CURRICULU AND SYLLABUS (R20150

CHOICE BASED CREDIT SYSTEM

M.TECH – ENVIRONMENTAL ENGINEERING
(FULL TIME)
I – IV SEMESTERS

SEMESTER – I							
S.No	**Category**	**Code**	**Subject Name**	**L**	**T**	**P**	**C**
1	PM	MMA108	Statistics for Environmental Engineers	4	0	0	4
2	PC	MER101	Environmental Chemistry	3	0	0	3
3	PC	MER102	Environmental Microbiology	3	0	0	3
4	PC	MER103	Air Pollution and Control	3	0	0	3
5	PC	MER104	Water and Sewage Conveyance	3	0	0	3
6	PC	MER1L1	Environmental Engineering Lab	0	0	4	2
			Total	16	0	4	18

SEMESTER – II

S.No	**Category**	**Code**	**Subject Name**	**L**	**T**	**P**	**C**
1	PC	MER201	Solid and Hazardous Waste Management	3	0	0	3
2	PC	MER202	Physical and Chemical Treatment of Water and Wastewater	3	1	0	4
3	PC	MER203	Biological Treatment of Wastewater	3	0	0	3
5	PC	MER204	Industrial Wastewater Management	3	0	0	3
6	PE	MER2E1	Professional Elective – I	3	0	0	3
7	PE	MER2E2	Professional Elective – II	3	0	0	3
8	PE	MER2E3	Professional Elective – III	3	0	0	3
			Total	21	1	0	22

SEMESTER – III

S.No	Category	Code	Subject Name	L	T	P	C
1	PE	MER3E1	Professional Elective – IV	3	0	0	3
2	PE	MER3E2	Professional Elective – V	3	0	0	3
3	OE	MER3E3	Open Elective	3	0	0	3
4	PR	MER3P1	Project Work (Phase – I)	0	0	12	6
			Total	9	0	12	15

SEMESTER – IV

S.No	Category	Code	Subject Name	L	T	P	C
1	PR	MER4P1	Project Work (Phase – II)	0	0	24	12
			Total	0	0	24	12

Total Credits for the Programme – 67

LIST OF ELECTIVES

PROFESSIONAL ELECTIVE (PE I)

S.No.	Code	Subject Name	L	T	P	C
1	MER051	Environmental Quality Modeling	3	0	0	3
2	MER052	Instrumental Monitoring of Environment	3	0	0	3
3	MER067	Advanced Oxidation Process	3	0	0	3

PROFESSIONAL ELECTIVE (PE II)

S.No.	Code	Subject Name	L	T	P	C
4	MER055	Ground Water Contamination and Transport Modelling	3	0	0	3
5	MER058	Indoor Air Quality	3	0	0	3
6	MER065	Environmental Impact Assessment	3	0	0	3

PROFESSIONAL ELECTIVE (PE III)

S.No.	Code	Subject Name	L	T	P	C

7	MER054	Ecological Engineering	3	0	0	3
8	MER056	Environmental Bio Technology	3	0	0	3
9	MER057	Membrane Separation for Water and Wastewater Treatment	3	0	0	3

PROFESSIONAL ELECTIVE (PE IV)

S.No.	Code	Subject Name	L	T	P	C
10	MER060	Environmental Policies and Legislation	3	0	0	3
11	MER064	Unit Operations and Unit Processes in Environmental Technology	3	0	0	3
12	MER059	Landfill Engineering and Remediation Technology	3	0	0	3

PROFESSIONAL ELECTIVE (PE V)

S.No.	Code	Subject Name	L	T	P	C
13	MER063	Marine Pollution Monitoring	3	0	0	3
14	MER053	Remote Sensing and GIS for Environmental Applications	3	0	0	3
15	MER062	Mass Transfer In Air – Water Soil Interaction	3	0	0	3

LIST OF OPEN ELECTIVES

S.No.	Code	Subject Name	L	T	P	C
16	MER061	Environmental Engineering Structures	3	0	0	3
17	MER066	Environment, Health and Safety in Industries	3	0	0	3
18	MER068	Research Methodology	3	0	0	3

SUMMARY OF CURRICULUM STRUCTURE AND CREDIT & CONTACT HOUR DISTRIBUTION

SYLLABUS

MMA108	**STATISTICS FOR ENVIRONMENTAL ENGINEERS**	**L**	**T**	**P**	**C**
	Total Contact Hours:45	**4**	**0**	**0**	**4**
	Prerequisite: Numerical Methods				
	Course Designed by :Department of Civil				

OBJECTIVES To Train the students in the analysis of Environmental data using Statistical tools

COURSE OUTCOMES (COs)

CO1	To make them understand the measures of Central tendency and Dispersion for grouped ungrouped Data.
CO2	To know the basics of estimation theory and Curve fitting by Principles of least squares and Regression lines.
CO3	To understand about Sampling distributions
CO4	To improve the knowledge on Design of Experiments and Analysis of variance
CO5	To know about the Statistical Policy Control and Statistical quality control

Mapping of Course Outcomes with Program outcomes (POs)
(H/M/L indicates strength of correlation) H-High, M-Medium, L-Low

1	COs/Pos	PO1	PO2	PO3	PO4	PO5
2	CO1	H		M	L	
	CO2	M		H		L
	CO3	L	M			H
	CO4	H		M	L	
	CO5	L		M		H
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
		√				

4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016

UNIT I EMPIRICAL STATISTICS **9**

Types of Sampling – Description of Discrete and continuous data – measures of Central tendency and Dispersion for grouped and ungrouped Data – Measures of position- Box and Whisker plot.

UNIT-II ESTIMATION THEORY **9**

Unbiased estimators – Methods of movements – Maximum Likelihood estimation – Curve fitting by Principles of least squares – Regression lines.

UNIT-III TESTING OF HYPOTHESIS **9**

Sampling distributions – Type-I and Type-II errors – Tests based on normal, t, $X^2$and F distributions for testing of mean, Arians and proportions-Test for independence of attributes and goodness of fit.

UNIT-IV DESIGN OF EXPERIMENTS **9**

Analysis of variance – one –way and two way classifications – completely randomized design-Randomized block design – Latin square designs.

UNIT-V STATISTICAL POLICY CONTROL **9**

Statistical quality control – Statistical process control – X and R or S, control chart – Attributes control chart – P-Chart and U-Chart – Control chart Performance.

Total Periods : 45

REFERENCES:

1. Montgomery, D.C and Runger .G.C..," Applied Statistics and probability for Engineers", Wiley Student Edition.2007.

2. Walpole,R.E.Myers, R.H,Mters,S.L.andye.K."Probability and statistics forengineers and scientists " Pearson education, Asia ,8th edition,2007.

3. Mann.P.S."Introductory Statistics" John wiley and sons, Inc 5th edition,2004.

4. Johnson.R.A.andgupta,C.B.” Miller and Freund’s Probability and statistics for Engineers ,” Pearson education,Asia,7th edition,2007.

MER101	ENVIRONMENTAL CHEMISTRY	L	T	P	C
	Total Contact Hours:45	3	0	0	3
	Prerequisite:Environmental studies				
	Course Designed by : Department of Civil Engineering				

OBJECTIVES

To educate the students in the area of water air and soil chemistry and train them in the laboratory in the determination of pollutants present in air,water, wastewater and soil.

COURSE OUTCOMES (COs)

CO1	To make them understand the fundamentals of chemistry, mainly green Chemistry and chromatographic principles
CO2	To know the basics of degradation principles, mainly degradation of pesticides, food stuffs etc.
CO3	To understand about the basics of aquatic chemistry and redox reactions
CO4	To improve the knowledge on the fundamentals of atmospheric Chemistry and various regions of atmosphere
CO5	To know about the soil Chemistry,salt and ion exchange theory

Mapping of Course Outcomes with Program outcomes (POs)
(H/M/L indicates strength of correlation) H-High, M-Medium, L-Low

1	COs/Pos	a	b	c	d	e
2	CO1	L	M		H	
	CO2	L			M	H
	CO3		H	L	M	
	CO4		H	L	M	
	CO5	M	H		M	

3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
			√			
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

UNIT-I FUNDAMENTALS **9**

Colloids – Redox Potentials – Partition Co-Efficient – Beer – Lambert's Law – Limitations UV Visible Spectroscopy – Basic Principle – Application – Atomic Absorption Spectroscopy – Principles- Applications Gas Chromatograph Principles And Applications – Principles Of Green Chemistry - Error Analysis of Environmental Data.

UNIT-II DEGRADATION **9**

Transport and Transformation Of Chemicals – DO, BOD And COD – Photo Catalysis – Degradation of Food Stuffs, Detergents, Pesticides And Hydrocarbons.

UNIT-III AQUATIC CHEMISTRY **9**

Metals, Complex Formation, Oxidation And Reduction And Sorption – Eh – PH Diagrams- Chemical Speciation – QSAR – Risk Evaluation Of Chemicals.

UNIT-IV ATMOSPHERIC CHEMISTRY **9**

Regions Of Atmosphere- Chemical And Photochemical Reactions – Photochemical Smog , Ozone Layer Depletion – Green House Gases And Global Warming – Acid Rain.

UNIT-V SOIL CHEMISTRY **9**

Soil Properties Clay Minerals – Acid – Base And Ion Exchange Reactions In Soil – Salt affected Soil And Its Remediation

Total Periods : 45

REFERENCES:

1.C.N. Sawyer, P.L. MacCarty and G.F. Parkin , Chemistry for Enviromental Engineering and Science , Tata MeGraw – Hill, fifth edition, New Delhi, 2003.

2.G.W. Vanloon and S.J. Duffy "Environmental Chemistry - a global perspective oxford university press, New York ,2000.

3.D.W. Connell, Basic concepts of Environmental Chemistry , Lewis publishers, New York, 1997.

4. Colin Baird ,"Environmental Chemistry" , Freeman and Company, New York, 1997.

5. S.E. Manathan, Environmental Chemistry , Sixth Edition, Lewis Publishers, New York, 1994.

MER 102	**ENVIRONMENTAL MICROBIOLOGY**	**L**	**T**	**P**	**C**
	Total Contact Hours:45	**3**	**0**	**0**	**3**
	Prerequisite:Environmental Engineering-I,II				
	Course Designed by : Department of Civil Engineering				

OBJECTIVES

To educate the students in microbiology and its applications in environmental engineering, an train them in experiments related to microbiological examination of water.

