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
REGULATIONS - 2019
CHOICE BASED CREDIT SYSTEM
M.E. ENVIRONMENTAL MANAGEMENT

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) –

Graduates of the M.E. Environmental Management Programme will

PEO1	Gain knowledge and skills in environmental management which will enable them to have a career and professional accomplishment in the public or private sector organizations
PEO2	Become consultants on sustainable development issues related to clean water and sanitation, solid waste management, climate change, environmental policies, environmental impact assessment, environmental management systems and pollution prevention.
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	Enter into research and development studies of Environmental Management and Environmental Policies leading to research degrees and innovative solutions
PEO5	Lead the implementation of environmental policies and practices and raise awareness at all levels of an organization, about emerging environmental issues with due consideration of health, safety, and socio cultural factors and advocate policies, systems, processes and equipment for sustainable development.

PROGRAMME OUTCOMES

Graduates of the M. E. Environmental Management Programme will be able to

PO1	Knowledge of Engineering Sciences	Apply the knowledge of mathematics, science and engineering fundamentals to the conceptualization of environmental problems
PO2	Problem analysis	Understand the environmental, social and economic framework in which environmental management decisions are made taking into account the life cycle perspective, systems approach and environmental technologies.
PO3	Design / development of solutions	Design solutions for complex environmental issues 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 extraction of pertinent information through literature survey, apply appropriate research methodologies, analysis and interpretation of data, and synthesis of information to provide valid conclusions
PO5	Modern Tool Usage	Utilize quantitative knowledge and modern tools to assess, analyze, plan, and implement environmental management systems
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 proficiently in writing and speaking for promoting and coordinating public consultations on environmental matters and for negotiating environmental service agreements and managing associated costs and revenues

PO8	Engineer and Society	Recognize, evaluate, and control factors in the workplace and the environment that cause health and environmental hazards. and liaison with regulatory agencies on issues pertaining to environmental protection
PO9	Ethics	Understand and commit to professional ethics and responsibilities of Environmental Managers and to contribute to the society for sustainable development.
PO10	Environment and Sustainability	Assess the potential environmental impact of development projects and design mitigation measures anticipating and evaluating environmental issues in a variety of sectors and industries
PO11	Project Management and Finance	Prepare, review, and update environmental monitoring and assessment Reports and monitor progress of environmental improvement programs
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 M.E. Environmental Management Programme will be able to		
PSO1	Knowledge of Environmental Management discipline	Demonstrate in-depth knowledge of environmental management, with an ability to develop, implement, monitor and maintain environmental strategies, policies, programmes and systems that promote sustainable development.
PSO2	Environmental Performance Evaluation and coordination	Evaluate environmental performance including compliance with environmental legislation across the organization, and coordinate all aspects of pollution control, waste management, environmental health and conservation.
PSO3	Conceptualization of Environmental Management Systems	Identify, formulate, analyze, and develop management systems and formulate solutions that are technically sound, economically feasible, and socially acceptable

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	Design of Water and Wastewater Treatment Systems												
		Environmental Chemistry and Microbiology	H	M	H	M	M	M	L	M	M	M	M	L
		Statistical Methods for Engineers												
		Principles of Sustainable Development		H	H	M		M	L	H	M	H	L	H
		Environmental Policies and Legislations	M	M	M	H	H	M	L	M	H	H	L	M
		Research Methodology and IPR												
		Audit Course – I												
		Environmental Chemistry and Microbiology laboratory	H	M	L	H	M	H	L	H	M	H	L	M
	SEMESTER II	Environmental Economics	H	M	H	M		M	L	M	M	M		L
		Environmental Impact Assessment	H	M	H	M	M	M	L	M	H	M	L	L
		Solid and Hazardous Waste Management	H	M	H	M	M	M	L	M	M	M	M	L
		Program Elective I												
		Program Elective II												
		Program Elective III												
		Audit Course –II												
		Technical Seminar												
YEAR II	SEMESTER III	Environmental Management Systems and Auditing	H	M	H	M	M	M	L	M	M	M		L
		Program Elective IV												
		Program Elective V												
		Open Elective												
		Dissertation I												
	SEMESTER IV	Dissertation II												

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M.E. ENVIRONMENTAL MANAGEMENT
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.	EM5101	Design of Water and Wastewater Treatment Systems	PCC	3	1	0	4	4
3.	EM5102	Environmental Chemistry and Microbiology	PCC	4	0	0	4	4
4.	EM5103	Principles of Sustainable Development	PCC	3	0	0	3	3
5.	EM5104	Environmental Policies and Legislations	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.	EM5111	Environmental Chemistry and Microbiology laboratory	PCC	0	0	2	2	1
			TOTAL	**20**	**2**	**2**	**24**	**21**

*****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.	EM5201	Environmental Economics	PCC	3	0	0	3	3
2.	EM5251	Environmental Impact Assessment	PCC	3	0	0	3	3
3.	EM5252	Solid and Hazardous Waste Management	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.	EM5211	Technical Seminar	EEC	0	0	2	2	1
			TOTAL	**20**	**0**	**2**	**22**	**19**

* 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.	EM5301	Environmental Management Systems and Auditing	PCC	3	0	0	3	3
2.		Program Elective IV	PEC	3	0	0	3	3
3.		Program Elective V	PEC	3	0	0	3	3
4.		Open Elective	OEC	3	0	0	3	3
PRACTICALS								
5.	EM5311	Dissertation I	EEC	0	0	12	12	6
			TOTAL	**12**	**0**	**12**	**24**	**18**

SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	EM5411	Dissertation II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS TO BE EARNED FOR AWARD OF THE DEGREE: 70

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

PROGRAM CORE COURSES (PCC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	EM5101	Design of Water and Wastewater Treatment Systems	3	1	0	4	1
2.	EM5102	Environmental Chemistry and Micro Biology	4	0	0	4	1
3.	EM5103	Principles of Sustainable Development	3	0	0	3	1
4.	EM5104	Environmental Policies and Legislations	3	0	0	3	1
5.	EM5111	Environmental Chemistry and Microbiology laboratory	0	0	2	1	1
6.	EM5201	Environmental Economics	3	0	0	3	2
7.	EM5251	Environmental Impact Assessment	3	0	0	3	2
8.	EM5252	Solid and Hazardous Waste Management	3	0	0	3	2
9.	EM5301	Environmental Management Systems and Auditing	3	0	0	3	3
					TOTAL CREDITS	**27**	

PROGRAM ELECTIVE COURSES [PEC]

SL. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			L	T	P	
1.	EM5001	Environmental Risk Assessment	3	0	0	3
2.	EM5002	Rural Water Supply and Onsite Sanitation	3	0	0	3
3.	EM5003	Environmental Quality Monitoring	3	0	0	3
4.	EM5004	Sludge and Septage Management	3	0	0	3
5.	EM5005	Remote Sensing and GIS Applications in Environmental Management	3	0	0	3
6.	EM5006	Sustainable Agriculture and Environmental Management	3	0	0	3
7.	EM5007	Life Cycle Analysis and Design for the Environment	3	0	0	3
8.	EM5008	Energy Management in Industries	3	0	0	3
9.	EM5009	Environment, Health and Safety in Industries	3	0	0	3
10.	EM5010	Landfill Engineering and Remediation Technologies	3	0	0	3
11.	EM5011	Environmental Toxicology and Monitoring	3	0	0	3
12.	EN5071	Marine Pollution and Control	3	0	0	3
13.	EN5072	Membrane Separation for Water and Wastewater Treatment	3	0	0	3
14.	EM5071	Climate Change and Modelling	3	0	0	3
15.	EM5072	Operation and Maintenance of Water and Wastewater Treatment Systems	3	0	0	3
16.	EM5073	Project Formulation and Implementation	3	0	0	3
17.	EN5251	Air Pollution Control	3	0	0	3
18.	EN5252	Industrial Wastewater Pollution- Prevention and control	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

S. 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	EM5211	Technical Seminar	0	0	2	1	3
2	EM5311	Dissertation I	0	0	12	6	3
3	EM5411	Dissertation II	0	0	24	12	4
TOTAL CREDITS						**19**	

Summary

	Name of the Programme: M. E. ENVIRONMENTAL MANAGEMENT					
	SUBJECT AREA	**CREDITS PER SEMESTER**				**CREDITS TOTAL**
		I	**II**	**III**	**IV**	
1.	FC	04	00	00	00	04
2.	PCC	15	09	03	00	27
3.	PEC	00	09	06	00	15
4.	RMC	02	00	00	00	02
5.	OEC	00	00	03	00	03
6.	EEC	00	01	06	12	19
7.	Non Credit/Audit Course	✓	✓	00	00	00
	TOTAL CREDIT	**21**	**19**	**18**	**12**	**70**

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.

EM5101 DESIGN OF WATER AND WASTEWATER TREATMENT SYSTEMS L T P C
3 1 0 4

OBJECTIVES:

- To educate the students on the principles and process designs of various treatment systems for water and wastewater.
- Develop an understanding of the characteristics of water and wastewater that must be considered during design of a treatment plant.
- Students will gain competency in the iterative process employed in design of treatment systems and the components comprising such systems, leading to the selection of specific process equipment items.

UNIT I PRINCIPLES OF TREATMENT 9

Pollutants in water and wastewater – characteristics - standards for performance, treatment processes – Selection criteria-types of reactors - kinetics – Unit operations and unit processes-physico-chemical treatment principles - screening, skimming, floatation – mixing, equalization, sedimentation, filtration – gas transfer – adsorption – Isotherms –membrane separation, electro dialysis – stripping neutralization - coagulation flocculation – precipitation – stabilization – disinfection, Ion exchange – advanced oxidation process – principles of biological treatment – aerobic and anaerobic treatment - kinetics of biological growth – attached and suspended growth process.

