDB.

Suggested Activities:

- Practical – Installation of NoSQL database like MongoDB.
- Practical – Demonstration on Sharding in MongoDB.
- Practical – Install and run Pig
- Practical – Write PigLatin scripts to sort, group, join, project, and filter data.
- Design and develop algorithms to be executed in MapReduce involving numerical methods for analytics.

Suggested Evaluation Methods:

- Mini Project (Group) – Real time data collection, saving in NoSQL, implement analytical techniques using Map-Reduce Tasks and Result Projection.

TOTAL: 45 PERIODS

OUTCOMES:

On completion of the course, the student will be able to:

- Identify the real world business problems and model with analytical solutions.
- Solve analytical problem with relevant mathematics background knowledge.
- Convert any real world decision making problem to hypothesis and apply suitable statistical testing.
- Write and Demonstrate simple applications involving analytics using Hadoop and MapReduce
- Use open source frameworks for modeling and storing data.
- Apply suitable visualization technique using R for visualizing voluminous data.

REFERENCES:

1. Vignesh Prajapati, “Big Data Analytics with R and Hadoop”, Packt Publishing, 2013.
2. Umesh R Hodeghatta, Umesha Nayak, “Business Analytics Using R – A Practical Approach”, Apress, 2017.
3. Anand Rajaraman, Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press, 2012.
4. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson, “Essentials of Business Analytics”, Cengage Learning, second Edition, 2016.
5. U. Dinesh Kumar, “Business Analytics: The Science of Data-Driven Decision Making”, Wiley, 2017.

6. A. Ohri, “R for Business Analytics”, Springer, 2012
7. Rui Miguel Forte, “Mastering Predictive Analytics with R”, Packt Publication, 2015.

Business Data Analytics

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	2	3	1
CO2	2	1	1	2	1	1
CO3	1	1	2	3	3	1
CO4	2	2	1	2	1	1
CO5	1	1	2	2	1	1
CO6	1	1	1	3	2	1

OE5092 INDUSTRIAL SAFETY LT P C
3 0 0 3

OBJECTIVES:

- Summarize basics of industrial safety
- Describe fundamentals of maintenance engineering
- Explain wear and corrosion
- Illustrate fault tracing
- Identify preventive and periodic maintenance

UNIT I INTRODUCTION 9

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

UNIT II FUNDAMENTALS OF MAINTENANCE ENGINEERING 9

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT III WEAR AND CORROSION AND THEIR PREVENTION 9

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT IV FAULT TRACING 9

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment’s like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

UNIT V PERIODIC AND PREVENTIVE MAINTENANCE 9

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

TOTAL: 45 PERIODS

OUTCOMES:

CO1: Ability to summarize basics of industrial safety
CO2: Ability to describe fundamentals of maintenance engineering
CO3: Ability to explain wear and corrosion
CO4: Ability to illustrate fault tracing
CO5: Ability to identify preventive and periodic maintenance

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Audels, Pump-hydraulic Compressors, Mcgrew Hill Publication, 1978.
2. Garg H P,Maintenance Engineering, S. Chand and Company,1987.
3. Hans F. Winterkorn ,Foundation Engineering Handbook, Chapman & Hall London,2013.
4. Higgins & Morrow , Maintenance Engineering Handbook,Eighth Edition,2008

OE5093 OPERATIONS RESEARCH L T P C
3 0 0 3

OBJECTIVES:

- Solve linear programming problem and solve using graphical method.
- Solve LPP using simplex method
- Solve transportation , assignment problems
- Solve project management problems
- Solve scheduling problems

UNIT I LINEAR PROGRAMMING 9

Introduction to Operations Research – assumptions of linear programming problems - Formulations of linear programming problem – Graphical method

UNIT II ADVANCES IN LINEAR PROGRAMMING 9

Solutions to LPP using simplex algorithm- Revised simplex method - primal dual relationships – Dual simplex algorithm - Sensitivity analysis

UNIT III NETWORK ANALYSIS – I 9

Transportation problems -Northwest corner rule, least cost method, Voges's approximation method - Assignment problem -Hungarian algorithm

UNIT IV NETWORK ANALYSIS – II 9

Shortest path problem: Dijkstra's algorithms, Floyds algorithm, systematic method -CPM/PERT

UNIT V NETWORK ANALYSIS – III 9

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models

TOTAL: 45 PERIODS

OUTCOMES:

CO1: To formulate linear programming problem and solve using graphical method.
CO2: To solve LPP using simplex method
CO3: To formulate and solve transportation, assignment problems
CO4: To solve project management problems
CO5: To solve scheduling problems

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010
2. Hitler Libermann, Operations Research: McGraw Hill Pub. 2009
3. Pant J C, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Pannerselvam, Operations Research: Prentice Hall of India 2010
5. Taha H A, Operations Research, An Introduction, PHI, 2008

OE5094 COST MANAGEMENT OF ENGINEERING PROJECTS L T P C
3 0 0 3

OBJECTIVES:

- Summarize the costing concepts and their role in decision making
- Infer the project management concepts and their various aspects in selection
- Interpret costing concepts with project execution
- Develop knowledge of costing techniques in service sector and various budgetary control techniques
- Illustrate with quantitative techniques in cost management

UNIT I INTRODUCTION TO COSTING *CONCEPTS* 9

Objectives of a Costing System; Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Creation of a Database for operational control.