COURSE OUTCOMES (COs)

CO1	To make them understand the fundamentals of classification of micro organisms,its culturing modes.
CO2	To know the basics of microbiology of environment and the distribution of microorganisms on land,air,water.
CO3	To understand about the metabolism of micro organisms and various modes of respirati

	in detail					
CO4	To improve the knowledge on the Biodegradation of toxic pollutants and its mechanism					
CO5	To know about the basics of the branch of toxicology and the term ecotoxicology					
Mapping of Course Outcomes with Program outcomes (POs) (H/M/L indicates strength of correlation) H-High, M-Medium, L-Low						
1	COs/Pos	a	b	c	d	e
2	CO1	L	H		M	
	CO2		H	L		M
	CO3	M		H		L
	CO4	H		L		M
	CO5		M	L		H
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
			√			
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

UNIT I EMPIRICAL STATISTICS **9**

Types of Sampling – Description of Discrete and continuous data – measures of Central tendency and Dispersion for grouped and ungrouped Data – Measures of position- Box and Whisker plot.

UNIT-II ESTIMATION THEORY **9**

Unbiased estimators – Methods of movements – Maximum Likelihood estimation – Curve fitting by Principles of least squares – Regression lines.

UNIT-III TESTING OF HYPOTHESIS 9

Sampling distributions – Type-I and Type-II errors – Tests based on normal, t, $X^2$and F distributions for testing of mean, Arians and proportions-Test for independence of attributes and goodness of fit.

UNIT-IV DESIGN OF EXPERIMENTS 9

Analysis of variance – one –way and two way classifications – completely randomized design-Randomized block design – Latin square designs.

UNIT-V STATISTICAL POLICY CONTROL 9

Statistical quality control – Statistical process control – X and R or S, control chart – Attributes control chart – P-Chart and U-Chart – Control chart Performance.

Total Periods : 45

REFERENCES:

1. Montgomery, D.C and Runger .G.C..," Applied Statistics and probability for Engineers", Wiley Student Edition.2007.

2. Walpole,R.E.Myers, R.H,Mters,S.L.andye.K."Probability and statistics forengineers and scientists " Pearson education, Asia ,8th edition,2007.

3. Mann.P.S."Introductory Statistics" John wiley and sons, Inc 5th edition,2004.

4.Johnson.R.A.andgupta,C.B." Miller and Freund's Probability and statistics for Engineers ," Pearson education,Asia,7th edition,2007.

MER103	**AIR POLLUTION AND CONTROL**	**L**	**T**	**P**	**C**
	Total Contact Hours:45	**3**	**0**	**0**	**3**
	Prerequisite:Environmental studies				

	Course Designed by : Department of Civil Engineering					
OBJECTIVESTo educate the students on various methods of control of particulate and gaseous air pollutants						
COURSE OUTCOMES (COs)						
CO1	To make them understand the fundamentals of air quality management classification of micro organisms,its culturing modes.					
CO2	To understand about the methods of particulate control like gravitational and centrifugal filters					
CO3	To understand in detail about the phenomenon of adsorption and absorption thus explaining more on control of gaseous air contaminants.					
CO4	To improve the knowledge on the emerging trends of air pollution control and discuss i detail about automobile air pollution					
CO5	To know about the basics of the standards of noise pollution and methods to prevent air pollution					
Mapping of Course Outcomes with Program outcomes (POs) (H/M/L indicates strength of correlation) H-High, M-Medium, L-Low						
1	COs/Pos	a	b	c	d	E
2	CO1	L	H		M	
	CO2	H		M		L
	CO3	H		L	M	
	CO4	L			H	M
	CO5	H		L	M	
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
			√			
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

UNIT-I INTRODUCTION **9**

Air resource management system – Air quality management – Scales of air pollution problem – Sources and classification of pollutants and their effect on human health vegetation and property - Global implications of air pollution – Meteorology Fundamentals – Atmospheric stability – Micrometeorology – Atmospheric turbulence-mechanical and thermal turbulence – wind profiles – Atmospheric Diffusion – Atmospheric diffusion theories – Steady-state atmospheric diffusion equation – Plume rise – Diffusion models – Software applications – Ambient air quality and emission standards – Air pollutions indices – Indoor Air Pollutants – models – Air Quality Sampling and Monitoring.

UNIT-II CONTROL OF PARTICULATE CONTAMINANTS **9**

Settling chambers – Filters, gravitational, Centrifugal – multiple type cyclones, prediction of collection efficiency, pressure drop, wet collectors, Electrostatic Precipitation theory – ESP design – Operational Considerations – Process Control and Monitoring – Case Studies.

UNIT-III CONTROL OF GASEOUS CONTAMINANTS **9**

Absorption – principles – description of equipment-packed and plate columns – design and performance equations – Adsorption – principal adsorbents – Equipment descriptions – Design and performance equations – Condensation – design and performance equation – Incineration – Equipment description – design and performance equations – Biological Air Pollution Control Technologies – Bio-Scrubbers, Biofilters – Operational Considerations – Process Control and Monitoring-Case Studies.

UNIT-IV EMERGING TRENDS **9**

Process Modification – Automobile Air Pollution and its control – Fuel Modification – Mechanical Particulate Collectors – Entrainment Separation - Internal Combustion Engines – Membrane Process – Ultraviolet Photolysis – High efficiency Particulate Air Filters – Technical

& Economic Feasibility of selected emerging technologies for Air pollution control – Control of Indoor Air Quality – Radio active pollution and its control.

UNIT-V NOISE CONTROL **9**

Noise Standards – Measurement – Modeling – Control and preventive measures.

Total Periods : 45

REFERENCES:

1.LawrenceK.Wang, Norman C Perelra, Yung- Tse Hung, "Air Pollution Control Engineering", Tokyo, 2004.

2.Noel de Nevers, Air Pollution Control Engg.,McGraw-Hill, New York, 1995.

3.David H.F Liu, BelaG.Liptak "Air Pollution", Lewis Publishers, 2000.

MER104	**WATER AND SEWAGE CONVEYANCE**	**L**	**T**	**P**	**C**
	Total Contact Hours:45	3	0	0	3
	Prerequisite: Environmental Engineering-I,II				
	Course Designed by : : Department of Civil Engineering				

OBJECTIVES

To educate the students in detailed concepts related to water transmission mains, water distribution system, sewer networks and storm water drain, with emphasis on computer application

COURSE OUTCOMES (COs)	
CO1	To make them understand the fundamentals of hydraulic engineering and the various fluid flow phenomenon
CO2	To understand about the methods of water transmission and distribution and the economics related to water transmission
CO3	To understand in detail about the waste water collection and conveyance and also the maintenance of sewers and design of sewer outfalls
CO4	To improve the knowledge on the planning and estimation of storm water flow

CO5	To know about the basics of the Case Studies and Computer applications for water transmissio					
Mapping of Course Outcomes with Program outcomes (POs) (H/M/L indicates strength of correlation) H-High, M-Medium, L-Low						
1	COs/Pos	a	b	c	d	e
2	CO1	H	M			L
	CO2		M	L		H
	CO3		M	L		H
	CO4		M	L		H
	CO5	L			H	M
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
			√			
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

UNIT-I PRINCIPLES OF HYDRAULICS **9**

Fluid properties; fluid flow – continuity principle, energy principle and momentum principle; frictional head loss in free and pressure flow, major and minor head loss, formula for estimation of head loss – pumping of fluids – selection of pumps – Flow measurement.

UNIT-II WATER TRANSMISSION AND DISTRIBUTION **9**

Planning factors – Water transmission main design – pipe material – economics – water hammer analysis; water distribution pipe networks - methods for analysis and optimization - Laying and maintenance, insitu lining – appurtenances – corrosion prevention – minimization of water losses – leak detection.

UNIT-IIIWASTEWATER COLLECTION AND CONVEYANCE **9**

Planning factors – Design of sanitary sewer; partial flow in sewers, economics of sewer design; sewer appurtenances; material, construction, inspection and maintenance of sewers; Design of sewer outfalls-mixing conditions; conveyance of corrosive wastewaters.

UNIT-IV STORM WATER DRAINAGE **9**

Planning – run-off estimation, rainfall data analysis, storm water drain design – rain water harvesting

UNIT-V CASE STUDIES AND COMPUTER APPLICATIONS **9**

Computer applications for water transmission, water distribution and sewer design.

Total Periods : 45

REFERENCES:

1.G.S.Bajwa, Practical Handbook on Public Health Engineering, Deep Publishers, Shimla, 2003.

2."Manual on water supply and Treatment", CPHEEO, Ministry of Urban Development, Gol, New Delhi, 1999.

3."Manual on sewerage and Sewage Treatment', CPHEEO, Ministry of Urban Development, Gol, New Delhi, 1993.

4.B.A. Hauser, Practical Hydraulics Handbook, Lewis Publishers, New York, 1991.

MER1L1	**ENVIRONMENTAL ENGINEERING LABORATORY**	**L**	**T**	**P**	**C**
	Total Contact Hours:45	**0**	**0**	**4**	**2**
	Prerequisite: Environmental Engineering-I				
	Course Designed by : : Department of Civil Engineering				
OBJECTIVESTo conduct laboratory studies on water and wastewater treatment units					
COURSE OUTCOMES (COs)					

CO1	To know about about the basic water sample analysis techniques used in water as well as waste water testing.
CO2	To know the principle of Air quality analysis to analyse major components of air like SO_2,NO_3etc
CO3	Having a deep knowledge about soil analysis techniques
CO4	With a true wisdom about serial dilution techniques and methods to prepare pure culture
CO5	Having a sound knowledge in the bacteriological analysis of waste water.

Mapping of Course Outcomes with Program outcomes (POs)
(H/M/L indicates strength of correlation) H-High, M-Medium, L-Low

1	COs/Pos	a	b	c	d	e
2	CO1			L	M	H
	CO2		M	L		H
	CO3		H		M	L
	CO4		M	L	H	
	CO5		L		H	M
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
			√			
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

Environmental Chemistry Laboratory

1. Physical and Chemical Analysis of Water **12**

Ph, Conductivity, Turbidity, Solids, Chlorides, Sulphates, Alkalinity, Fluorides, Nitrate and heavy metals.