UNIT II DESIGN OF WATER TREATMENT PLANTS 9

Design of treatment plant units – selection of process - upgrading existing plants – aerators – chemical feeding – Flash mixer- Clari-flocculator – lamella and plate settlers- – filters – rapid sand filters, pressure filter, dual media filters-Multimedia filters – disinfectors- design of softeners – demineralization plant –reverse osmosis plants Hydraulic profiles for treatment plants.

UNIT III DESIGN OF CONVENTIONAL WASTEWATER TREATMENT PLANTS 9

Design of treatment units - screens- grit chamber - settling tanks - design of aerobic treatment systems - activated sludge process and variations, trickling filters-bio tower-RBC-aerated lagoons – natural treatment systems- waste stabilization ponds, constructed wetland – Disinfection – Design of anaerobic treatment system - septic tanks – Nutrient removal systems

UNIT IV DESIGN OF ADVANCED WASTEWATER TREATMENT PLANTS 9

Design of 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- UASB – post treatment systems for UASB reactor- anaerobic filters – expanded bed and fluidized bed anaerobic systems - design of nutrient removal systems - anaerobic ammonium oxidation process -recent trends.

UNIT V RESIDUAL MANAGEMENT OPERATION AND MAINTENANCE ASPECTS 9

Characteristics of sludge from WTP and STP-Design of sludge management facilities for WTP and STP-sludge thickening-sludge digestion- design of anaerobic digester-biogas generation-sludge dewatering –filter press-vacuum filtration- centrifugation-- sludge drying beds - construction, operation and Maintenance aspects of WTP and STP – trouble shooting – Planning, Organizing and controlling of plant operations – capacity building, case studies of Retrofitting.

TOTAL(45+15):60 PERIODS

OUTCOMES:

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

CO1	Understand the principle of water and wastewater treatment
CO2	Design and sizing the different components of water treatment plant.
CO3	Design of conventional wastewater treatment units
CO4	understand in detail about the design of advanced wastewater treatment units
CO5	design the different elements of sludge treatment systems and understand the importance O&M issues pertaining to WTP and STP

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 on “Sewerage and Sewage Treatment Systems Part A, Part B &Part C” CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2013.
3. Metcalf & Eddy, INC, „Wastewater Engineering – Treatment and Reuse, Fourth Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2014.
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 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	M	M	M		M	
PO2	Problem analysis	M	H	H	H	M	
PO3	Design / development of solutions	H	H	H	M	M	
PO4	Investigation	M	H	M	H	M	
PO5	Modern Tool Usage		L		L		
PO6	Individual and Team work		M		M		
PO7	Communication	M		M			
PO8	Engineer and Society	M		M	M	M	
PO9	Ethics		M		M		
PO10	Environment and Sustainability	H		M		M	
PO11	Project Management and Finance		H		M	M	
PO12	Life Long Learning	M		M			
PSO1	Knowledge of Environmental Management discipline		M		M	M	
PSO2	Environmental Performance Evaluation and coordination	H		H			
PSO3	Conceptualization of Environmental Management Systems			M		M	

EM5102 ENVIRONMENTAL CHEMISTRY AND MICROBIOLOGY L T P C
4 0 0 4

OBJECTIVES:

- To impart knowledge on the relevance and applications of environmental chemistry and microbiology in managing environmental problems

UNIT I ENVIRONMENTAL AQUATIC CHEMISTRY 12

Stoichiometry and mass balance-chemical equilibria, acid base, solubility product(Ksp), chemical kinetics , fate of chemicals and typical pollutants in aquatic environment, -characteristics of water pollution, volatilization, coagulation, partitioning, hydrolysis, photochemical transformation– Degradation of synthetic chemicals-Metals, complex formation, oxidation and reduction

UNIT II ATMOSPHERIC AND ENVIRONMENTAL SOIL CHEMISTRY 12

Atmospheric structure – major air pollutants – oxides of carbon, nitrogen, sulphur – Hydrocarbons - chemical and photochemical reactions – photochemical smog. Ozone layer depletion – greenhouse gases and global warming, Acid rain- origin and composition of particulates, evolution of soil chemistry- contaminants in soil – soil decontamination – inorganic soil components- primary soil minerals, secondary soil minerals, nature and composition of soil-clays- ion-exchange reactions in soil – agricultural chemicals in soil, Heavy metals-Chemical speciation and their toxicity- humic substances- retention of pesticides and other organic substances by humic substances - Nano materials, CNT, titania, composites , applications.

UNIT III CLASSIFICATION AND CHARACTERISTICS OF MICROORGANISMS 12

Classification and distribution of microorganisms – aerobic and anaerobic cultures, synchronous and asynchronous culture, batch, fed batch and continuous culture. measurement of growth, factors affecting growth. extremophiles:, Microbial interactions - chemolithotrophic organisms and biogeochemical cycles – 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 - importance (NO_3 respiration, SO_4 respiration, Halorespiration)

UNIT IV MICROORGANISMS IN WASTEWATER 12

Water borne pathogens and their effects, transmission of pathogens, - total coliforms, E-coli, streptococcus, clostridium, concentration and detection of virus, factors influencing toxicity. effects – acute, chronic, test organisms – toxicity testing, microbial toxicology and degradation of xenobiotics - bioconcentration – bioaccumulation, biomagnification, bioassay, biomonitoring, bioleaching.- emerging Contaminants biodrgradation – factors affecting biodegradation.

UNIT V APPLICATIONS OF MICROORGANISMS FOR CLEAN ENVIRONMENT 12

Microbial assessment of water quality, microbes as bio-indicators, potability of water, treatment of municipal water. solid and liquid based treatment, biological (aerobic, anaerobic, primary, secondary & tertiary) treatment.

Nutrients removal – BOD, nitrogen, phosphate, nitrification and denitrification, eutrophication – causes and effects, removal of pathogens from water and wastewater – bacteria, protozoa, virus – methods – physical, chemical and biological.

TOTAL: 60 PERIODS

OUTCOMES:

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

CO1	Explain the various chemical pollutants present in aquatic environment, their sources, characteristics, and the chemical reactions involved
CO2	Demonstrate knowledge and understanding of various soil and atmospheric chemical environment arise in nature, apply the knowledge to explain the real-world environmental chemistry. Capable of using theoretical knowledge to solve real-world type problems.
CO3	Gain knowledge on the distribution of various microorganisms in different ecosystems, the factors affecting the growth of the organisms, the significance of the organisms in organic matter decomposition and environmental clean up
CO4	Select appropriate techniques to enumerate the pathogens in wastewater, exploitation of microorganisms to indicate the various pollutants in water and design experiments to remove the pollutants from wastewater using microorganisms
CO5	Apply the knowledge to design appropriate methods or experiments to treat the wastewater to remove the nutrients by utilising the suitable microorganisms, their nutrient requirement and the metabolic pathway

REFERENCES:

1. Chemistry for Environmental Engineering and Science, Sawyer,C.N., MacCarty, P.L. and Parkin, G.F Tata McGraw – Hill, Fifth edition, New Delhi (2003).
2. Environmental Chemistry', Freeman and company, New York, (2012).

3. Environmental Chemistry, Eighth Edition, Colin Baird and Michael Cann Manahan, S.E., CRC press(2005)
4. P.K. Goel, Water Pollution: Causes, Effects and Control, New Age International, New Delhi, 2006
4. Hand Book of Environmental Microbiology, S.C.Bhatia, Vol 1, 2 and 3, Atlantic Publisher,2008.
5. Text Book of Environmental Microbiology, Pradipa K. Mohapatra, I.K. International Publishing House pvt. Ltd., 2008
6. A Text Book of Microbiology, R.C. Dubey and D. K. Maheswari S. Chand & Company Ltd - New Delhi, 2013
7. Environmental Microbiology: Fundamentals and Applications Bertrand**,** J.-C., Caumette**,** P., Lebaron, P., Matheron, R., Normand, P., Sime**-**Ngando, T. (Eds.) Springer, 2015

CO – PO Mapping- ENVIRONMENTAL CHEMISTRY AND MICROBIOLOGY

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	M	M
PO3	Design / development of solutions					H	H
PO4	Investigation		M	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	M	H	H	H		H
PSO2	Environmental Performance Evaluation and coordination	M	M	M	M	M	M
PSO3	Conceptualization of Environmental Management Systems			H	H		H

EM5103 PRINCIPLES OF SUSTAINABLE DEVELOPMENT L T P C
3 0 0 3

OBJECTIVES:

- To impart knowledge on environmental, social and economic dimensions of sustainability and the principles evolved through landmark events so as to develop an action mindset for sustainable development.

UNIT I SUSTAINABILITY AND DEVELOPMENT CHALLEGES 9

Definition of sustainability – environmental, economical and social dimensions of sustainability - sustainable development models – strong and weak sustainability – defining development-millennium development goals – mindsets for sustainability: earthly, analytical, precautionary, action and collaborative– syndromes of global change: utilisation syndromes, development syndromes, and sink syndromes – core problems and cross cutting Issues of the 21 century - global, regional and local environmental issues – social insecurity - resource degradation –climate change – desertification.

UNIT II PRINCIPLES AND FRAME WORK 9

History and emergence of the concept of sustainable development - our common future - Stockholm to Rio plus 20– Rio Principles of sustainable development – Agenda 21 natural step-peoples earth charter – business charter for sustainable development –UN Global Compact - Role of civil society, business and government – United Nations' 2030 Agenda for sustainable development – 17 sustainable development goals and targets, indicators and intervention areas

UNIT III SUSTAINABLE DEVELOPMENT AND WELLBEING 9

The Unjust World and inequities - Quality of Life - Poverty, Population and Pollution - Combating Poverty - - Demographic dynamics of sustainability - Strategies to end Rural and Urban Poverty and Hunger – Sustainable Livelihood Framework- Health, Education and Empowerment of Women, Children, Youth, Indigenous People, Non-Governmental Organizations, Local Authorities and Industry for Prevention, Precaution , Preservation and Public participation.