UNIT II INTRODUCTION TO PROJECT MANAGEMENT 9

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities, Detailed Engineering activities, Pre project execution main clearances and documents, Project team: Role of each member,Importance Project site: Data required with significance, Project contracts.

UNIT III PROJECT EXECUTION AND COSTING CONCEPTS 9

Project execution Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis, Various decision-making problems, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing.

UNIT IV COSTING OF SERVICE SECTOR AND BUDGETERY CONTROL 9

Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis, Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets.

UNIT V QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT 9

Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory.

TOTAL: 45 PERIODS

OUTCOMES

CO1 – Understand the costing concepts and their role in decision making
CO2– Understand the project management concepts and their various aspects in selection

CO3– Interpret costing concepts with project execution
CO4– Gain knowledge of costing techniques in service sector and various budgetary control techniques
CO5 - Become familiar with quantitative techniques in cost management

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓		✓			✓	✓		✓	✓
CO2	✓	✓	✓		✓				✓		✓	✓
CO3	✓	✓	✓		✓	✓					✓	✓
CO4	✓	✓	✓		✓		✓				✓	✓
CO5	✓	✓	✓		✓	✓	✓				✓	✓

REFERENCES:

1. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher, 1991
2. Charles T. Horngren and George Foster, Advanced Management Accounting, 1988
3. Charles T. Horngren et al Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi, 2011
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting, 2003
5. Vohra N.D., Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd, 2007

OE5095 COMPOSITE MATERIALS L T P C
3 0 0 3

OBJECTIVES:

- Summarize the characteristics of composite materials and effect of reinforcement in composite materials.
- Identify the various reinforcements used in composite materials.
- Compare the manufacturing process of metal matrix composites.
- Understand the manufacturing processes of polymer matrix composites.
- Analyze the strength of composite materials.

UNIT I INTRODUCTION 9

Definition – Classification and characteristics of Composite materials - Advantages and application of composites - Functional requirements of reinforcement and matrix - Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT II REINFORCEMENTS 9

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers - Properties and applications of whiskers, particle reinforcements - Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures - Isostrain and Isostress conditions.

UNIT III MANUFACTURING OF METAL MATRIX COMPOSITES 9

Casting – Solid State diffusion technique - Cladding – Hot isostatic pressing - Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving - Properties and applications.

UNIT IV MANUFACTURING OF POLYMER MATRIX COMPOSITES 9

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding - Properties and applications.

UNIT V STRENGTH 9

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TOTAL: 45 PERIODS

OUTCOMES:

- CO1 - Know the characteristics of composite materials and effect of reinforcement in composite materials.
- CO2 – Know the various reinforcements used in composite materials.
- CO3 – Understand the manufacturing processes of metal matrix composites.
- CO4 – Understand the manufacturing processes of polymer matrix composites.
- CO5 – Analyze the strength of composite materials.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		✓	✓	✓								
CO2		✓	✓	✓	✓						✓	
CO3			✓	✓	✓		✓				✓	
CO4			✓	✓	✓		✓				✓	
CO5				✓	✓		✓					

REFERENCES:

1. Cahn R.W. - Material Science and Technology – Vol 13 – Composites, VCH, West Germany.
2. Callister, W.D Jr., Adapted by Balasubramaniam R, Materials Science and Engineering, An introduction, John Wiley & Sons, NY, Indian edition, 2007.
3. Chawla K.K., Composite Materials, 2013.
4. Lubin.G, Hand Book of Composite Materials, 2013.

OE5096 WASTE TO ENERGY L T P C
3 0 0 3

OBJECTIVES:

- Interpret the various types of wastes from which energy can be generated
- Develop knowledge on biomass pyrolysis process and its applications
- Develop knowledge on various types of biomass gasifiers and their operations
- Invent knowledge on biomass combustors and its applications on generating energy
- Summarize the principles of bio-energy systems and their features

UNITI INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE 9

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

UNITII BIOMASS PYROLYSIS 9

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT III BIOMASS GASIFICATION 9

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNIT IV BIOMASS COMBUSTION 9

Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNITV BIO ENERGY 9

Properties of biogas (Calorific value and composition), Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production -Urban waste to energy conversion - Biomass energy programme in India.