2. Physical and Chemical Analysis of Wastewater **8**

Phosphate, COD, BOD, Organic and ammonical nitrogen, Oil & grease.

3. Air Quality Analysis **6**
SPM, SO_2, CO, NO_X

4. Soil Analysis **4**
pH, Conductivity, Cation exchange capacity, Sodium Absorption ratio

30

Environmental Microbiology Laboratory

1. Preparation of media, serial dilution and plating, Growth curve 6

2. Sampling of Microorganisms from air, water and soil, staining-simple and gram staining. 6

3. Effect of pH, temperatures and nutrients on growth of bacteria 2

4. Bacteriological analysis of water – Coli forms and streptococcus fecalis by MPN and membrane filter techniques 10

5. Study of aquatic organisms – Algae, Protozoa and fungi 6

30

MER201	**SOLID AND HAZARDOUS WASTE MANAGEMENT**	**L**	**T**	**P**	**C**
	Total Contact Hours:45	**3**	**0**	**0**	**3**
	Prerequisite: Environmental Health Engineering				
	Course Designed by : Department of Civil Engineering				

OBJECTIVES
To educate the students on the principles involved in the management of municipal solid waste and hazardous wastes- from source identification up to disposal.

COURSE OUTCOMES (COs)

CO1	To make them understand the fundamentals of solid and hazardous wastes and also the types, need and sources of solid and hazardous wastes.
CO2	To understand about the methods of waste characterisation and source reduction and to study the various methods of generation of wastes.
CO3	To understand in detail about the storage, collection and transport of wastes.

	and also to study about the methods used for handling and segregation of wastes.					
CO4	To improve the knowledge on the waste processing techniques which includes incineration, solidification and stabilization of hazardous wastes					
CO5	To know about the basics of the waste disposal options and also a detailed study on the disposal in landfills and also to learn about landfill remediation.					
Mapping of Course Outcomes with Program outcomes (POs) (H/M/L indicates strength of correlation) H-High, M-Medium, L-Low						
1	COs/Pos	a	b	c	d	e
2	CO1		H		M	L
	CO2		M		L	H
	CO3		H		L	M
	CO4		M		L	H
	CO5		L		M	H
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
			√			
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

UNIT-I INTRODUCTION **9**

Types and Sources of solid and hazardous wastes-Need for solid and hazardous waste management- Elements of integrated waste management and roles of stakeholders- Salient features of Indian legislations on management and handling of municipal solid wastes, hazardous wastes, biomedical wastes, lead acid batteries, plastics and fly ash,financing waste management.

UNIT-IIWASTE CHARACTERISATION AND SOURCE REDUCTION **9**

Waste generation rates and variation-Composition, physical, chemical and biological properties of solid wastes- Hazardous Characteristics- TCLP tests- waste sampling and characterization plan- source reduction of wastes- Recycling and reuse- waste exchange.

UNIT-III STORAGE, COLLECTION AND TRANSPORT OF WASTES 9

Handling and segregation of wastes at source- storage and collection of municipal solid wastes- Analysis of collection systems- Need for transfer and transport- Transfer stations Optimizing Waste allocation- compactability, storage, labeling and handling of hazardous wastes- hazardous waste manifests and transport.

UNIT-IV WASTE PROCESSING TECHNIQUES 9

Objectives of waste processing- material separation and processing technologies- biological and chemical conversion technologies-method and controls of composting- thermal conversion technologies and energy recovery- incineration- solidification and stabilization of hazardous wastes- treatment of biomedical wastes.

UNIT-V WASTE DISPOSAL 9

Waste disposal options- Disposal in landfills- Landfill Classification, types and methods- site selection- design and operation of sanitary landfills, secure landfills and landfill bioreactors- leachate and landfill gas management- landfill closure and environmental monitoring- closure of landfills- landfill remediation.

Total Periods : 45

REFERENCES:

1. GeorgeTchobanoglous, Hilary Theisen and Samuel A, Vigil "Integrated Solid Waste Management, McGraw- Hill International edition, New York, 1993.
2. CPHEEO "Manual on Municipal Solid waste management, Central Public Health and Environmental Engineering Organisation, Government of India, New Delhi, 2000.

3. Micheael D. Lagrega, Philip L Buckingham, Jeffrey C. E vans and Environmental Resources Management, Hazardous waste Management, McGraw- Hill International edition, New york, 2001.

4. Vesilind P.A., Worrell W and Reinhart, Solid Waste Engineering, Thomson Learning Inc., Singapore, 2002.

MER202	PHYSICAL AND CHEMICAL TREATMENT OF WATER AND WASTEWATER	L	T	P	C
	Total Contact Hours:45	3	0	0	3
	Prerequisite: Unit Operations and Unit Processes in Environmental Technology				
	Course Designed by : Department of Civil Engineering				

OBJECTIVES

To educate the student on the working principles and design of various physical and chemical treatment systems for water and wastewater.

COURSE OUTCOMES (COs)

CO1	To make them understand the fundamentals of waste water treatment .To learn about th various Pollutants in water and waste water and also to study about their characteristics
CO2	To understand about the methods of waste characterization , source reduction and to stu the various methods of generation of wastes.
CO3	To understand in detail about the various principles of chemical treatment which inclu precipitation coagulation etc.
CO4	To improve the knowledge on the Selection of unit operation and processes and to study the design oriented aspects of sand filters and other treatment processes.
CO5	To know about the basics of thedesign of industrial waste water treatment and reclamation processes.

Mapping of Course Outcomes with Program outcomes (POs)
(H/M/L indicates strength of correlation) H-High, M-Medium, L-Low

1	COs/Pos	a	b	c	d	e
2	CO1		H		L	M
	CO2	H	M			L
	CO3	H	M			L
	CO4	H	M			L

	CO5	H	M			L
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
			√			
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

UNIT-I INTRODUCTION **9**

Pollutant in water and wastewater – characteristics, standards for performance – significant and need for physic – chemical treatment.

UNIT-II PHYSICAL TREATMENT PRINICIPLES **9**

Principles of screening – mixing, equalizations –sedimentation – filtration –modeling – backwashing –evaporation-incineration- gas transfer-mass transfer coefficients. Adsorption-isotherms-principles, equilibrates and kinetics, reactors, regeneration, membrane separation, reverse osmosis, nano filtration ultra filtration and hyper filtration – electro dialysis, distillation – stripping and crystallization-recent advances.

UNIT-III CHEMICAL TREATMENT PRINCIPLES **9**

Principles of chemical treatment – coagulation flocculation – precipitation –floatation, solidification and stabilization- disinfection .ion exchange, electrolytic methods -Solvent extraction –advanced oxidation / reduction –recent advances.

UNIT-IV DESIGN OF CONVENTIONAL TREATMENT PLANTS **9**

Selection of unit operation and processes – design of conventional water treatment plant units – aerators –chemical feeding –flocculation –clarifier – filters –rapid sand filter, slow sand filter, pressure filter-chlorinators. Displacement and gaseous type.layouts- flowcharts –hydraulic

profile –O & M aspects- case studies , residue management – up gradation of existing plants – recent advances.

UNIT-V DESIGN OF INDUSTRIAL WATER TREATMENT AND RECLAMATION 9

Selection of process –design of softeners – demineralisers –wastewater reclamation – reverse osmosis plants –residue management – O & M aspects –recent advances –case studies.

Total Periods : 45

REFERENCES:

1. Metcalf and Eddy, Wastewater Engineering, Treatment and Reuse Tata McGraw-Hill, New Delhi, 2003.
2. Manual on water supply and Treatment CPHEEO, Ministry of Urban Development ,GOI, New Delhi,1999.
3. Lee ,CC and Shun dar Lin , Handbook of Environmental Engineering Calculations , McGraw-hill,Newyork , 1999.
4. Qasim,S.R motely, E.N., Zhu, G. water works Engineering – planning ,design and operation,PrenticeHall,New Delhi, 2002.
5. Casey, T.J.Unit treatment processes in water and wastewater Engineering, John Wiley and Sons, London1993.

MER203	BIOLOGICAL TREATMENT OF WASTEWATER	L	T	P	C
	Total Contact Hours:45	3	0	0	3
	Prerequisite:Environmental Engineering-II				
	Course Designed by : Department of Civil Engineering				

OBJECTIVES

To educate the students on principles and design of various biological treatment units used for wastewater treatment.

COURSE OUTCOMES (COs)

CO1	To make them understand the fundamentals of biological treatment and its significance aerobic and anaerobic waste water treatment along with its kinetic studies.
CO2	To understand about the methods of aerobic treatment of wastewater which includes

	design of trickling filter, rotating biological contactor, activated slide process
CO3	To understand in detail about the anaerobic treatment of wastewater which includes design of attached and suspended growth, along with UASB.
CO4	To improve the knowledge on the sludge treatment and disposal and the recent advancements in this field.
CO5	To know about the operations, maintenance, management and case studies related to biological treatment of waste water.

Mapping of Course Outcomes with Program outcomes (POs)
(H/M/L indicates strength of correlation) H-High, M-Medium, L-Low

1	COs/Pos	a	b	c	d	e
2	CO1		M		H	L
	CO2	H			M	L
	CO3	H			M	L
	CO4	H			M	L
	CO5		H		L	M
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
			√			
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

UNIT-I INTRODUCTION **9**

Objectives of biological treatment – significant – aerobic and anaerobic treatment – kinetics of biological growth-Factor affecting growth – attached and suspended growth-Determination of kinetics coefficient for organics removal – biodegradability assessment-selection of process.

UNIT-II AEROBIC TREATMENT OF WASTEWATER **9**

Design of sewage treatment plant units – screen chamber, grit chamber with proportional flow weir, sedimentation tank- Trickling filter, Rotating Biological contactor, activated slide process & variations, aerated lagoons waste stabilization ponds –nutrients removal systems- natural

treatment systems –disinfected disposal option- reclamation and reuse –flow charts, layouts hydraulic profile-recent advances.

UNIT-III ANAEROBIC TREATMENT OF WASTEWATER 9

Attached and suspended growth, design of units – UASB, up flow filters fluidized beds-septic tanks and disposal –nutrient removal systems –layouts and hydraulic profile-recent advances.