UNIT IV SUSTAINABLE SOCIO-ECONOMIC SYSTEMS 10

Sustainable Development Goals and Linkage to Sustainable Consumption and Production – Investing in Natural Capital- Agriculture, Forests, Fisheries - Food security and nutrition and sustainable agriculture- Water and sanitation - Biodiversity conservation and Ecosystem integrity – Ecotourism - Sustainable Cities – Sustainable Habitats- Green Buildings - Sustainable Transportation –– Sustainable Mining - Sustainable Energy– Climate Change –Mitigation and Adaptation - Safeguarding Marine Resources - Financial Resources and Mechanisms

UNIT V ASSESSING PROGRESS AND WAY FORWARD 8

Nature of sustainable development strategies and current practice**-** Sustainability in global, regional and national context –Approaches to measuring and analysing sustainability– limitations of GDP- Ecological Footprint- Human Development Index- Human Development Report – National initiatives for Sustainable Development - Hurdles to Sustainability - Science and Technology for sustainable development –Performance indicators of sustainability and Assessment mechanism – Inclusive Green Growth and Green Economy – National Sustainable Development Strategy Planning and National Status of Sustainable Development Goals

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1	Explain and evaluate current challenges to sustainability, including modern world social, environmental, and economic structures and crises.
CO2	Identify and critically analyze the social environmental, and economic dimensions of sustainability in terms of UN Sustainable development goals
CO3	Develop a fair understanding of the social, economic and ecological linkage of Human well being, production and consumption
CO4	Evaluate sustainability issues and solutions using a holistic approach that focuses on connections between complex human and natural systems.
CO5	Integrate knowledge from multiple sources and perspectives to understand environmental limits governing human societies and economies and social justice dimensions of sustainability.

REFERENCES:

1. Tom Theis and Jonathan Tomkin, Sustainability: A Comprehensive Foundation, Rice University, Houston, Texas, 2012
2. A guide to SDG interactions:from science to implementation, International Council for Science, Paris,2017
3. Karel Mulder, Sustainable Development for Engineers - A Handbook and Resource Guide, Rouledge Taylor and Francis, 2017.
4. The New Global Frontier - Urbanization, Poverty and Environmentin the 21st Century - *George Martine,Gordon McGranahan,Mark Montgomery and Rogelio Fernández-Castilla,* IIED and UNFPA, Earthscan, UK, 2008

5. Nolberto Munier, Introduction to Sustainability: Road to a Better Future, Springer, 2006
6. Barry Dalal Clayton and Stephen Bass, Sustainable Development Strategies- a resource book", Earthscan Publications Ltd, London, 2002.

CO – PO Mapping –Principles of Sustainable Development

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

EM5104 ENVIRONMENTAL POLICIES AND LEGISLATIONS L T P C
3 0 0 3

OBJECTIVES:

- The course will analyze the legislative and judicial responses to environmental problems and the administrative system of environment related laws such as air, water, land, and hazardous substances etc. Environment advocacy and approaches for using litigation in environment protection will receive special attention

UNIT I INTRODUCTION TO ENVIRONMENTAL LEGISLATIONS AND INTERNATIONAL SCENARIO 9

Significance of Environmental Law **-**International Environmental Law **-**Development of International Environmental Law **-**Source and General principals of International Environmental Law **–**General rights and obligations of States **-**General Issues of the international law related to environmental protection **-**Stockholm Declaration**-**Rio Declaration on Environment and Development**-**Basel Convention on the Control of Trans boundary Movement of Hazardous Wastes and their disposal**-** Convention of Biological Diversity**-**U.N Frame Work Convention on Climate Change**-**Montreal Protocol on Substances that deplete Ozone Layer**-**Kyoto Protocol**.**

UNIT II INDIAN CONSTITUTIONS AND ENVIRONMENTAL PROTECTION 9

Indian Constitution and Environmental Protection -Constitutional provisions concerning Environment Articles 14,15,(2) (b) 19 (e),21,31,32,38,39,42,47, 48-A,49,51,51-A: Indian Environmental Policy 2006 Administrative machinery for pollution control Common Law & Criminal Law Nuisance, Negligence, Strict liability and Absolute liability, Provisions of IPC relating to environmental problems (public nuisance u/s 268 and others (Sections 269,270,277,284,285,286,425 to 440) Section 133 of Cr.P.C.

UNIT III REMEDIES FOR ENVIRONMENTAL POLLUTION 9

Common Law Remedies/Remedies under Law of Tort – Penal Remedies – Indian Penal Code and Code of Criminal Procedure – Remedies under Constitutional Law – Writs – Public Interest Litigation - Public Liability Insurance Act, 1991 – The National Green Tribunal Act 2010

UNIT IV MAJOR INDIAN LEGISLATIONS 9

Water Act (1974) Air Act (1981) Environmental Protection Act (1986) Major Notifications, The Municipal solid Wastes (Management and Handling) Rules 2000-Bio Medical Wastes (Management and Handling) Rules 1998- Hazardous Wastes (Management and Handling Rules 1989- Environment Impact Assessment Notifications- Coastal Regulation Zone Notification- Public Hearing Notifications

UNIT V ENVIRONMENT AND DEVELOPMENT CASE LAWS 9

Meaning and concept of development - Its impact on environment; conflict between environment and development, Concept of Sustainable Development., Polluter Pay Principle, Precautionary Principle, Public Trust Doctrine. Landmark Judgments **-** Olium gas leakage case, Rural Litigation and Entitlement Kendra, Dehradun, (1985) Supp SCC 487) Vellore Citizen Welfare Forum v. Union of India, (1996) 5SCC 647) Ganga Pollution case (1988) I SCC) S. Jagannath v. UOI (1997) SCC867) Vellore Citizens welfare forum case M.C. Mehta V. Kamalnath (1997) I SCC 388)

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1	Understand origins and sources of environmental laws, and understand how and by whom environmental laws are made and interpreted
CO2	Understand the key principles of, and actors within, environmental laws
CO3	Understand the National Environmental Policy and Various Legislations enacted in line with Policy
CO4	Critically analyze environmental laws within various contexts and to evaluate laws against procedural and substantive criteria.
CO5	Understand and the Legal system operating in India and will be in a position to prepare compliance reports for getting environmental clearance.

REFERENCES:

1. Leelakrishnan P., Environmental Law in India, Butterworths,1998
2. Leelakrishnan P., Environmental Case Book, Lexis Nexis,2000
3. Shanthakumar S. , Environmental Law – An Introduction, Butterworths,2004
4. Shyam Diwan and Armin Rosencranz, Enviromental Law and Policy in India, Oxford, 2001
5. Statutory Materials
6. Bare Act/s
7. Hand Book of International Environmental Law UNEP Publication
8. Alan Boyle and Patricia Bernie, International Law and Environment, Oxford,1997
9. Philippe Sands, Principles of International Environmental Law, Cambridge,1998
10. Elli Louka, International Environmental Law, Cambridge,1999'

CO – PO Mapping – ENVIRONMENTAL POLICIES AND LEGISLATIONS

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

RM5151 RESEARCH METHODOLOGY AND IPR LT 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 TECHNICALWRITING /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

EM5111 ENVIRONMENTAL CHEMISTRY AND MICROBIOLOGY LABORATORY L T P C
0 0 2 1

A: Environmental Chemistry

1. Estimation of hardness in Water sample by volumetric titration
2. Estimation of Chloride in Water sample by volumetric titration
3. Determination of sulphate
4. Determination of phosphate
5. Determination of Total Solids, Total suspended solids, Total dissolved solids
6. Determination of COD in the wastewater sample
7. Determination of BOD in the wastewater sample

B: Environmental Microbiology

1. Preparation of culture media
2. Isolation and Culturing of Microorganisms
3. Gram Staining of bacteria
4. Bacteriological analysis of wastewater (Coliforms & Streptococcus) – MPN Technique
5. Bacteriological analysis of wastewater (Coliforms & Streptococcus MF technique

TOTAL: 30 PERIODS

OUTCOMES:

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

CO1	Test the water sample- analyse the water parameters like - hardness chloride, sulphates
CO2	Characterise the wastewater - analyse the wastewater parameters like phosphate, solids COD,BOD
CO3	Prepare culture media necessary for microbial growth.
CO4	Isolate and culture the bacteria - identify the bacteria -able to handle microscope
CO5	Analysis the coliform count in the 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. Charles P. Gerba, "Environmental Microbiology: A laboratory manual", Elsevier Publications, 3rd, 2014

CO-PO Mapping - ENVIRONMENTAL CHEMISTRY AND MICROBIOLOGY LABORATORY

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

EM5201 ENVIRONMENTAL ECONOMICS L T P C
3 0 0 3

OBJECTIVES:

- To provide the basis for economic thinking of environmental issues and provide policy recommendations to improve related problems including the economics of natural resources, valuing environment, cost benefit analysis, market based instruments and economic policies for environmental management.