TOTAL: 45 PERIODS

OUTCOMES:

CO1 – Understand the various types of wastes from which energy can be generated
CO2 – Gain knowledge on biomass pyrolysis process and its applications
CO3 – Develop knowledge on various types of biomass gasifiers and their operations
CO4 – Gain knowledge on biomass combustors and its applications on generating energy
CO5 – Understand the principles of bio-energy systems and their features

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓		✓									✓
CO2	✓		✓									✓
CO3	✓	✓	✓		✓							✓
CO4	✓	✓	✓		✓		✓					✓
CO5	✓	✓	✓		✓							✓

REFERENCES:

1. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
2. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.

AUDIT COURSES (AC)

AX5091 ENGLISH FOR RESEARCH PAPER WRITING L T P C
2 0 0 0

OBJECTIVES

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

UNIT I INTRODUCTION TO RESEARCH PAPER WRITING 6

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

UNIT II PRESENTATION SKILLS 6

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

UNIT III TITLE WRITING SKILLS 6

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

UNIT IV RESULT WRITING SKILLS 6

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT V VERIFICATION SKILLS 6

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first- time submission

TOTAL: 30 PERIODS

OUTCOMES

CO1 –Understand that how to improve your writing skills and level of readability
CO2 – Learn about what to write in each section
CO3 – Understand the skills needed when writing a Title
CO4 – Understand the skills needed when writing the Conclusion
CO5 – Ensure the good quality of paper at very first-time submission

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3										✓		✓
CO4										✓		✓
CO5										✓		✓

REFERENCES

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

AX5092 **DISASTER MANAGEMENT** **L T P C**
2 0 0 0

OBJECTIVES

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION 6

Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS 6

Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

UNIT III DISASTER PRONE AREAS IN INDIA 6

Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT 6

Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V RISK ASSESSMENT 6

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival

TOTAL : 30 PERIODS

OUTCOMES

CO1: Ability to summarize basics of disaster
CO2: Ability to explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
CO3: Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
CO4: Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
CO5: Ability to develop the strengths and weaknesses of disaster management approaches

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES

1. Goel S. L., “Disaster Administration And Management Text And Case Studies”, Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. NishithaRai, Singh AK, “Disaster Management in India: Perspectives, issues and strategies” NewRoyal book Company,2007.
3. Sahni, PardeepEt.Al. ,”Disaster Mitigation Experiences And Reflections”, Prentice Hall OfIndia, New Delhi,2001.

AX5093 SANSKRIT FOR TECHNICAL KNOWLEDGE L T P C
2 0 0 0

OBJECTIVES

- Illustrate the basic sanskrit language.
- Recognize sanskrit, the scientific language in the world.
- Appraise learning of sanskrit to improve brain functioning.
- Relate sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power.
- Extract huge knowledge from ancient literature.

UNIT I ALPHABETS 6

Alphabets in Sanskrit

UNIT II TENSES AND SENTENCES 6

Past/Present/Future Tense - Simple Sentences

UNIT III ORDER AND ROOTS 6

Order - Introduction of roots

UNIT IV SANSKRIT LITERATURE 6

Technical information about Sanskrit Literature

UNIT V TECHNICAL CONCEPTS OF ENGINEERING 6

Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

TOTAL: 30 PERIODS

OUTCOMES

- CO1 - Understanding basic Sanskrit language.
- CO2 - Write sentences.
- CO3 - Know the order and roots of Sanskrit.
- CO4 - Know about technical information about Sanskrit literature.
- CO5 - Understand the technical concepts of Engineering.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3												✓
CO4												✓
CO5												✓

REFERENCES

1. “Abhyaspustakam” – Dr. Vishwas, Samskrita-Bharti Publication, New Delhi
2. “Teach Yourself Sanskrit” Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. “India’s Glorious Scientific Tradition” Suresh Soni, Ocean books (P) Ltd., New Delhi, 2017.

AX5094 **VALUE EDUCATION** **L T P C**
2 0 0 0

OBJECTIVES
Students will be able to
- Understand value of education and self-development
- Imbibe good values in students
- Let the should know about the importance of character

UNIT I
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

UNIT II
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

UNIT III
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 brother hood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature

UNIT IV
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.

TOTAL: 30 PERIODS

OUTCOMES
Students will be able to
- Knowledge of self-development.
- Learn the importance of Human values.
- Developing the overall personality.