UNIT-IV SLUDGE TREATMENT AND DISPOSAL 9

Design of sludge management facilities, slude thickening, sludge digestion, biogas generation, sludge dewatering (mechanical and gravity)- upgrading existing plants-ultimate residue disposal- recent advances.

UNIT-V OPERATIONS,MAINTENANCE, MANAGEMENT AND CASE STUDIES 9

Operational problems-trouble shooting, planning, organizing and controlling of plants operations- capacity building, case studies on sewage treatment plants- sludge management facilities.

Total Periods : 45

REFERENCES:

1. Arecivala, S.J., Wastewater treatment for pollution control, TMH, New Delhi 1998.
2. Manual on "Sewerage and sewage treatment" CPHEEO, ministry of Urban development, Gol, New Delhi 1999.
3. Metcalf& Eddy, INC , "wastewater Engineering treatment and Reuse. Third edition Tata McGraw-hill publishing company limited, New Delhi,2003.
4. Qasim S.R. Wastewater Treatment Plant, Planning, Design & Operation Technomic Publications, Newyork,1994.

		L	T	P	C
MER204	**INDUSTRIAL WASTEWATER MANAGEMENT**				

	Total Contact Hours:45	**3**	**0**	**0**	**3**
	Prerequisite:Industrial Waste Treatment and Disposal				
	Course Designed by : Department of Civil Engineering				

OBJECTIVES

To educate the students on complete management principles related to individual Waste water-starting from wastewater source identification up to reuse concepts

COURSE OUTCOMES (COs)

CO1	To make them understand the fundamentals of uses of water by industry-sources and types of industrial wastewaters
CO2	To understand about the methods of prevention vs. control of industrial pollution including the various benefits and barriers
CO3	To understand in detail about the Industrial Wastewater Treatmentand all the processes in detail.
CO4	To improve the knowledge on the emerging trends of wastewater reuse and residual management
CO5	To know about the case studies which involves the various industrial manufacturing processes

Mapping of Course Outcomes with Program outcomes (POs)
(H/M/L indicates strength of correlation) H-High, M-Medium, L-Low

1	COs/Pos	a	b	c	d	e
2	CO1			L	M	H
	CO2		M	L		H
	CO3		H		M	L
	CO4		M	L	H	
	CO5		L		H	M
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
			√			

4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016

UNIT-I INTRODUCTION **9**

Industrial scenario in India- Industrial and Environment-Uses of water by industry-Sources and types of industrial wastewater- Industrial wastewater and environmental impacts-regulatory requirements for treatment of industrial wastewater-Industrial waste survey-Industrial Wastewater generation rates, characterization and variables-Population equivalent-Toxicity of Industrial effluents and Bioassay tests.

UNIT-II INDUSTRIAL POLLUTION PREVENTION **9**

Prevention Vs control of Industrial Pollution-Benefits and Barriers-Source reduction techniques-Waste audit-Evaluation of Pollution Prevention options-Environmental statement as a tool for Pollution Prevention-Waste minimization Circles.

UNIT-III INDUSTRIAL WASTEWATER TREATMENT **9**

Equalisation- Neutralisation- Oil separation-Flotation-Precipitation-Heavy metal Removal - Refractory organics separation by adsorption-Aerobic and anaerobic biological treatment-Sequencing batch reactors-High Rate reactors-Chemical Oxidation - Ozonation- Photocatalysis-Wet Air Oxidation-Evaporation-Ion Exchange-Membrane Technologies - Nutrient removal.

UNIT-IV WASTEWATER REUSE AND RESIDUAL MANAGEMENT **9**

Individual and Common Effluent Treatment Plants-Joint treatment of industrial Wastewater-Zero effluent discharge Systems-Quality requirements for Wastewater reuse-Industrial reuse-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 **9**

Industrial manufacturing Process description, wastewater characteristics, source reduction options and waste treatment flow sheet for Textiles-Tanneries-pulp and paper-metal finishing-

Petroleum Refining-Pharmaceuticals-Sugar and Distilleries-Food Processing-fertilizers-Thermal Power Plants and Industrial Estates.

Total Periods : 45

REFERENCES:

1. Eckenfelder,W.W., "Industrial Water Pollution Control", McGraw-Hill, 1999.
2. Arceivala, S.J., "Wastewater Treatment for Pollution Control", Tata McGraw-Hill. 1998.
3. Frank Woodard Industrial Waste treatment Handbook,ButterworthHeinemann,New Delhi, 2001.
4. World Bank Group, "Pollution Prevention and Abatment Handbook-Towards Cleaner Production,World Bank and UNEP,Washington D.C.1998.
5. Paul L.Bishop "Pollution Prevention;- Fundamentals and practice", McGraw-Hill International, 2000

MER051	**ENVIRONMENTAL QUALITY MODELLING**	**L**	**T**	**P**	**C**
	Total Contact Hours:45	**3**	**0**	**0**	**3**
	Prerequisite:				
	Course Designed by : Department of Civil Engineering				

OBJECTIVES

To educate the students on the basic principles,development and application of air and water quality models with computer applications.

COURSE OUTCOMES (COs)	
CO1	To make them understand the fundamentals of mathematical Modeling and explain ho modeling can be used as as a tool in assessing environmental quality
CO2	To understand about the methods of application of these models in simulation, parameter estimation and experimental design.
CO3	To understand in detail about the water quality modeling process ,dissolved oxygen mo and models on Groundwater
CO4	To improve the knowledge on the emerging trends of air pollution modeling and prediction,performance and its utilization
CO5	To know about the various case studies on air quality modeling and water quality

	modeling and other software package applications					
Mapping of Course Outcomes with Program outcomes (POs) (H/M/L indicates strength of correlation) H-High, M-Medium, L-Low						
1	COs/Pos	a	b	c	d	e
2	CO1		H		L	M
	CO2		M		H	L
	CO3	H			L	M
	CO4		M		L	H
	CO5		H		L	M
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
				√		
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

UNIT-I INTRODUCTION **9**

Basics of mathematical Modeling- Modeling as a tool.Procedures of model development.Importance of model building.Characteristics of deterministic models.Classical approach to constrained and unconstrained optimization. State of the art in environmental engineering systems models-climate and system modeling-Erosion and sediment transport.

UNIT-II COMPUTER BASED SOLUTIONS **9**

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

UNIT-III WATER QUALITY MODELLING **9**

Rivers and streams water quality modeling-river hydrology and flow-low flow analysis-dispersion and mixing-flow, depth; water quality modeling process-model sensitivity-assessing model performance; Models for dissolved oxygen, pathogens; Groundwater modeling.

UNIT-IV AIR QUALITY MODELLING **9**

Air pollution modeling and prediction, modeling technique, modeling for non reactive pollutants, single source short term impact; multiple sources and area sources, model performance, accuracy and utilization.

UNIT-V CASE STUDIES **9**

Software package applications: Air quality modeling and water quality modeling.

Total Periods : 45

REFERENCES:

1. John Wainwright and Mark Mulligan, Environmental Modelling Finding Simplicityin Complexity, John Wiley and sons Ltd, USA, 2004
2. Dynamic Modeling of Environmental Systems by Deaton and Wine brake, Wiley & Sons, 2002.
3. Steven C. Chapra, Surface water quality modeling, McGraw-Hill Inc., New York, 1997.
4. Boubel R.W., Fox, D.L., Turner D.B.& Stern, A C. "Fundamentals of Air Pollution, Academic Press, New York,1994.

MER052	**INSTRUMENTAL MONITORING OF ENVIRONMENT**	**L**	**T**	**P**	**C**
	Total Contact Hours:45	**3**	**0**	**0**	**3**
	Prerequisite:Environmental Engineering I,II				
	Course Designed by : Department of Civil Engineering				

OBJECTIVES

To educate the students on the various instruments used for analysis of air water and soil.

COURSE OUTCOMES (COs)

CO1	To make them understand the fundamentals of various Instrumental methods in monitoring the environment.

CO2	To understand about the various Spectroscopic Methods of determining the precision and accuracy of the instrument**.**
CO3	To understand in detail about the Chromatographic methods of separation and the classification of these methods in detail.
CO4	To improve the knowledge on the various Electro and Radio Analytical Methods of instrumentation
CO5	To know about the various Continuous Monitoring Instruments such as NDIR analyzers

Mapping of Course Outcomes with Program outcomes (POs)
(H/M/L indicates strength of correlation) H-High, M-Medium, L-Low

1	COs/Pos	a	b	C	d	e
2	CO1		H		L	M
	CO2		M		H	L
	CO3	H			L	M
	CO4		M		L	H
	CO5		H		L	M
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
				√		
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

UNIT-I INTRODUCTION **9**

Instrumental Methods, Selection of method, Precision and Accuracy, Errors in measuring signals, Noise/signal ratio, base line drift, indicator tubes.

UNIT-II SPECTROSCOPIC METHODS **9**

Electromagnetic radiation, matter radiation interactions; Colorimetry and spectrophotometry, fluorimetry, nephelometry and turbidimetry, flame photometry Atomic Absorption Spectrometry

(AAS), Atomic Emission Spectrometry (AES)- Inductively coupled plasma (ICP) and Direct Current Plasma (DCP) Spectrometry. ICP- MS (Mass spectrometry).

UNIT-III CHROMATOGRAPHIC METHODS 9

Classical methods, Column, Paper and thin layer chromatography (TLC),gas chromatography (GC),GC-MS,High performance liquid chromatography (HPLC) and ion chromatography (IC).

UNIT-IV ELECTRO AND RADIO ANALYTICAL METHODS 9

Conductometry, potentiometry, coulometry, amperometry polarography, neutron activation analysis (NAA), X-ray fluorescence (XRF) and X-ray diffraction (XRD) methods

UNIT-V CONTINUOUS MONITORING INSTRUMENTS 9

Non-dispersive infra-red (NDIR)analyzer for CO, Chemiluminescent analyzer for NOx, fluorescent analyzer for SO2,auto analyzer for water quality using flow injection analysis, permeation devices.

Total Periods : 45

REFERENCES:

1. Willard.H. Merritt, L., Dean, D.A.and Settle. F.A. "Instrumental methods of analysis, 7th Edn. Words Worth, New York, 2004.