UNIT I PRINCIPLES OF ECONOMICS 9

Economic concepts of Wealth, Welfare, Scarcity, Growth, Sustainability, Costs, Benefits, willingness to pay, Opportunity costs ,Social Costs, Marginal Costs and Marginal Benefits - Positive and Normative criteria for decision making - Point vs. Nonpoint Sources - Stock vs. Fund Pollutants - Efficient level of pollution, total cost of efficient level of pollution - Polluter pays

Principle –Economic Optimum level of Pollution- Marginal Damage Functions – Marginal Abatement Costs -Consumer Choice theory –Economic Efficiency and Markets–Static and dynamic efficiency - Supply and Demand– market failures – property rights, externalities and environmental problems – Coase Theorem - Public Goods and Externalities - Free rider problem – Tragedy of the commons

UNITII ECONOMIC VALUATION OF ENVIRONMENTAL RESOURCES 9

Types of Economic value - Environmental Benefits and Environmental Costs - Valuing the Environment – Direct and indirect methods – Surrogate markets – Stated Preference and Revealed Preference methods- hedonic prices, travel cost models, contingent valuation, benefit transfer –economic valuation of ecosystem services- Assessment of Loss of Ecology - Valuation of Health impacts - Environmental accounting

UNITIII ECONOMICS OF POLLUTION PREVENTION AND CONTROL 9

Economics of Environmental Quality- - Cost benefit analysis and Cost effectiveness analysis – Principles, methodology and Limitations – Discounting - Profitability of Pollution Prevention - Pay back period – Present value estimation – Internal rate of return –Economic analysis of Pollution Prevention Case studies– economically efficient pollution control programmes – Economics of Enforcement - Efficient allocation of pollution from mobile and stationery source – Total Cost Assessment- Life cycle costing-Green Accounting and Economic indicators -

UNIT IV ECONOMIC INSTRUMENTS FOR ENVIIRONMENTAL PROTECTION 9

Allocation of Stock and Fund Pollutants - Economic analysis of Environmental Policy -Regulatory versus Economic Instruments – Decentralized Policies: Liability Laws, Property Rights, and Moral Suasion - Command-and-Control Strategies - Pigovian and Pollution Taxes – Incentive-Based Strategies: Emission Charges and Subsidies– Marketable permits – Emission trading -– Non Compliance fees, bonds and deposit refunds –Evaluation of Instruments – Choice of instruments for Environmental policy

UNIT V NATURAL RESOURCE ECONOMICS 9

Types, scarcity and classification of Natural Resources – Economics of depletable and non renewable resources – Recyclable resources – Replenishable but depletable resources – Storable renewable resources – Renewable common property Resources– Economic Theory of Depletable Resources- Optimal Use of Exhaustible Resources- – Natural resources accounting - Economics of Forestry and fisheries exploitation –Trade and environment – Income Effects and Environmental Kuznets Curves – Race to the Bottom and Pollution Haven Hypothesis - Porter Hypothesis - Economics of Climate Change

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1	explain the various terms and basic principles of environmental economics
CO2	apply the knowledge of science and engineering fundamentals to analyse costs, benefits and value of environmental and natural resources accounting
CO3	design of economic instruments and policies for optimal pollution, economics of exhaustible resources and renewable resources
CO4	select appropriate economic instruments and policies for environmental management taking into account the impact of the solutions in a sustainability context
CO5	conduct research pertinent to environmental economics and communicate effectively to different stakeholders as well as engage in independent life-long learning

REFERENCES:

1. Tom Tietenberg, and Lynne Lewis, “Environmental and Natural Resource Economics’, 11th Edition, Pearson Publishers, 2018.
2. Barry Field and Martha Field, Environmental Economics: An Introduction, McGraw-Hill, 2016.

3. Nancy Olewiler; Barry Field, Environmental Economics , McGraw-Hill Ryerson, 2015
4. Kate Raworth, Doughnut Economics - Seven ways to think like a 21st century Economist, Random House Business Books, UK, 2017
5. Kolstad, Charles, Environmental Economics", Oxford University Press, New York, 2011
6. John Asafu Adjaye, " Environmental Economics for non-Economists – techniques and policies for Sustainable Development, World Scientific,2005

CO – PO Mapping –Environmental Economics

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

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

EM5301 ENVIRONMENTAL MANAGEMENT SYSTEMS AND AUDITING L T P C
3 0 0 3

OBJECTIVES:

- To impart an understanding of systems approach to Environmental Management as per ISO 14001 and skills for environmental performance assessment in terms of legal compliance, pollution prevention and continual improvement.

UNIT I ENVIRONMENTAL MANAGEMENT STANDARDS 9

Unique Characteristics of Environmental Problems - Classification of Environmental Impact Reduction Efforts - Systems approach to Corporate environmental management - Business Charter for Sustainable Production and Consumption – Tools and Barriers - Evolution of Environmental Stewardship –National policies on abatement of pollution and conservation of resources - Charter on Corporate responsibility for Environmental protection - Environmental quality objectives – Rationale of Environmental standards: Concentration and Mass standards, Effluent and stream standards, Emission and ambient standards, Minimum national standards, environmental performance evaluation: Indicators, benchmarking

UNIT II PREVENTIVE ENVIRONMENTAL MANAGEMENT 9

Pollution control Vs Pollution Prevention - Opportunities and Barriers – Cleaner production and Clean technology, closing the loops, zero discharge technologies – Four Stages and nine approaches of Pollution Prevention - Getting management commitment – Analysis of Process Steps- source reduction, raw material substitution, toxic use reduction and elimination, process modification –Material balance – Technical, economical and environmental feasibility evaluation of Pollution Prevention options in selected industries –Preventive Environmental Management over Product cycle.

UNIT III ENVIRONMENTAL MANAGEMENT SYSTEM 10

ISO 14000 family- EMS as per ISO 14001– benefits and barriers of EMS – Understanding the organisation and its context- Understanding the needs and expectations of interested parties- Determining the scope of the environmental management system- Leadership and commitment- Environmental policy- Organizationalroles, responsibilities and authorities- Actions to address risks and opportunities- Environmental objectives and planning – Resources- Competence-Awareness- Communication-Documented Information –Operational Planning and Control- Emergency preparedness and response- Monitoring, measurement, analysis and evaluation - Management review

UNIT IV ENVIRONMENTAL AUDIT 8

Environmental management system audits as per ISO 19011-Internal Audits and Certification Audits – Principles of auditing- Roles and qualifications of auditors - Determining auditor competence- Managing an audit programme – Establishing and Implementing audit programme- Selecting audit team members and Assigning responsibility - Conducting an audit- opening meeting, Audit evidence gathering - Collecting and verifying information - Managing and maintaining audit programme records- closing meeting and reporting - Non conformance – Corrective and preventive actions - Continual improvement - compliance audits – waste audits and waste minimization planning – Environmental statement (form V) - Due diligence audit

UNIT V CASE STUDIES 9

Case studies on applications of EMS, Waste Audits and Pollution Prevention in Textile industry , Tanning industry, Electroplating, Pulp & Paper, Dairy, Chemical industries and service organizations.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1	Explain the various elements of Corporate Environmental Management systems and audits complying to international environmental management system standards
CO2	Apply the knowledge of science and engineering fundamentals to pollution prevention assessment and environmental performance evaluation
CO3	Develop environmental management systems for organisations
CO4	Conduct environmental management system audits taking into account the sustainability context
CO5	Conduct research pertinent to pollution prevention and communicate effectively to different stakeholders as well as engage in independent life-long learning

REFERENCES:

1. ISO 14001/14004:2015 Environmental management systems – Requirements and Guidelines – International Organisation for Standardisation, 2015
2. ISO 19011: 2018, “Guidelines for auditing Management Systems, International Organisation for Standardisation, 2018
3. ISO 14031:2013, Environmental management -- Environmental performance evaluation Guidelines, International Organisation for Standardisation, 2015
4. Marek Bugdol and Piotr Jedynak, Integrated Management Systems, Springer International, 2015.
5. Ryan Dupont, Kumar Ganesan, Louis Theodore, Pollution Prevention: Sustainability, Industrial Ecology, and Green Engineering, Second Edition, CRC Press, 2016
6. Paul L Bishop ‘Pollution Prevention: Fundamentals and Practice’, McGraw- Hill International, Boston,2004.
7. Lennart Nilsson, Per Olof Persson, Lars Rydén, Siarhei Darozhka and Audrone Zaliauskiene,Cleaner Production Technologies and Tools for Resource Efficient Production, The Baltic University Environmental Management book series, Uppsala 2007

CO – PO Mapping – Environmental Management Systems and Auditing

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	M	M
PO3	Design / development of solutions			H			H
PO4	Investigation		M			M	M
PO5	Modern Tool Usage						
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	M		M
PO11	Project Management and Finance						
PO12	Life Long Learning					L	L
PSO1	Knowledge of Environmental Management discipline	H	H	H	H		H
PSO2	Environmental Performance Evaluation and coordination	H	M	M	M	M	H
PSO3	Conceptualization of Environmental Management Systems	H	H	H	H	H	H

EM5001 ENVIRONMENTAL RISK ASSESSMENT L T P C
3 0 0 3

OBJECTIVE:

- To provide knowledge on environmental risk assessment for industries, its regulatory requirements, methodology and tools used in predicting and managing risks.

UNIT I INTRODUCTION 9

Definition of Risk and Risk Assessment- Types of Risk- Hazards-Types and Sources and Effects of Environmental hazards-Factors affecting–Environmental risk assessment framework-Elements – Regulatory perspectives and requirements

UNIT II HAZARD IDENTIFICATION AND DOSE RESPONSE EVALUATION 9

Hazard identification and accounting-HAZOP-MSDS–Fate and behaviour of toxics and persistent substances in the environment – Dose-Response Evaluation, Linear and Non Linear Dose Response Curves–NOAEL-LOAEL- Slope Factor Calculations; Estimation of carcinogenic and non carcinogenic risks to human health

UNIT III EXPOSURE ASSESSMENT AND RISK CHARACTERIZATION 9

Receptor exposure to Environmental Contaminants –– Exposure Assessment – Direct and Indirect Methods-Exposure Factors– Instantaneous and Life Term Exposure Calculations– Multimedia and multipathway exposure modeling of contaminant migration for estimation of contaminant concentrations in air, water, soils, vegetation– Risk Characterization and consequence determination.