Suggested reading
1. Chakroborty, S.K."Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi

AX5095 **CONSTITUTION OF INDIA** **L T P C**
2 0 0 0

OBJECTIVES
Students will be able to:
- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional
- Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION
History, Drafting Committee, (Composition & Working)

UNIT II PHILOSOPHY OF THE INDIAN CONSTITUTION
Preamble, Salient Features

UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES

Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT IV ORGANS OF GOVERNANCE

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT V LOCAL ADMINISTRATION

District's Administration head: Role and Importance, • Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy(Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT VI ELECTION COMMISSION

Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
- Discuss the intellectual origins of the framework of argument that informed the conceptualization
- of social reforms leading to revolution in India.
- Discuss the circumstances surrounding the foundation of the Congress Socialist Party[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- Discuss the passage of the Hindu Code Bill of 1956.

Suggested reading

1. The Constitution of India,1950(Bare Act),Government Publication.
2. Dr.S.N.Busi, Dr.B. R.Ambedkar framing of Indian Constitution,1st Edition, 2015.
3. M.P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis,2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

AX5096	PEDAGOGY STUDIES	L	T	P	C
		2	0	0	0

OBJECTIVES

Students will be able to

- Review existing evidence on there view topic to inform programme design and policy
- Making under taken by the DfID, other agencies and researchers.
- Identify critical evidence gaps to guide the development.

UNIT I INTRODUCTION AND METHODOLOGY

Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions **-** Overview of methodology and Searching.

UNIT II THEMATIC OVERVIEW

Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.

UNIT III EVIDENCE ON THE EFFECTIVENESS OF PEDAGOGICAL PRACTICES

Methodology for the in depth stage: quality assessment of included studies - How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? - Theory of change - Strength and nature of the body of evidence for effective pedagogical practices - Pedagogic theory and pedagogical approaches - Teachers' attitudes and beliefs and Pedagogic strategies.

UNIT IV PROFESSIONAL DEVELOPMENT

Professional development: alignment with classroom practices and follow up support - Peer support - Support from the head teacher and the community - Curriculum and assessment - Barriers to learning: limited resources and large class sizes

UNIT V RESEARCH GAPS AND FUTURE DIRECTIONS

Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment - Dissemination and research impact.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to understand

- What pedagogical practices are being used by teachers informal and informal classrooms in developing countries?
- What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
- How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

Suggested reading

1. Ackers J, HardmanF (2001) Classroom interaction in Kenyan primary schools, Compare, 31(2): 245-261.
2. Agrawal M (2004)Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36(3):361-379.
3. Akyeampong K (2003) Teacher training in Ghana-does it count? Multi-site teacher education research project (MUSTER) country report 1.London:DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33(3): 272–282.
5. Alexander RJ(2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M(2003) Read India: Amass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf

AX5097 STRESS MANAGEMENT BY YOGA L T P C
2 0 0 0

OBJECTIVES

- To achieve overall health of body and mind
- To overcome stress

UNIT I

Definitions of Eight parts of yoga.(Ashtanga)

UNIT II

Yam and Niyam - Do‘s and Don’t’s in life - i) Ahinsa, satya, astheya, bramhacharya and aparigraha, ii) Ahinsa, satya, astheya, bramhacharya and aparigraha.

UNIT III

Asan and Pranayam - Various yog poses and their benefits for mind & body - Regularization of breathing techniques and its effects-Types of pranayam

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Develop healthy mind in a healthy body thus improving social health also
- Improve efficiency

SUGGESTED READING

1. ‘Yogic Asanas for Group Tarining-Part-I”:Janardan Swami Yoga bhyasi Mandal, Nagpur
2. “Rajayoga or conquering the Internal Nature” by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

AX5098	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS	L T P C 2 0 0 0

OBJECTIVES

- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To awaken wisdom in students

UNIT I

Neetisatakam-holistic development of personality - Verses- 19,20,21,22 (wisdom) - Verses-29,31,32 (pride & heroism) – Verses- 26,28,63,65 (virtue) - Verses- 52,53,59 (dont’s) - Verses-71,73,75,78 (do’s)

UNIT II

Approach to day to day work and duties - Shrimad Bhagwad Geeta: Chapter 2-Verses 41, 47,48 - Chapter 3-Verses 13, 21, 27, 35 Chapter 6-Verses 5,13,17,23, 35 - Chapter 18-Verses 45, 46, 48.

UNIT III

Statements of basic knowledge - Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68 Chapter 12 -Verses 13, 14, 15, 16,17, 18 - Personality of role model - shrimad bhagwad geeta - Chapter2-Verses 17, Chapter 3-Verses 36,37,42 - Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
- The person who has studied Geeta will lead the nation and mankind to peace and prosperity
- Study of Neet is hatakam will help in developing versatile personality of students.

Suggested reading

1. Gopinath, Rashtriya Sanskrit Sansthanam P, Bhartrihari’s Three Satakam, Niti-sringar-vairagya, New Delhi,2010
2. Swami Swarupananda , Srimad Bhagavad Gita, Advaita Ashram, Publication Department, Kolkata, 2016.