2. Ewing 'Instrumental Methods of Chemical Analysis, 5th Edn., McGraw-Hill,New York, 1995.

MER053	**REMOTE SENSING AND GIS FOR ENVIRONMENTAL APPLICATION**	**L**	**T**	**P**	**C**
	Total Contact Hours:45	**3**	**0**	**0**	**3**
	Prerequisite:Remote Sensing and GIS				
	Course Designed by : Department of Civil Engineering				

OBJECTIVES

To educate the students on the principles and application of remote sensing and GIS in environmental engineering.

COURSE OUTCOMES (COs)	
CO1	To make them understand the principles of Electro Magnetic Radiation and also the concepts of remote Sensing
CO2	To understand about the Remote Sensing Platforms,various sensors used and also about the various Indian space programmed satellite data products.
CO3	To understand in detail about the Data Processing and image processing techniques and softwares used in GIS.
CO4	To study about the introduction to GIS concepts and GIS softwares
CO5	To know about the **INDUSTRIAL APPLICATIONS AND ECONOMIC ASSESSMENT OF AOTs** .

Mapping of Course Outcomes with Program outcomes (POs)
(H/M/L indicates strength of correlation) H-High, M-Medium, L-Low

1	COs/Pos	a	b	c	d	E
2	CO1		M		H	L
	CO2	H			M	L
	CO3	H			M	L
	CO4	H			M	L
	CO5		H		L	M
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
				√		
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

UNIT-I PRINCIPLES OF ELECTRO MAGNETIC RADIATION 9

Concepts of remote Sensing – Energy sources and radiation principles, Energy interactions in the atmosphere – Spectral reflectance of earth surface features

UNIT-II REMOTE SENSING PLATFORMS **9**

Aerial photographs, photographic Systems – visual infra red and microwave sensing – active and passive sensors – satellites and their sensors, Indian space programmed satellite data products

UNIT-III DATA PROCESSING **9**

Photogrammetric – satellite data analysis – visual interpretation equipments – digital image processing – image rectification, enhancement, classification, data merging and biophysical modeling – image processing software

UNIT-IV GEOGRAPHIC INFORMATION SYSTEM **9**

Introduction to GIS concepts – Data base structure – Data analysis – GIS software

UNIT-VREMOTE SENSING AND GIS APPLICATIONS9

Management and monitoring of environment, conservation of resources, coastal zone management – limitations

Total Periods : 45

REFERENCES:

1.Lillesand, T.M. and Kiefer, R.W., Remote Sensing and image interpretation, John Wiley and Sons, New York,2004.

2.Burrough,P.A.and McDonnell, R.A., Principles of Geographic information systems, Oxford University press, New York,2001.

3.Linz. andSimonet, Remote Sensing of Environment, Addison Wesley publishing Company, New Jersey,1998.

MER054	**ECOLOGICAL ENGINEERING**	**L**	**T**	**P**	**C**
	Total Contact Hours:45	**3**	**0**	**0**	**3**
	Prerequisite:Environmental studies				
	Course Designed by : Department of Civil Engineering				
OBJECTIVES					

To educate the students on the principles of ecology as applied to environmental engineering	
COURSE OUTCOMES (COs)	
CO1	To make them understand the introduction to Ecology and Ecological Engineering and its application in all other fields.
CO2	To understand about the Principles, components and characteristics of Systems approach in Ecological Engineering
CO3	To understand in detail about the Ecological Engineering Processes anddetermination of sustainable loading of ecosystems
CO4	To improve the knowledge on the emerging trends of ecotechnology for waste treatment and also the applications of ecological engineering for marine systems
CO5	To know about the case studies of integrated ecological engineering systems and their commercial prospects.

Mapping of Course Outcomes with Program outcomes (POs)
(H/M/L indicates strength of correlation) H-High, M-Medium, L-Low

1	COs/Pos	a	b	c	d	e
2	CO1		M		H	L
	CO2	H			M	L
	CO3	H			M	L
	CO4	H			M	L
	CO5		H		L	M
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
				√		
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

UNIT-I INTRODUCTION TO ECOLOGY AND ECOLOGICAL ENGINEERING 9

Aim, scope and applications of ecology – Development and evolution of ecosystems – principles and concepts pertaining to communities in ecosystem – Energy flow and material cycling in ecosystems – productivity in ecosystems – Rationale of ecological engineering and ecotechnology – classification of ecotechnology – principles of ecological engineering

UNIT-II SYSTEMS APPROACH IN ECOLOGICAL ENGINEERING 9

Principles, components and characteristics of systems – Classification of systems – Structural and functional interactions of environmental systems – Environmental systems as energy systems – Mechanisms of steady maintenance in open and closed systems – Modelling and ecotechnology – Elements of modeling – Modelling procedure – Classification of ecological models – Applications of models in ecotechnology – Ecological economics.

UNIT-III ECOLOGICAL ENGINEERING PROCESSES 9

Self – organizing design and processes – Multi seeded microcosms – Interface coupling in ecological systems – Concept of energy – Determination of sustainable loading of ecosystems

UNIT-IV ECOTECHNOLOGY FOR WASTE TREATMENT 9

Ecosanitation – principles and operation of soil in infiltration systems – Wetland and ponds – Source separation systems – Aqua cultural systems – Agro ecosystems – Detritus based treatment for solid wastes – Applications of ecological engineering for marine systems.

UNIT-V CASE STUDIES 9

Case studies of Integrated Ecological Engineering Systems and their commercial prospects

Total Periods : 45

REFERENCES:

1.Kangas, P.C. and Kangas, P., Ecological Engineering: Principles and practice. Lewis Publishers, New Yark.2003.

2.Etnier, C. and Guterstan, B., Ecological Engineering for Wastewater Treatment, Lewis Publishers, New York,1997.

3.White, I.D., Mottershed, D.N. and Harrison, S.J., Environmental Systems – An Introductory Text, Chapman Hall,Landon.1994.

4.Mitsch, J.W. and Jorgensen, S.E., Ecological Engineering – An Introduction to Ecotechnology, John Wiley & sons, New York. 1989.

MER055	**GROUND WATER CONTAMINATION AND TRANSPORT MODELLING**	**L**	**T**	**P**	**C**
	Total Contact Hours:45	**3**	**0**	**0**	**3**
	Prerequisite:Environmetnal Studies				
	Course Designed by : Department of Civil Engineering				

OBJECTIVES

To educate the students on the hydraulics related ground water contamination and modeling ground water quality.

COURSE OUTCOMES (COs)

CO1	To make them understand the fundamentals of Ground water and the various hydrologic cycles
CO2	To understand about the various steady state hydrologic budgets and various case studies associated with it.
CO3	To understand about the various steady state hydrologic budgets and various case studies associated with it.
CO4	To improve the knowledge on the basics of Chemical equilibrium and Geochemical interpretation of ^{14} C Dates
CO5	To know about the basics of the Transport process in solute transfer and hydro chemical behavior of contaminants in the ground water.

Mapping of Course Outcomes with Program outcomes (POs)
(H/M/L indicates strength of correlation) H-High, M-Medium, L-Low

1	COs/Pos	a	b	c	d	e
2	CO1		H		L	M
	CO2		M		H	L
	CO3	H			L	M
	CO4		M		L	H
	CO5		H		L	M
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
				√		
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

UNIT-I INTRODUCTION **9**

Ground water and the hydrologic cycles – Ground water as resources – Ground water contamination –Water quality standards-Sources of contamination-Land disposal of solid wastes – Sewage disposal on Land.Ground water and geologic processes.Physical properties and principles-Darcy's Law- Hydraulic Head and Fluid Potential- Piezometers and Nestes. Hydraulic conductivity and permeability- Homogeneity and Anisotropy – Porosity and voids Ratio-Unsaturated flow and the water table- steady state flow and transient flow – Compressibility and effective stress – Transmissivity and storability – Equations of ground water flow – Limitations of Darcian Approach – Hydro dynamic dispersion – Case Studies.

UNIT-II HYDROLOGIC CYCLE AND FLOW NETS **9**

Flow nets – Graphical construction – Flow nets by numerical simulation. Steady state Regional Ground Water flow – steady state hydrologic budgets – Fluctuations in ground water levels– Case Studies.

UNIT-III RESOURCE EVALUATION **9**

Development of Ground Water resources – Exploration for Aquifers – the response of Ideal acquifers to pumping – Measurement of parameters – Laboratory tests - Piezometer test – Pumping tests – Estimation of saturates Hydraulic conductivity – Numerical simulation for aquifer yield prediction – Artificial recharge and induced infiltration – Land subsidence – Sea water intrusion –Case Studies.

UNIT-IV CHEMICAL PROPERTIES AND PRINCIPLES 9

Constituents – Chemical equilibrium _ Association and Dissociation of dissolved species – effects of concentration gradients – Mineral dissolution and solubility – Oxidation and reduction process – Ion exchange and Adsorption – Environmental isotopes – Field Measurment of Index parameters- Hydro chemical facies – Ground water in carbonate terrain – Ground Water in crystalline rocks- ground water in complex sedimentary systems – Geochemical interpretation of ^{14} C Dates – Process rates and molecular diffusion.

UNIT-V SOLUTE TRANSPORT 9

Transport process – non-reactive constituents in homogeneous media and Heterogeneous media – Transport in Fracture media – Hydro chemical behavior of contaminants- trace metals – Trace nonmetals – Nitrogen, organic substances- Measurement of parameters – Velocity – Dispersivity – chemical partitioning.

Total Periods : 45

REFERENCES:

1. Randall J. Charbeneau, "Ground water Hydraulics and Pollutant transport " Prentice Hall,Upper Saddle.
2. Todd David Keith , Ground water Hydrology, second edition , john Wiley and sons New York, 1980.
3. Allen Freeze, R. and John A. Cherry , "Ground Water ", Prentice Hall, Inc.1979

	ENVIRONMETAL BIOTECHNOLOGY	L	T	P	C
	Total Contact Hours:45	3	0	0	3
MER056	Prerequisite:Environmental Engineering I				

	Course Designed by : Department of Civil Engineering

OBJECTIVES

To educate the students on the principles and application of biotechnology in environmental engineering with special reference to waste treatment.