UNIT IV RISK ASSESSMENT AND RISK MANAGEMENT 9

Event Tree Analysis and Fault Tree Analysis- What if Analysis- FMEA method- Risk Priority Number–Vulnerability assessment– Uncertainty analysis - Design of risk management programs - Risk communication and Risk Perception – comparative risks – Risk based decision making – Risk based environmental standard setting – risk based remediation

UNIT V APPLICATIONS 9

Case studies on risk assessment and management for hazardous chemical storage – Chemical industries – Tanneries – Textile industries – Mineral processing and Petrochemical plants – Hazardous waste disposal facilities–contaminated site remediation – Case histories on Bhopal, Chernobyl, Seveso, Three Mile Island.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1	Explain the various types of hazards and associated risks and regulatory perspectives of Risk Assessment
CO2	Identify various hazards, assess the dose-responses and estimate carcinogenic and non-carcinogenic risks
CO3	Assess receptor exposure to Environmental Contaminants by Direct and Indirect Methods for single and Multimedia and multi-pathway and characterize
CO4	Apply various tools such as ETA, FTA on Risk Analysis and Design of risk management programs
CO5	Understand the risk scenario and management actions for Chemical industries, Tanneries, Textile industries, Mineral processing and Petrochemical plants, Hazardous waste disposal facilities based on similar case studies

REFERENCES:

1. Cutter, S.L., Environmental Risk and Hazards, Prentice-Hall of India Pvt. Ltd., New Delhi, 1999.
2. Kolluru Rao, Bartell Steven, Pitblado R and Stricoff "Risk Assessment and Management Handbook", McGraw Hill Inc., New York,1996.
3. Kofi Asante Duah "Risk Assessment in Environmental management", John Wiley and sons, Singapore, 1998.,.
4. Kasperson, J.X. and Kasperson, R.E. and Kasperson,R.E., Global Environmental Risks, V.N.University Press, New York, 2003.
5. Risks and Decisions for Conservation and environmental management, Mark Burman, Cambridge University Press.
6. Joseph F Louvar and B Diane Louver Health and Environmental Risk Analysis fundamentals with applications, Prentice Hall, New Jersey 1997

CO – PO Mapping – ENVIRONMENTAL RISK ASSESSMENT

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

EM5002 RURAL WATER SUPPLY AND ONSITE SANITATION L T P C
3 0 0 3

OBJECTIVES:

- To educate the students on the principles rural water supply and sanitation.
- Develop understanding of events governing the rural water supply and sanitation.

UNIT I DEVELOPMENT OF WATER SOURCES 9

Sources of water –– Alternate ways of water supply- Issues of water supply in rural areas- Surface and ground water sources – Traditional drinking water ponds- Development of deep bore wells- Estimation of yield–- Rain water harvesting – sanitation of rural wells - Types and selection of pumps for rural wells – system performance- Construction –Operation and maintenance.

UNIT II WATER TREATMENT 9

Quality of water - Standard conventional water treatment for rural areas– Technologies for removal of specific contaminants- Low cost filtration-Iron and manganese removal technologies– Arsenic removal - deflouridation- Nitrate removal- Disinfection – Alternate disinfection methods.

UNIT III SANITATION AND PLUMBING 9

Basic requirement of sanitation- Swachh Bharat Abhiyan- on site sanitation technologies- Rural sanitation-Composting toilets-Ecological sanitation- small bore / settled effluent sewer - drainage in buildings – sanitary fixtures – plumbing systems for drainage in residential and commercial buildings.

UNIT IV DECENTRALISED WASTEWATER TREATMENT SYSTEMS 9

Fundamentals of sewage treatment- Decentralized sewage treatment- Ecology and self-purification effect-Septic tank with soil absorption systems - DEWATS components- Design of anaerobic baffled reactors-Constructed wetland-Design aspects of vertical and horizontal flow planted gravel filter-Vertical sand filters- Operation and maintenance.

UNIT V SEPTAGE MANAGEMENT 9

Sources of Septage – characteristics- Elements of septage management- Pumping and Desludging Septic Tanks-Transportation- Treatment- Operation and maintenance - Planning and implementation of septage management schemes-Case studies

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1	Ability to identify alternate sources of water for rural water supply scheme
CO2	Develop conceptual schematics required for the treatment of water for rural application.
CO3	Ability to function on a multi – disciplinary team.
CO4	Capability to identify pertinent criteria for the design of DEWATS system
CO5	Understand septage management

REFERENCES:

1. Manual for "Sewerage and Sewage Treatment Systems" CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2013.
2. Metcalf & Eddy, INC, Wastewater Engineering – Treatment and Reuse, Fourth Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2017.
3. "Manual on water supply and Treatment", CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 1999.
4. Todd, D.K. Ground Water Hydrology, John Wiley & Sons, New York, 2000.
5. Hand Book of Drinking Water Quality, 2nd Edition, DeZuane J. John Wiley & Sons, New York 2013.

CO – PO Mapping – RURAL WATER SUPPLY AND ONSITE SANITATION

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	M	H		H	H	
PO3	Design / development of solutions	H	H	M	H	H	
PO4	Investigation	H	H		M		
PO5	Modern Tool Usage	L		M	M	L	
PO6	Individual and Team work		M	H			
PO7	Communication			M	M		
PO8	Engineer and Society	H	M			H	
PO9	Ethics			M		M	
PO10	Environment and Sustainability		M	M			
PO11	Project Management and Finance	M		M		M	
PO12	Life Long Learning				M	M	
PSO1	Knowledge of Environmental Management discipline	M		H		M	
PSO2	Environmental Performance Evaluation and coordination		M		H		
PSO3	Conceptualization of Environmental Management Systems	M		H		M	

EM5003 ENVIRONMENTAL QUALITY MONITORING L T P C
3 0 0 3

OBJECTIVES:

- To educate the students on the sample collection and various instrumental methods of monitoring the quality of air, water and solid waste.

UNIT I MONITORING AND CHARACRATERIZATION OF ENVIRONMENT 9

General approach to environmental analysis, Choice of Lab.Vs. Field analysis, Environmental monitoring-current and future status, Lab. Standards, Data quality objectives, statistics in environmental monitoring, Accuracy and precision, detection limit, types of errors, Automated Data acquisition and processing-sensors and transducers , Monitoring Network and real time monitoring

UNIT II ENVIRONMENTAL SAMPLING 9

Location, planning, sampling equipment's for water, solids and air, sample storage for physical and chemical contaminants ,types of sampling, representative samples, sample preparation techniques-Solvent Extraction, SPE, Head space, Purge and trap and SPME

UNIT III WATER ANALYSIS 9

Techniques for analysis of major ions-UV-visible Spectrophotometer, Flame photometer, AAS, ICP(AES and MS), Trace organic pollutants(PCB, dioxins, pecticides) GC and HPLC (Columns Detectors and Application)

UNIT IV ATMOSPHEREIC ANALYSIS 9

Ambient air and flue gas, Gaseous pollutants-Determination of time weighted average concentration(Absorption trains, solid adsorbents and differential tubes), Direct reading instruments(fluorescence ,chemiluminescent,IR and Electrochemical sensors, GC-MS for trace organics, Particulate sampling methods- High volume sampler, personal sampler, PM 10 and 2.5, Metals Direct(XRF) and dissolution methods(AAS/AES)

UNIT V ANALYSIS OF SOIL AND WASTE 9

Problem in analysis of soil and Waste -sampling, pretreatment -extraction and clean up, New extraction techniques, Automated soxhlet and solvent extraction,microwave digestion and sonication,SCF(CO_2), Analysis for trace pollutants, Analysis of leachate.

TOTAL : 45 PERIODS

OUTCOMES:

CO1: Understand the basics of environmental monitoring
CO2: Able to select appropriate sampling protocol for chemical analysis
CO3: Understand various methods of analysis of pollutants in water
CO4: Select correct method for toxic pollutants estimation in air
CO5: Familiar with analysis of land and wastes

REFERENCES:

1. Reeve, R.N., "Introduction to Environmental Analysis", Analytical Techniques in the Sciences, John Wiley & Sons, Chichester, UK, 2002.
2. Barcelo, D.(editor), "Environmental analysis. Techniques, Applications and Quality Assurance", Elsevier, The Netherlands, 1996
3. Paul R. Loconto Trace Environmental Quantitative Analysis: Principles, Techniques, and Applications**,** Marcel Dekker; 2nd Edition , 2005,
4. Janick Artiola, Ian Pepper and Mark Brusseau**,** ENVIRONMENTAL MONITORING AND CHARACTERIZATION **,** Academic Press,2004.

CO – PO Mapping – ENVIRONMENTAL QUALITY MONITORING

		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
PO9	Ethics						
PO10	Environment and Sustainability	M				M	M
PO11	Project Management and Finance	M					M
PO12	Life Long Learning	M	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

EM5004 SLUDGE AND SEPTAGE MANAGEMENT L T P C
3 0 0 3

OBJECTIVES

- To gain knowledge and skills on sources, characteristics and treatment of sludge
- To understand the importance of septage management.