COURSE OUTCOMES (COs)

CO1	To make them understand the of principles and concepts of environmental biotechnology
CO2	To understand about the concept of Environmental biotechnology and its detoxification methods , biotransformation of metals
CO3	To understand in detail about the microbial technology for waste treatment and the biotechnological remedies for environmental pollution
CO4	To improve the knowledge on the emerging trends ofRecombinant DNA Technology and its application in genetic engineering
CO5	To know about the environmental effects,patents and ethics of microbial technology which includes the safe use of animals in EBT.

Mapping of Course Outcomes with Program outcomes (POs)
(H/M/L indicates strength of correlation) H-High, M-Medium, L-Low

1	COs/Pos	a	b	c	d	e
2	CO1			L	M	H
	CO2		M	L		H
	CO3		H		M	L
	CO4		M	L	H	
	CO5		L		H	M
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
				√		

4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016

UNIT-I INTRODUCTION **9**

Principles and concepts of environmental biotechnology – usefulness to mankind, current status.

UNIT-II DETOXIFICATION OF ENVIRONMENTAL POLLUTANTS **9**

Degradation of high concentrated toxic pollutants – halogenated ,non-halogenated petroleum hydrocarbons, metals, mechanisms of detoxification – oxidation, dehalogenation, biotransformation of metals ,biodegradation of solid wastes.

UNIT-III MICROBIAL TECHNOLOGY FOR WASTE TREATMENT **9**

Biotechnological remedies for environmental pollution – decontamination of ground water system, subsurface environment – reclamation concepts – bioremediation. Production of proteins – biofertilizers . Physical, chemical and microbiological factors of composting – health risk – pathogens – odour management –Microbial cell / enzymes technology – adapted microorganisms – biological removal of nutrients – algal biotechnology and application in agriculture – role of extracellular polymers. Biogas Technology-case studies.

UNIT-IVRECOMBINANT DNA TECHNOLOGY AND GENETIC APPLICATION **9**

Concept of rDNA technology – expression vectors – cloning of DNA –mutation – construction of microbial strains, radioactive probes , protoplast fusion technology- applications.

UNIT-VETHICAL AND REGULATORY ISSUES **9**

Environmental effects and ethics of microbial technology – safety of genetically engineered organisms – microbial containment – Risk assessment, IPR- patents.

Total Periods : 45

REFERENCES:

1. Chaudhury, G.R. ”Biological degradation and Bioremediation of toxic chemicals” Dioscorides press, Oregon, 1994.
2. MartinA.M,”Biological degradation of Wastes”, Elsevier Applied Science,London, 1991

Blaine Metting .F (Jr.) Soil Microbiology Ecology ,Marcel DekkarInc, 1993.

3.Wainwright M, An Introduction to environmental Biotechnology, 1999.

4.Old, R.W. and Primrose, S.B. Principles of Gene Manipulation 3rd Ed. Blackwell Sci. Publ., Cambridge, 1985.

MER057	**MEMBRANE SEPARATION FOR WATER AND WASTEWATER TREATMENT**	**L**	**T**	**P**	**C**
	Total Contact Hours:45	**3**	**0**	**0**	**3**
	Prerequisite:Environmental Engineering I				
	Course Designed by : Department of Civil Engineering				

OBJECTIVES

To introduce the concept and principles of membrane separation and its applications in water and wastewater treatment.

COURSE OUTCOMES (COs)

CO1	To make them understand the of principles and concepts of membrane filtration processes
CO2	To understand about the concept of different membrane systems and their Economics
CO3	To understand in detail about the membrane bioreactors and the design principles
CO4	To improve the knowledge on the pretreatment systems and membrane fouling
CO5	To know about the Case studies on the design of membrane based water and wastewater treatment systems.

Mapping of Course Outcomes with Program outcomes (POs)
(H/M/L indicates strength of correlation) H-High, M-Medium, L-Low

1	COs/Pos	a	b	c	d	e
2	CO1			L	M	H
	CO2		M	L		H
	CO3		H		M	L
	CO4		M	L	H	
	CO5		L		H	M

3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
				√		
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

UNIT 1MEMBRANEFILTRATION PROCESSES **10**

Solid Liquid separation systems- Theory of Membrane separation – mass Transport Characteristics - Cross Flow filtration - Membrane Filtration- Flux and Pressure drop -Types and choice of membranes, porous, non porous, symmetric and asymmetric – Plate and Frame, spiral wound and hollow fibre membranes – Liquid Membranes

UNITIIMEMBRANESYSTEMS **10**

Microfiltration principles and applications – Ultra filtration principles and applications - Nano Filtration principles and applications – Reverse Osmosis: Theory and design of modules, assembly, plant process control and applications – Electro dialysis : Ion exchange membranes, process design- Pervaporation – Liquid membrane – Liquid Pertraction – Supported Liquid Membrane and Emulsion Liquid membrane - Membrane manufactures – Membrane Module/Element designs – Membrane System components – Design of Membrane systems - pump types and Pump selection – Plant operations – Economics of Membrane systems

UNITIII MEMBRANEBIOREACTORS **9**

Introduction and Historical Perspective of MBRs, Biotreatment Fundamentals, Biomass Separation MBR Principles, Fouling and Fouling Control, MBR Design Principles, Design Assignment, Alternative MBR Configurations, Commercial Technologies, Case Studies

UNITIV PRETREATMENTSYSTEMS **8**

Membrane Fouling – Control of Fouling and Concentration Polarisation-Pretreatment methods and strategies – monitoring of Pretreatment – Langlier Index, Silt Density Index, Chemical cleaning , Biofoulant control

UNIT V CASE STUDIES **8**

Case studies on the design of membrane based water and wastewater treatment systems – zero Liquid effluent discharge Plants – Desalination of brackish water.

TOTAL : 45 PERIODS

MER058	**INDOOR AIR QUALITY**	**L**	**T**	**P**	**C**
	Total Contact Hours:45	**3**	**0**	**0**	**3**
	Prerequisite:Air &Noise Pollution				
	Course Designed by : Department of Civil Engineering				

OBJECTIVES

To educate the students on air pollution and control in the indoor environment.

COURSE OUTCOMES (COs)

CO1	To make them understand the fundamentals of Design and operation of buildings for improvements of public health associated with indoor air quality.
CO2	To understand about the air pollutants in indoor environments and its characteristics, consequences
CO3	To understand in detail about the classification and control of pollutants and case studies associated with it.
CO4	To improve the knowledge on the Concepts and tools in indoor air quality along with the statistical models associated with it.
CO5	To know about the basics of the Indoor air pollution from outdoor sources.

Mapping of Course Outcomes with Program outcomes (POs)
(H/M/L indicates strength of correlation) H-High, M-Medium, L-Low

1	COs/Pos	a	b	c	d	e
2	CO1		H		L	M
	CO2		M		H	L

	CO3	H			L	M
	CO4		M		L	H
	CO5		H		L	M
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
				√		
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

UNIT-I INTRODUCTION **9**

Indoor activities of inhabitants – residence time.Levels of many pollutants in indoor and outdoor air. Design and operation of buildings for improvements of public health.IAQ policy issues: Sustainability; indoor air quality as a basic human right

UNIT-II INDOOR AIR POLLUTANTS **9**

Air pollutants in indoor environments, private residences, offices, schoolssand public buildings, factors that govern pollutant indoors concentrations, including ventilation. Characteristics, Consequences.

UNIT-III CONTROL OF POLLUTANTS **9**

Control of several pollutant classes, such as radon ,toxic organic gases, combustion byproducts, and microorganisms such as molds and infectious bacteria. Case study by an exploration of public policy related to indoor air.

UNIT-IV CONCEPT AND TOOLS **9**

Concepts and tools: exposure, material-balance models, statistical models ventilation.

UNIT-V INDOOR AIR POLLUTION FROM OUTDOOR SOURCES **9**

Indoor air pollution from outdoor sources: particulate matter and ozone ;Combustion byproducts; Radon and its decay products. Volatile organic compounds: odors and sick-building syndrome, Humidity Bio-aerosols: infectious disease transmission. Special indoor environments: A/C units in indoor: museums -labs; Measurement methods, Control Technologies, Control strategies.

Total Periods : 45

MER059	**LANDFILL ENGINEERING AND REMEDIATION TECHNOLOGY**	**L**	**T**	**P**	**C**
	Total Contact Hours:45	**3**	**0**	**0**	**3**
	Prerequisite:Environmental Engineering I,II				
	Course Designed by : Department of Civil Engineering				

OBJECTIVES

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

COURSE OUTCOMES (COs)

CO1	To understand about the fundamentals of landfill basics and the Legal framework for landfilling
CO2	To understand about the landfill liners and the cover systems and their design
CO3	To understand in detail about leachate and landfill gas generation, Design of Landfill gas collection and removal systems
CO4	To improve the knowledge on Landfill Construction and Operational Controls
CO5	To know about the contaminated site remediation, Audits of landfill environmental performance and management

Mapping of Course Outcomes with Program outcomes (POs)
(H/M/L indicates strength of correlation) H-High, M-Medium, L-Low

1	COs/Pos	a	b	C	d	e
2	CO1		H		L	M
	CO2		M		H	L
	CO3	H			L	M

	CO4		M		L	H
	CO5		H		L	M
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
				√		
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

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 flowadvection-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 – Leachate 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, Cutoff 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

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

MER060	**ENVIRONMENTAL POLICIES AND LEGISLATION**	**L**	**T**	**P**	**C**
	Total Contact Hours:45	**3**	**0**	**0**	**3**
	Prerequisite:Environmental Engineering I				
	Course Designed by : Department of Civil Engineering				

OBJECTIVES

To make them understand the fundamentals of environmental law and its relation with other disciplines of law

COURSE OUTCOMES (COs)

CO1	To understand about basics of Indian Constitution and Environment and about various pollution control policies
CO2	To understand about basics of Indian Constitution and Environment and about various pollution control policies
CO3	To understand in detail about the Administrative regulation –India and to learn about the constitution of various state Pollution control boards
CO4	To improve the knowledge on the various Pollution Control Lawsand its amendments
CO5	To know about the relevant notifications in environmental (protection) act 1986 and

	their amendments in the subsequent years					
Mapping of Course Outcomes with Program outcomes (POs) (H/M/L indicates strength of correlation) H-High, M-Medium, L-Low						
1	COs/Pos	a	b	c	d	E
2	CO1	L	H		M	
	CO2		H	L		M
	CO3	M		H		L
	CO4	H		L		M
	CO5		M	L		H
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
				√		
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

UNIT-I INTRODUCTION **9**

Basics of jurisprudence- environmental law relation with other disciplines-criminal law-common law-relevant section of the code of civil procedure, criminal procedure code –Indian Penal Code.