UNIT I SOURCES AND CHARACTERISTICS OF SLUDGE 9

Objectives of sludge treatment – sources of sludge- Sludge from WTP, STP and CETP-Sludge-Quantification-generation from various treatment plants – Characteristics in each stage of treatment –-Physico-chemical and biological-- Mass balance in sludge treatment

UNIT II SLUDGE THICKENING AND DEWATERING 9

Sludge thickening- Gravity thickening - Drum thickener - Air floatation – Centrifugation-conditioning -Sludge Dewatering- Centrifuge- Vacuum Filtration-Sludge drying bed- performance of thickener and dewatering systems-operation and maintenance

UNIT III SLUDGE STABILIZATION 9

Objectives-Aerobic and Anaerobic Sludge digestion processes – Types of anaerobic digesters – design of Low rate and High rate digesters – Two stage digester-Aerobic digestion- Pure oxygen and thermopilic aerobic digestion - Chemical and Thermal stabilization process

UNIT IV REUSE AND LAND APPLICATION OF SEWAGE SLUDGE 9

Introduction- beneficial use-requirements and associated risks-handling and management-storage - operation aspects of transport and application of biosolids application land- Lagooning-Landfilling- land farming-Composting-windrow composting -Vermicomposting -Laws and regulations on sludge management

UNIT V SEPTAGE MANAGEMENT 9

Sources of Septage – characteristics- Public health and environmental hazards- Elements of septage management- Pumping and Desludging Septic Tanks-Transportation- Treatment-Dewatered septage sludge reuse- Operation and maintenance - Planning and implementation of septage management schemes-Case studies

TOTAL : 45 PERIODS

OUTCOMES:

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

CO1	Understand sources and characteristics of various sources of sludge.
CO2	Design sludge thickening and dewatering units
CO3	Design of sludge stabilization units
CO4	Know about the requirements and associated risk while reusing sewage sludge
CO5	Plan and implement septage management scheme

REFERENCES

1. Septage management in urban India, National Urban Sanitation policy, Ministry of Urban Development Government of India,2013
2. National Policy on Faecal Sludge and Septage Management (FSSM) Ministry of Urban Development Government of India,2017
3. A.F. Ismail, Takeshi Matsuura, Membrane Technology for Water and Wastewater Treatment, Energy and Environment, CRC Press, 2016
4. Michael D. Nelson, Chair, Operation of municipal waste water treatment plants, Water environment federation, vol.2 liquid process.
5. Michael D. Nelson, Chair, Operation of municipal waste water treatment plants, Water environment federation, vol.1Management and support systems, sixth edition.
6. 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- SLUDGE AND SEPTAGE MANAGEMENT

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

EM5005 REMOTE SENSING AND GIS APPLICATIONS IN ENVIRONMENTAL MANAGEMENT **L T P C 3 0 0 3**

OBJECTIVES:

- To educate the students on the aspects of Remote Sensing and GIS and develop the knowledge of remote sensing and GIS for monitoring and management of environmental field.

UNIT I ELEMENTS OF REMOTE SENSING **9**

Historical Perspective, Principles of remote sensing, components of Remote Sensing, Energy source and electromagnetic radiation, Electromagnetic spectrum, Energy interaction, Spectral response pattern of earth surface features, Energy recording technology

UNIT II REMOTE SENSING TECHNOLOGY **9**

Classification of Remote Sensing Systems, Aerial photographs, Photographic systems – Across track and along track scanning, Multispectral remote sensing, Thermal remote sensing, Microwave remote sensing – Active and passive sensors, RADAR, LIDAR

UNIT III SATELLITE REMOTE SENSING **9**

Satellites and their sensors, satellite orbits, Indian space programme - Research and development - ISRO satellites, LANDSAT, ERS, SPOT, TERRA and NOOA satellite series, Characteristics of Remote Sensing data, Satellite data Products

UNIT IV REMOTE SENSING APPLICATIONS AND CASE STUDIES 9

Visual image interpretation, Digital image processing – Image rectification, Enhancement, transformation, Classification, Data merging – Remote sensing applications in Monitoring and management of environment - Conservation of resources, Disaster management, Sustainable urban land use, Agriculture, EIA, Marine and Coastal zone management – Case studies

UNIT V GEOGRAPHICAL INFORMATION SYSTEM CASE STUDIES 9

GIS - Concepts and components, Spatial and non-spatial data, Vector and raster data structures, Data analysis, Database management – RS – GIS Integration, Image processing software, GIS software GIS applications in Monitoring and management of environment - Case studies.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1	Know the remote sensing principle and the different stages of remote sensing
CO2	Understand the various type remote sensing technology.
CO3	Apply the knowledge of satellite sensing system for different environmental issues.
CO4	Apply the knowledge of GIS and image analysis for environmental applications.
CO5	Develop the GIS data base. And work with multi-disciplinary team.

REFERENCES:

1. Lillesand, T.M. and Kiefer, R.W, "Remote sensing and image interpretation", John Wiley and sons, New York, 2018.
2. Golfried Konechy, Geoinformation: "Remote sensing, Photogrammetry and Geographical Information Systems", CRC press, 1st Edition, 2017.
3. Burrough, P.A. and McDonnell, R.A., "Principles of Geographic Information systems" Oxford University Press, New York, 2017..
4. "Pmapler and Applications of Imaging RADAR", Manual of Remote Sensing, Vol.2, ASPR, 2011.

CO – PO Mapping- REMOTE SENSING AND GIS APPLICATIONS IN ENVIRONMENTAL MANAGEMENT

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		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		M
PO9	Ethics		M	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	H	M	H

EM5006 SUSTAINABLE AGRICULTURE AND ENVIRONMENTAL MANAGEMENT L T P C
3 0 0 3

OBJECTIVES:

- To educate the students to know the types and characteristics of different wastes and how effectively the wastes could be utilized for production of value added products to increase the crop yield.

UNIT I SOURCES OF WASTES AND IMPACT ON ENVIRONMENT 9

Types –domestic, Industrial- tannery, electroplating, fertilizer, textile, Dairy, pesticide, pulp and paper, distillery, rubber manufacturing, Agriculture- crop production, livestock production, poultry production, slaughtering, meat packaging, aquaculture, fish processing, horticulture, Characteristics – physical, chemical, biological, Impact – air, water, soil

UNIT II WASTEWATER CHARACTERISTIS 9

Guidelines – irrigation water quality criteria, wastewater quality in relation to soils, plant growth and public health – Trace elements and heavy metals – Salinity – Irrigation water salinity hazard, soil permeability hazard, specific ions – chlorides, aluminum, nitrogen, phosphorus, potassium, miscellaneous problems, organic matter

UNIT III WASTEWATER FOR IRRIGATION 9

Management in relation to land use and environment, total land area requirement – storage lagoons, irrigation area, Irrigation methods – flood irrigation, furrow irrigation, spray irrigation, - micro irrigation – soil water – Irrigation scheduling – Irrigation for food crops – cereals, pulses, millets, fruits and vegetables – irrigation for non-food crops – trees, pastures, leaching

UNIT IV AGRICULTURAL USE OF SLUDGE 9

Sludge characteristics – Pretreatment technologies - organic matter reduction, nurients solubilization, pathogens reduction, trace organic contaminants removal, heavy metal removal – sludge treatment – sludge pasteurization, mesophilic anaerobic digestion, composting, vermicomposting, stabilization, dewatering and storage

UNIT V EFFECT OF WASTES ON AGRICULTURE 9

Utilization of municipal and industrial organic wastes in agriculture – benefits, limitations, Management practices- crop residue reuse – amendments – mulching- soil aeration, water holding capacity, soil nutrition, crop yield, Industrial wastes for pest and disease management - Risks involved – crop health, animal health, groundwater quality, surface water quality, air quality - Case studies

TOTAL: 45 PERIODS

OUTCOME

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

CO1	Explain the various types of wastes generated from industries and domestic and their physical, chemical and biological characteristics and their impacts on the environment
CO2	To study the possibilities of utilizing the wastewater generated by different means, requirement for treating the wastewater and utilising it irrigation
CO3	Get knowledge on the sludge generated by various industrial processes, their characteristics and converting it into nutritive products for increasing crop yield
CO4	Select appropriate techniques to enumerate the pathogens in wastewater, exploitation of microorganisms to indicate the various pollutants in water and design experiments to remove the pollutants from wastewater using microorganisms
CO5	Apply the knowledge to design appropriate methods or experiments to treat the wastewater to remove the nutrients by utilising the suitable microorganisms, their nutrient requirement and the metabolic pathway

REFERENCES:

1. Wealth from Waste, S. C. Bhatia, Atlantic Publishers, 2007
2. Farmers Handbook on Basic Agriculture, Chandra Sekar et al,(Eds), 2016
3. The complete Technology Book on Vermiculture and Vermicomposting, NPCS Board of Consultants and Engineers, Asia Pacific Business Press Inc., 2004
4. Biomass Based Products, NPCS Board of Consultants and Engineers, Asia Pacific Business Press Inc., 2015
5. Agricultural Waste Management Problems, Processes and Approaches 1st Edition, Raymond Loehr(Ed.) Academic Press, 1974.
6. Science and technology of Organic farming, Allen V Barker(Ed.) CRC Press, 2010
7. Principles of Agronomy for Sustainable Agriculture, Villalobos, Francisco J., Fereres**,** Elias (Eds.), Springer, 2016.

CO – PO Mapping- SUSTAINABLE AGRICULTURE AND ENVIRONMENTAL 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	M	M		M	M	M
PO3	Design / development of solutions					H	H
PO4	Investigation		M	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	M	H	H	H		H
PSO2	Environmental Performance Evaluation and coordination	M	M	M	M	M	M
PSO3	Conceptualization of Environmental Management Systems			H	H		H

EM5007 LIFE CYCLE ANALYSIS AND DESIGN FOR THE ENVIRONMENT L T P C
3 0 0 3

OBJECTIVES:

- To impart knowledge and skills on the concept and methodology of Life Cycle Assessment as per international standards and its potential applications to develop sustainable products and promote sustainable consumption.