UNIT-II INDIAN CONSTITUTION AND ENVIRONMENT **9**

Introduction –fundamental rights-directive principles of state polices-Article 48 (A)and 51-A(g) Judicial enforceability – constitution and Resources management and pollution control- Indian forest policy(1990)-Indian environmental policy(1992).

UNIT-III ADMINSTRATIVE REGIME AND LEGAL REGIME **9**

Administrative regulation –constitution of pollution control boards powers, functions accounts audit etc.-formal justice delivery mechanism higher and lower of judiciary-constitutional

remedies writ jurisdiction article 32,226 136 special reference to mandamus and certiorari for pollution abatement- equitable remedies for pollution control.

UNIT-IVPOLLUTION CONTROL LAWS **9**

Administrative regulation under recent legislation s in wear pollution control water (prevention & control of pollution) Act 1974 as amended by amendment Act 1988. water (prevention and control of pollution)Ruler 1975 water (prevention & control or pollution) Cess Act . 1977 as amended by amendment Act 1987 and relevant notifications.

UNIT-V ENVIRONMENTAL (PROTECTION) ACT 1986 **9**

Relevant notifications in connection with hazardous wastes (management and handling) biomedical wastes(management and management and handling), Nosing pollution , Eco-labelling, and E.I.A

Total Periods : 45

REFERENCES:

1. Constitution of India Esastern Book Company Lucknow 12 thEdn. 1997.
2. onstitutional Law of India- J.N.Pandey 1997 (31 stEdn.) Central Law Agency Allahabad.
3. Administrative Law U.P.D.Kesari 1998. Universal Book Trade Delhi.
4. Environmental Law H.N. Tiwari, Allahabad Law. Agency 1997.
5. Environmental, A.,Divan and Noble M. Environmental Law and Policy in India (cases,Materials and Statues) 1991 Tripathi Bombay.
6. Environmental Policy.Forest Policy. Bare Acts- Government Gazette Notification.

MER061	**ENVIRONMENTAL ENGINEERING STRUCTURES**	**L**	**T**	**P**	**C**
	Total Contact Hours:45	**3**	**0**	**0**	**3**
	Prerequisite:Design and Drawing –I				

	Course Designed by : Department of Civil Engineering

OBJECTIVES

To make them understand the fundamentals of Structural design and their application in Environmental Engineering

COURSE OUTCOMES (COs)

CO1	To make them understand the fundamentals of Structural design of Concrete, Prestressed Concrete, Steel and Castironetc
CO2	To understand about the methods of analysis and design of water tanks and the types of cement roofing system
CO3	To understand in detail about the design of special purpose structures like underground reservoirs and swimming pools
CO4	To improve the knowledge on the repair and rehabilitation of structures and also diagonising and identification of the cause and damage,.
CO5	To know about the exposure on steel, lattice structures used in water and sewerage works.

Mapping of Course Outcomes with Program outcomes (POs)
(H/M/L indicates strength of correlation) H-High, M-Medium, L-Low

1	COs/Pos	a	b	c	d	E
2	CO1		H		L	M
	CO2		M		H	L
	CO3	H			L	M
	CO4		M		L	H
	CO5		H		L	M
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
					√	
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

UNIT-I DESIGN OF PIPES **9**

Structural design of a) Concrete b) Prestressed Concrete c) Steel and d) Castiron piping mains, sewerage tanks design - anchorage for pipes - massive outfalls - structural design and laying - hydrodynamic considerations. Advances in the manufacture of pipes.

UNIT-II ANALYSIS AND DESIGN OF WATER TANKS **9**

Design of concrete roofing systems a) Cylindrical b) Spherical and c) Conical shapes using membrane theory and design of various types of folded plates for roofing with concrete. IS Codes for the design of water retaining structures.Design of circular, rectangular, spherical and Intze type of tanks using concrete. Design of prestressed concrete cylindrical tanks - Economic analysis - introduction to computer aided design and packages.

UNIT-III DESIGN OF SPECIAL PURPOSE STRUCTURES **9**

Underground reservoirs and swimming pools, Intake towers, Structural design including foundation of water retaining structures such as settling tanks, clarifloculators, aeration tanks etc. - effect of earth pressure and uplift considerations - selection of materials of construction.

UNIT-IV REPAIR AND REHABILITATION OF STRUCTURES **9**

Diagonising the cause and damage, identification of different types of structural and non-structural cracks - repair and rehabilitation methods for Masonry, Concrete and Steel Structures.

UNIT-V Exposure on Steel, Lattice Structures used in Water and Sewerage Works **9**

Exposure on Steel, Lattice Structures used in Water and Sewerage Works

Total Periods : 45

TEXT BOOKS:

1. Reinforced Concrete by P .Dayaratnam.
2. Prestressed Concrete by Krishna Raju, Tata McGraw-ill Publishing Co. 2nd Edition 1988.
3.Reinforced Concrete by N.C.Sinha&S.K.Roy - S.Chand and Co. 1985.

REFERENCES:

1. Hulse R., and Mosley, W.H., "Reinforced Concrete Design by Computer", Macmillan Education Ltd., 1986.
2. Ramaswamy, G.S., "Design and Construction of Concrete shell roofs", CBS Publishers, India, 1986.
3. Green, J.K. and Perkins, P.H., "Concrete liquid retaining structures", Applied Science Publishers, 1981.

MER062	**MASS TRANSFER IN AIR-WATER-SOIL INTERACTION**	**L**	**T**	**P**	**C**
	Total Contact Hours:45	**3**	**0**	**0**	**3**
	Prerequisite:Applied Mechanics				
	Course Designed by : Department of Civil Engineering				

OBJECTIVES

To educate the students on the mechanism of material transfer between environmental components - air, water and soil

COURSE OUTCOMES (COs)

CO1	To make them understand the fundamentals and occurrences of chemical equilibrium and thermal equilibrium at enviror1mental interfaces
CO2	To understand about the mass transfer theories and mass transfer coefficients along with environment fundamentals of heat transfer
CO3	To understand in detail about the exchange rates between air and water and also the water interface of lakes and oceans
CO4	To improve the knowledge on the exchange rates between water and the earthern material
CO5	To know about the basics of the exchange rates between air and soil and to study about the turbulence above the air - soil interface

Mapping of Course Outcomes with Program outcomes (POs)
(H/M/L indicates strength of correlation) H-High, M-Medium, L-Low

1	COs/Pos	a	b	c	d	e
2	CO1	H	M			L
	CO2		M	L		H
	CO3		M	L		H

	CO4		M	L		H
	CO5	L			H	M
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
					√	
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

UNIT-I EQUILIBRIUM AT ENVIRONMENTAL INTERFACE 9

Ideal solutions - air - water equilibrium occurrences - pure gases in contact with water pure liquid in contact with air - partition coefficient for the air - water system. Earthern solid - waste equilibrium occurrences - pure solid and liquid chemicals in contact with water and earthern solids.Earthern solid - air equilibrium occurrences - water - liquid chemical equilibrium occurrences - thermal equilibrium at enviror1mental interfaces.

UNIT-II TRANSPORT MECHANISMS 9

Diffusion and mass transfer - molecular diffusion - eddy diffusion - mass transfer theories - mass transfer coefficients - binary mass transfer coefficients in two phases and two resistance theory of interphase mass transfer turbulence in the environment fundamentals of heat transfer - analogy theories of momentum, heat and mass transfer.

UNIT-III EXCHANGE RATES BETWEEN AIR AND WATER 9

Desorption of gases and liquids from aerated basins and rivers - completely mixed basin - plug flow basin - gas exchange rates between the atmosphere and the surface of rivers - exchange of chemical across the air - water interface of lakes and oceans.

UNIT IV EXCHANGE RATES BETWEEN WATER AND THE EARTHERN MATERIAL 9

Dissolution of chemicals on the bottom of flowing streams - geometric forms - stream bottom mass transfer coefficients - natural convection dissolution - the upsurge of chemicals from the sediment - water interface of lakes - a Fikian analysis - allnual upsurge rate at sediment - water interface - mass transfer coefficients at the sediment water interface. Flux of chemicals .between sediment and the overlying seawater movement of chemicals through the benthic boundary layer.

UNIT-V EXCHANGE RATES BETWEEN AIR AND SOIL 9

Turbulence above the air - soil interface - the Richardson number - chemical flux rates through the lower layer of the atmosphere - Thronthwaite - Holzman equation evaporation of liquid chemicals spilled on land - chemical flux rates through the upper layer of earthern material.

Total Periods : 45

REFERENCES:

1. Thibodeaux, L.J, "Environmental Chemo dynamics: Movement Of Chemicals In Air, Water and Soil", edition 2., Wiley - Interscience, New York, 1996.