UNIT I LIFE CYCLE THINKING AND LIFE CYCLE MANAGEMENT 9

Introduction to Life Cycle Thinking – Industrial ecology – Life cycle management (LCM) and Stakeholder Expectations - LCM drivers and issues - materials flow analysis - Life cycle of Products and services- International organizations and networks - History and definition of LCA - analytical tools for product and service systems —-Value creation along the life cycle–technical characteristics – applications - limitations

UNIT II LCA GOAL, SCOPE AND INVENTORY 9

ISO 14040 framework for LCA - Life cycle goal and scope definition - function, functional unit and reference flow System boundaries, data categories, inputs and outputs, data quality, critical review and other procedural aspects - Inventory Analysis: Raw Material Extraction and Processing , Manufacturing and Production , Product Use and Consumption , End-of-life Management , Transportation and Distribution - Dealing with Allocation Issues - Solutions to the multifunctionality problem - Flow diagram - Format and data categories - Attributional versus consequential LCI – LCA softwares and database - Data quality - Data collection and relating data to unit processes – Data validation - Cut-off and data estimation -

UNIT III LIFE CYCLE IMPACT ANALYSIS AND INTERPRETATION 9

Characterization factors and principle of characterization - Selection of impact categories, category indicators and characterization models – Classification -Characterization - Optional elements - normalization , grouping, weighting ,data quality analysis - Characterization models – Impact assessment Case studies -Simplified/streamlined Life Cycle Assessments - procedural approaches, numerical approaches - Examples of numerical approaches - contribution analysis, perturbation analysis, uncertainty - analysis, comparative analysis, key issue analysis - Treatment of uncertainties - Elements in uncertainty handling - Sensitivity of LCA results - Sustainability analysis - Extending LCA - economic dimension, social dimension - Life cycle costing - Eco-efficiency - Combining LCA and LCC – Case studies

UNIT IV DESIGN FOR ENVIRONMENT AND ECOLABELLING 9

Sustainable consumption – Eco-efficiency - green consumerism - product stewardship and green engineering - Extended producer responsibility – Design For Environment Strategies, Practices, Guidelines, Methods, And Tools .Ecodesign strategies –Design for Disassembly - Dematerialization, rematerialization, transmaterialization – Green procurement and green distribution - Analysis framework for reuse and recycling – Typical constraints on reuse and recycling - Communication of Life Cycle Information - Indian ecomark scheme - Environmental product declarations – Environmental marketing

UNIT V LCA SOFTWARES AND CASE STUDIES 9

LCA Softwares - LCA Software Demo: SimaPro, GREET, BEES, CMU EIO,GABI - Advances in LCA: Hybrid LCA, Thermodynamic LCA - LCA case studies on Product Design, Product Improvement, Product Comparison and Policy development.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1	explain the various functional elements of Life Cycle Analysis and Design for Environment
CO2	apply the knowledge of science and engineering fundamentals to characterize the environmental interactions of products and services
CO3	design of engineering systems taking into account the material flow and pollutant interactions between engineering decisions and the environment
CO4	select appropriate LCA tools to support product/process design and decision making, taking into account the impact of the solutions in a sustainability context
CO5	conduct research pertinent to Life Cycle Management and communicate effectively to different stakeholders in terms of eco labels as well as engage in independent life-long learning

REFERENCES:

1. ISO 14040-2016-Environmental management - Life cycle assessment - Principles and framework, International Organization for Standardization, 2016
2. T. E. Graedel, Braden R. Allenby, Industrial Ecology and Sustainable Engineering, Prentice Hall, 2010
3. Ralph Horne, Tim Grant, Karli Verghese, Life Cycle Assessment: Principles, Practice and Prospects, Csiro Publishing, 2009

4. ISO/TR 14047:2003, Environmental management - Life cycle impact assessment - Examples of application of ISO 14042, International Organization for Standardization, 2007
5. International Organization for Standardization: ISO TR 14062 Environmental management - Integrating environmental aspects into product design and development, 2002.
6. European Commission - Joint Research Centre - Institute for Environment and Sustainability: International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment - Detailed guidance. Luxembourg. European Union; 2010
7. Catherine Benoît, UQAM/CIRAIG, and Bernard Mazijn, Guidelines for Social Life Cycle Assessment of Products, United Nations Environment Programme,2009

CO – PO Mapping – LIFE CYCLE ASSESSMENT AND DESIGN FOR ENVIRONMENT

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
PO5	Modern Tool Usage					H	H
PO6	Individual and Team work		M	M	M	M	M
PO7	Communication					L	L
PO8	Engineer and Society	M			M	M	M
PO9	Ethics	M				M	M
PO10	Environment and Sustainability	H	H	H	H	H	H
PO11	Project Management and Finance						
PO12	Life Long Learning					L	L
PSO1	Knowledge of Environmental Management discipline	H	M	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

EM5008 ENERGY MANAGEMENT IN INDUSTRIES L T P C
3 0 0 3

OBJECTIVES:

- To provide an understanding of the basics of energy conservation method and energy auditing in industries
- To understand the environmental and economical benefits associated with energy management.

UNIT I INTRODUCTION 8

Energy Scenario – India and World – Energy Resources in India – Energy consumption Pattern, Energy Conservation and Energy Efficiency – Needs and Advantages, Role of Energy Manager – Energy Conservation Act.

UNIT II AUDITING AND INSTRUMENTATION IN ENERGY MANAGEMENT 9

Energy Audit – Purpose, Types, Methodologies, Barriers with respect to Process Industries, Power Plants, Boilers and Certain Energy Intensive Industries; Energy Audit Questionnaire - Role of instrumentation in energy conservation - total energy systems - concept of total energy – advantages, limitations & Application.

UNIT III ENERGY MANAGEMENT 9

Thermal energy management-Various Energy management Measures in Steam Systems – Losses in Boiler – Methodology of upgrading Boiler programme – Energy Conservation in Refrigeration and Air-conditioning Systems - Electrical Energy management- Potential Areas for Electrical Energy management in Various Industries-Energy Management Opportunities in Electrical Heating, Lighting system, Cable selection - Energy Efficient Motors - Factors involved Determination of Motor Efficiency Adjustable AC Drives, Applications & its use variable speed Drives/Belt Drives

UNIT IV ENERGY ECONOMICS 8

Energy Economics – Discount Rate, Payback Period, Internal Rate of Return, Life Cycle Costing, risk and Sensitivity Analysis, Financing Options, Energy Performance Contract and Role of ETCOS.

UNIT V APPLICATIONS 8

Case studies on sugar Industry –Co generation, Thermal power plant; Petrochemical Industries.

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1	Understand Energy Scenario and Energy Resources in India and Energy consumption Pattern, Energy Conservation and Energy Efficiency, Needs and Advantages, Role of Energy Manager and Energy Conservation Act.
CO2	Understand principles of Energy Audit and Methodologies, Barriers with respect to Process Industries, Power Plants, Boilers and Certain Energy Intensive Industries;
CO3	Understand various Energy management Measures in Steam Systems
CO4	Estimate Energy Economics, Life Cycle Costing, risk and Sensitivity Analysis, understand Financing Options and Energy Performance
CO5	Plan energy management measures for sugar Industry –Co generation, Thermal power plant; Petrochemical Industries based on similar case studies.

REFERENCES:

1. Handbook on Energy Efficiency, TERI, New Delhi, 2001
2. Jefferson W. Tester, Elisabeth M. Drake, Michael J Driscoll, Michael W. Golay, William A Peters, Sustainable Energy – Choosing among options, Prentice Hall of India, 2006
3. Murphy W.R. and Mckay G., Energy Management, Elsevier, 2007.
4. Roger A. Hinrichs and Merlin H. Kleinbach, Energy: Its Use and the Environment, Cengage Learning, 2012.
5. Barney L. Capehart, Wayne C. Turner and William J. Kennedy, Guide to Energy Management, 7th Ed., Keinnedu Fairmant Press, 2011.

CO – PO Mapping – ENERGY MANAGEMENT IN INDUSTRIES

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
PO5	Modern Tool Usage					H	H
PO6	Individual and Team work		M	M	M	M	M
PO7	Communication					L	L
PO8	Engineer and Society	M			M	M	M
PO9	Ethics	M				M	M
PO10	Environment and Sustainability	H	H	H	H	H	H
PO11	Project Management and Finance						

PO12	Life Long Learning					L	L
PSO1	Knowledge of Environmental Management discipline	H	M	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

EM5009 ENVIRONMENT, HEALTH AND SAFETY IN INDUSTRIES L T P C
3 0 0 3

OBJECTIVES:

- To educate overview of EHS in industries and related Indian regulations, types of Health hazards, effect, assessment and control methods and EHS Management System

UNIT I INTRODUCTION 9

Need for developing Environment, Health and Safety systems in work places- International initiatives, National Policy and Legislations on EHS in India - Regulations and Codes of Practice - Role of trade union safety representatives - Ergonomics.

UNIT II OCCUPATIONAL HEALTH AND HYGIENE 10

Definition of occupational health and hygiene - Categories of health hazards – Exposure pathways and human responses–Exposure Assessment-occupational exposure limits - Hierarchy of control measures - Role of personal protective equipment and the selection criteria

UNIT III WORKPLACE SAFETY AND SAFETY SYSTEMS 11

Features of Satisfactory and Safe design of work premises – good housekeeping - lighting and color, Ventilation and Heat Control, Noise, Chemical and Radiation Safety – Electrical Safety – Fire Safety – Safety at Construction sites, ETP – Machine guarding – Process Safety, Working at different levels

UNIT IV HAZARDS AND RISK MANAGEMENT 8

Safety appraisal – Job Safety Analysis-Control techniques – plant safety inspection – Accident investigation - Analysis and Reporting – Hazard and Risk Management Techniques –Onsite and Offsite emergency Plans. Employee Participation- Education and Training- Case Studies

UNIT V ENVIRONMENTAL HEALTH AND SAFETY MANAGEMENT 7

Concept of Environmental Health and Safety Management – Elements of Environmental Health and Safety Management Policy and implementation and review – ISO 45001-Strucure and Clauses-Case Studies

TOTAL: 45 PERIODS

OUTCOMES:

After completion of this course, the students are expected to be able to understand:

CO1	Need for EHS in industries and related Indian regulations
CO2	Various types of Health hazards, effect, assessment and control methods
CO3	Various safety systems in working environments
CO4	The methodology for preparation of Emergency Plans and Accident investigation
CO5	EHS Management System and its elements

REFERENCES:

1. ISO 45001:2018 Occupational health and safety management systems - Requirements with guidance for use, International Organisation for Standardisation, 2018
2. Industrial Health and Safety Acts and Amendments, by Ministry of Labour and Employment, Government of India
3. Fundamentals of Industrial Safety and Health by Dr.K.U.Mistry, Siddharth Prakashan, 2012
4. The Facility Manager's Guide to Environmental Health and Safety by Brian Gallant, Government Inst Publ., 2007.
5. Effective Environmental, Health, and Safety Management Using the Team Approach by Bill Taylor, Culinary and Hospitality Industry Publications Services, 2005.
6. Environmental and Health and Safety Management by Nicholas P.Cheremisinoff and Madelyn L. Graffia, William Andrew Inc. NY, 1995

CO – PO Mapping – ENVIRONMENT, HEALTH AND SAFETY IN INDUSTRIES

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

EM5010 LANDFILL ENGINEERING AND REMEDIATION TECHNOLOGIES L T P C
3 0 0 3

OBJECTIVE:

- To understand the important characteristics and design principles of the waste containment and remediation industry as well as know the relevant regulations and engineering design requirements of landfills and contaminated site remediation

UNIT I LANDFILL BASICS 8

Waste management Hierarchy- Need for landfills –Environmental Protection by Landfills- Landfill Classification – Sanitary and Secure Landfills - Components and Configuration - Legal framework for landfilling – Landfill Site investigation- Regional Landfills- Environmental control using site design –- Landfill Design Tasks

UNIT II LANDFILL LINERS AND COVER SYSTEMS 10

Landfill barrier system components – Design of Compacted clay liners: Factors affecting hydraulic conductivity , Water content-density criteria, Thickness, Desiccation - Geo synthetic Clay Liners and Geomembranes; types, manufacturing, handling, seaming and testing - Asphalt Barriers and Capillary barrier - Composite Liner system design- liner construction and quality control- Leakage through Liners- vapor transmission and chemical compatibility - Installation of Geo membranes - Liner Leakage Mechanism – Diffusion - Controls on advection through liners - Single phase flow-advection-diffusion- Landfill cover systems- Design of Cover Systems – Daily Cover – Intermediate Cover – Final Cover - Flow through Landfill Covers- Design and Analysis of Slope Stability- Anchor Trenches- Access ramps - Erosion control

UNIT III LEACHATE AND LANDFILL GAS MANAGEMENT 9

Waste decomposition in landfills - Factors affecting leachate and landfill gas generation – Factors affecting Leachate Quantity in active and post closure conditions- Hydrologic Evaluation of *Landfill* Performance (HELP) model – Leachate Drainage Layer – Geotextile and Geonet design – achate Collection and Removal systems-Temporal trends in leachate composition – Design of Landfill gas collection and removal systems- Gas condensate issues & knockouts - Leachate treatment methods (biological and physico-chemical)- Leachate re-circulation & bioreactor landfills-monitoring and control of leachate and Landfill gas- Landfill Settlement

UNIT IV LANDFILL OPERATION AND CLOSURE 8

Landfill Construction and Operational Controls – Fill Sequencing Plans – Cell Construction- Dozer and Compactor operations-Selection of Landfill Equipment- Landfill Administration-Record Keeping - Topographic mapping-Environmental Controls – Odour, Vector and Litter Control – Landfill Safety - Fire Control – Ground and Surface water Monitoring – Methane Gas monitoring - Audits of landfill environmental performance and management – Post Closure care and use of landfills – Landfill Economics- landfill construction and operational cost estimation – establishing tipping fees

UNIT V CONTAMINATED SITE REMEDIATION 10

Contaminated sites - Fate and behaviour of toxics and persistent substances in the environment – Engineering Issues in Site Remediation - Site Characterization - Framework for risk assessment at landfill sites - Remediation Principles: Source Control and Management of Migration Covers, Cut-off Walls, Solidification / Stabilization - Pump-and-Treat Systems - Solvent Vapor Extraction, Air Sparging, Soil Flushing – Bioremediation - Natural Attenuation - Remedy Selection and Risk Assessment – Geotechnical Aspects of In Situ Remediation Technology - Specific case studies in contaminated site remediation – Rehabilitation of Open dumps- Landfill Mining

TOTAL: 45 PERIODS

OUTCOMES:

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

CO1	Have an overview of the Indian and international landfill regulations and guidelines for the design, construction, operation and management of landfills
CO2	Understand the design and construction of landfills, processes in landfills, methods for management and treatment of landfill gas and leachate
CO3	Have an in-depth understanding of the key pollutants in leachate and gas, their potential environmental impacts and the
CO4	Make engineering design and study performance of control systems used to manage and treat pollutant and waste emissions from sites.
CO5	Be able to apply a risk based assessment of contaminated sites and implement site remediation technologies

REFERENCES:

1. Robert M. Koerner and Donald H Gray "Geotechnical aspects of Landfill Design and Construction", Prentice Hall, New Jersy.2002
2. Neal Bolton P.E “The Handbook of Landfill Operations”, Blue Ridge Services Inc., Atascadro, CA – ISBN 0-9646956-0-x, 1995

3. David E Daniel and Robert M. Koerner "Waste Containment Facilities –Guidance for construction Quality Assurance and Construction Quality Control of Liner and Cover Systems, American Socirty of Civil Engineers, ASCE Press.2007,
4. Donald L Wise and Debra J Trantolo, "Remediation of Hazardous Waste Contaminated Soils, Marcel Dekker Inc., New York,1994
5. George Tchobanoglous, Hilary Theisen and Samuel A, Vigil, "Integrated Solid Waste Management, Mc-Graw Hill International edition, New York, 1993.
6. Hari D Sharma and Krishna R. Reddy, Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Techonolgies, John Wiely, New Jersy, 2004
7. Oweis, I.S. and Khera, R.P *Geotechnology of Waste Management*, 2nd Edition, PWS Publishing Co., Boston, MA, 1998

CO – PO Mapping – LANDFILL ENGINEERING AND REMEDIATION TECHNOLOGIES

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		H	
PO3	Design / development of solutions		H		H	H	
PO4	Investigation			M			
PO5	Modern Tool Usage				M	M	
PO6	Individual and Team work		M		M	M	
PO7	Communication						
PO8	Engineer and Society			H	H	H	
PO9	Ethics						
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	

EM5011 ENVIRONMENTAL TOXICOLOGY AND MONITORING L T P C
3 0 0 3

OBJECTIVE

- To impart knowledge on the environmental toxicology.
- To understand the toxicants in the environment, its toxic action, and its implication of human health.
- To understand the toxicants in air, water and soil and their effects, and mechanism of action on the body.
- To study the metabolism of toxicants, their fate and transport in the environment, and risk assessment.

UNIT I INTRODUCTION TO TOXICOLOGY 8

Definition of Environmental toxicology, basics of toxic action, biochemical, molecular, behavioural, nutritional toxicology, applications of toxicology in clinical, veterinary, forensic and environmental sciences, Regulatory issues in toxicology.

UNIT II TOXICANTS IN AIR, WATER AND SOIL 12

Sources of toxic compounds, dose response relationships, exposure classes, movement of toxicants in the environment, toxicants in air, water, soil, domestic and occupational environments—types of air pollutants, particulate matter, sources and environmental effects.

UNIT III TOXICANTS AND TOXIC ACTION 10

Classes of toxicants, common toxic mechanisms and action of lead, cadmium mercury, chromium, arsenic and pesticides and their mode of action. Food additives and flavours, toxins from microbes and their action.

UNIT IV METABOLISM OF TOXICANTS 8

Toxicants and metabolic reactions involving toxicants, physiological effects, genetic effects, environmental effects, nutritional effects of toxicants. Environmental persistence, degradation, accumulation. Toxicity testing—acute toxicity, chronic toxicity

UNIT V FATE OF TOXICANTS AND RISK ASSESSMENT 7

Fate of toxicants in the environment, risk assessment—sources and transport of toxicants, transformation and environmental fate of toxicants and monitoring. Risk assessment of toxicants, prevention of toxicity, human health risk, exposure and characterization of risk and management.

TOTAL : 45 PERIODS

OUTCOMES:

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

CO1	Understand basics of Environmental toxicology, biochemical, molecular behavioural, nutritional toxicology, applications, Regulatory issues in toxicology.
CO2	Understand Sources of toxic compounds, dose response relationships, exposure classes, movement of toxicants in the environment, toxicants in air, water, soil, domestic and occupational environments
CO3	Understand Classes of toxicants, common toxic mechanisms and action of lead, cadmium mercury, chromium, arsenic and pesticides and their mode of action
CO4	Understand toxicants and metabolic reactions involving toxicants, physiological effects, genetic effects, environmental effects, nutritional effects of toxicants. Environmental persistence, degradation, accumulation.
CO5	Understand the fate of toxicants in the environment, risk assessment—sources and transport of toxicants, transformation and environmental fate of toxicants and monitoring.

REFERENCES:

1. Calow. P. (1994). Handbook of Ecotoxicology. Blackwell Scientific Publications, London.
2. Forbes V.E. and T. L. Forbes (1994). Ecotoxicology in Theory and Practice. Chapman & Hall, London.
3. Hayes W.A. (2001). Principles and Methods of Toxicology, CRC Press, USA
4. Jacobson – Kram, D. (2006). Toxicological Testing Handbook: Principles, Applications and Data Interpretation, Taylor and Francis, New York.
5. Klaassen C.D. and Watkins, J.B. (2003). Essentials of Toxicology, McGraw Hill Professional, New Delhi.
6. Levin, S. A. and M. A. Harwell, J. R. Kelley and K. D. Kemball (1989). Ecotoxicology: Problems and Approaches. Springer-Verlag, New York.
7. Pery, G. (1980). Introduction to Environmental Toxicology, Elsevier, Amsterdam.
8. Subramanian M. A. (2004). Toxicology – Principles and Methods, MJP publishers, Chennai.
9. Walker, C.H., R.M. Sibly, S.P. Hopkin and D.B. Peakall (2012). Principles of Ecotoxocology, CRC Press, New York.
10. Wright D. A and P. Welbourn (2002). Environmental Toxicology, Cambridge Univ. Press, London.

CO – PO Mapping – ENVIRONMENTAL TOXICOLOGY AND MONITORING

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			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	

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	

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

OBJECTIVE:

- To impart knowledge on types and sources of Air Pollution and 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 – Long- term 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", Mc Graw 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

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 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.