2. Cusssler, E.L, "Diffusion: Mass Transfer In Fluid Systems, "Cambridge University press, 1994.

		L	T	P	C
MER063	**MARINE POLLUTION MONITORING**				
	Total Contact Hours:45	**3**	**0**	**0**	**3**
	Prerequisite:Coastal Engineering				
	Course Designed by : Department of Civil Engineering				

OBJECTIVES

To educate the students on aspects of marine pollution and methods of water quality assessment and marine pollution control

COURSE OUTCOMES (COs)

CO1	To make them understand the fundamentals of General features of oceans and principles of marine geology
CO2	To understand about the Living resources in and around the oceans
CO3	To understand in detail about the planning and preparation of marine Surveying and sea surveying which includes the oceanographic instrumentation
CO4	To improve the knowledge on the emerging trends of marine pollution applications of

	remote sensing and GIS in marine studies					
CO5	To know about the control strategies of marine pollution associated with sustainable development					
Mapping of Course Outcomes with Program outcomes (POs) (H/M/L indicates strength of correlation) H-High, M-Medium, L-Low						
1	COs/Pos	a	b	c	d	e
2	CO1	L	H		M	
	CO2		H	L		M
	CO3	M		H		L
	CO4	H		L		M
	CO5		M	L		H
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
				√		
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

UNIT-I OCEANOGRAPHY **9**

General features of ocean- Conservation laws- Wave characteristics and theories- Sediment transport- Tides- ocean Currents- Thermocline circulation- General circulation of ocean waters, Tsunamis, Storm Surge- Principles of Marine geology

UNIT-II COASTAL ENVIRONMENT **9**

Living resources- coral reefs, mangroves, seagrass, seaweeds, fishery potential- nonliving resources- manganese nodules, heavy minerals-Beaches, Estuaries, Lagoons- Shoreline changes

UNIT-III MARINE SURVEYING **9**

Sea surveying planning and preparation- Oceanographic instrumentation- Hydrographic Surveying- Underwater surveying- Measurement of physical properties of ocean water- sea bad sampling

UNIT-IVMARINE POLLUTION AND MONITORING **9**

Physiochemical properties of sea water- Sources of marine pollution and impacts on coastal ecosystems, Oil pollution- oil spill detection, dispersion, impacts on adjacent area- Oil spill modeling, mitigation measures- Oil exploration and their effects- Marine outfalls- Impacts of Ports and Harbour on marine water quality- dredging- Human intervention in estuarine ecosystem- sea water classification- Physical modeling in Coastal Engineering-Ocean monitoring satellites- Applications of Remote sensing and GIS in marine studies

UNIT-VMARINE POLLUTION CONTROL **9**

National and International treaties, protocols in marine pollution- Exclusive Economic Zone- Sustainable development.

Total Periods : 45

REFERENCES:

1.Kennish, M.J., Pollution impacts on Marine Biotic Communities, CRC press New York,1998.

2.Newman, M.C., Roberts Jr. M.H., Male R.C.(Editors), Coastal and Estuarine Risk Assessment, Lewis Publishers, Washington,D.C.,2002.

3.U.S. Army Corps of Engineers, Shore protection Manual, Washington D.C.,2002.

MER064	**UNIT OPERATIONS AND UNIT PROCESSES IN ENVIRONMENTAL TECHNOLOGY**	**L**	**T**	**P**	**C**
	Total Contact Hours:45	**3**	**0**	**0**	**3**
	Prerequisite: Environmental Engineering-I,II				

	Course Designed by : Department of Civil Engineering					
OBJECTIVES To conduct laboratory studies on water and wastewater treatment units.						
COURSE OUTCOMES (COs)						
CO1	To Know about selection of unit operations and unit processes.					
CO2	To Know the principles of sedimentation and flotation processes .					
CO3	Having a deep knowledge about the filtration processes and filter media.					
CO4	To understand chemical unit processes and disinfection methods.					
CO5	Having a sound knowledge in the biological treatment process .					
Mapping of Course Outcomes with Program outcomes (POs) (H/M/L indicates strength of correlation) H-High, M-Medium, L-Low						
1	COs/Pos	a	b	c	d	e
2	CO1	H		L	M	
	CO2	H		L	M	
	CO3	H		L	M	
	CO4	H		L	M	
	CO5	H		L	M	
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
			√			
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

UNIT-I FUNDAMENTAL PHYSICAL UNIT OPERATIONS 9

Factors in selection of unit operations and processes – Principal type of Reactors – Flow measurement – Screening – Flow Equalisation – Mixing – static and Mechanical mixers – Coagulation and Flocculation – Perikinetic and Orthokinetic flocculation.

UNIT-II PRINCIPLES OF SEDIMENTATION AND FLOTATION 9

Sedimentation – Type of setlting – Removal ratio – Clarifier-thickener- Floatation - Dissolved air flotation.

UNIT-III FILTRATION **9**

Filtration – classification of filters-Head loss through filters– Darcy equation.

UNIT-IV CHEMICAL UNIT PROCESSES **9**

Chemical precipitation – phosphate removal – Adsorption – Activated carbon – Isotherms – Disinfection – principles – types of chlorination – Dechlorination.

UNIT-V BIOLOGICAL UNIT PROCESSES **9**

Kinetics of Biological growth - Suspended and attached growth processes - Aerobic and Anaerobic - Determination of kinetic co-efficients.

REFERENCES:

1. Metcalf& Eddy, Inc. 'Wastewater Engineering, Treatment, Disposal and Reuse, Third Edition, Tata McGraw- Hill Publishing Company Limited, New Delhi 2003.
2. Lee, CC & Shun dar Lin, Hand book of Environmental Engineering Calculations, McGraw Hill, New York,1999.
3. Casey T.J. Unit treatment processes in water and wastewater engineering, John Willeys Sons, London, 1993.

MER065	**ENVIRONMENTAL IMPACT ASSESSMENT**	**L**	**T**	**P**	**C**
	Total Contact Hours:45	**3**	**0**	**0**	**3**
	Prerequisite: Environmental Engineering-II				
	Course Designed by : Department of Civil Engineering				

OBJECTIVES

To educate the students on the scope, steps involved and various methods related to assessment of environmental impact due to development projects.

COURSE OUTCOMES (COs)

CO1	To make them understand the basics of EIA and its limitations across sectoral issues a terms of references in EIA. It also includes the study of participation of Public and Non Governmental Organizations in environmental decision making.
CO2	To understand about the methods and components of EIA and to learn about the expe systems.
CO3	To understand in detail about the prediction tools for EIA along with the mathematical

	modeling for impact prediction.
CO4	To improve the knowledge on the ethical and quality aspects of Environmental Impact Assessment.
CO5	To know in detail about the Case studies of EIA related to the various sectors in a country like infrastructure, sources of energy etc.

Mapping of Course Outcomes with Program outcomes (POs)
(H/M/L indicates strength of correlation) H-High, M-Medium, L-Low

1	COs/Pos	a	b	c	d	E
2	CO1		H		L	M
	CO2		M		H	L
	CO3	H			L	M
	CO4		M		L	H
	CO5		H		L	M
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
				√		
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

UNIT-I INTRODUCTION **9**

Environment Impact Assessment (EIA) - Environmental Impact statement – EIA in Project Cycle – Legal and Regulatory aspects in India according to Ministry of Environment and Forests – Types and Limitations of EIA- cross sectoral issues and terms of references in EIA- participation of Public and Non-Governmental Organizations in environmental decision making.

UNIT-II COMPONENTS AND METHODS **9**

Components of EIA – Processes – screening – scoping – setting – analysis - mitigation. Matrices-Networks –Checklists – connections and combinations of processes – Cost benefit analysis - Analysis of alternatives - Software packages for EIA-Expert systems in EIA.

UNIT-III PREDICTION, ASSESSMENT OF IMPACTS AND REPORTING 9

Prediction tools for EIA-Mathematical modeling for impact prediction-Assessment of impacts-air-water-soil-noise-biological-socio-cultural environments-Cumulative Impact Assessment-Documentation of EIA findings-planning-organization of information and visual display materials-Report preparation.

UNIT-IV 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-Ethical and Quality aspects of Environmental Impact Assessment.

UNIT-VCASE STUDIES 9

Case studies related to the following sectors-Infrastructure-Mining-industrial-Thermal Power – River valley and Hydroelectric-Nuclear Power.

Total Periods : 45

REFERENCES:

1.Lawrence, D.P., Environmental Impact Assesment - Practical solutions torecurrent problems, Wiley- Interscience, New Jersey, 2003.

2.Petts, J., Handbook of Environmental Impact Assessment, Vol., I and II, Blackwell Science London,1999.

3.Canter, L.W., Environmental Impact Assessment , McGraw- Hill, New York,1996.

4.Biswas, A.K. and Agarwala, S.B.C. Environmental Impact Assessment for Developing Countries, Butterworth Heinemann, London,1994.

5. The World Bank Group, Environmental Assessment Source Book Vol. I, IIand III. The World Bank, Washington,1991.

		L	T	P	C
MER066	**ENVIRONMENT, HEALTH AND SAFETY IN INDUSTRIES**				
	Total Contact Hours:45	**3**	**0**	**0**	**3**
	Prerequisite:Industrial Waste Treatment and Disposal				
	Course Designed by : Department of Civil Engineering				

OBJECTIVES

To educate the students on principles related to Environment, Health and Safety systems in work places, occupational health and hygiene.

COURSE OUTCOMES (COs)

CO1	To make them understand the Need for developing Environment, Health and Safety systems in work places
CO2	To understand about the occupational health and hygiene
CO3	To understand in detail about the workplace safety and safety systems
CO4	To improve the knowledge on Elements of a health and safety policy and methods of its effective implementation
CO5	To know about the Principles and methods of effective training in Environment, Health and Safety systems in work places

Mapping of Course Outcomes with Program outcomes (POs)
(H/M/L indicates strength of correlation) H-High, M-Medium, L-Low

1	COs/Pos	a	b	c	d	e
2	CO1			L	M	H
	CO2		M	L		H
	CO3		H		M	L
	CO4		M	L	H	
	CO5		L		H	M
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
					√	
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

UNIT I INTRODUCTION **9**

Need for developing Environment, Health and Safety systems in work places. Status and relationship of Acts, Regulations and Codes of Practice .Role of trade union safety representatives. International initiatives.Ergonomics and work place.

UNIT II OCCUPATIONAL HEALTH AND HYGIENE **9**

Definition of the term occupational health and hygiene.Categories of health hazards. Exposure pathways and human responses to hazardous and toxic substances.

Advantages and limitations of environmental monitoring and occupational exposure limits. Hierarchy of control measures for occupational health risks. Role of personal protective equipment and the selection criteria. Effects on humans, control methods and reduction strategies for noise, radiation and excessive stress.

UNIT III WORKPLACE SAFETY AND SAFETY SYSTEMS **9**

Features of the satisfactory design of work premises HVAC, ventilation. Safe installation and use of electrical supplies. Fire safety and first aid provision. Significance of human factors in the establishment and effectiveness of safe systems. Safe systems of work for manual handling operations. Control methods to eliminate or reduce the risks arising from the use of work equipment. Requirements for the safe use of display screen equipment. Procedures and precautionary measures necessary when handling hazardous substances. Contingency arrangements for events of serious and imminent danger.

UNIT IV TECHNIQUES OF ENVIRONMENTAL SAFETY **9**

Elements of a health and safety policy and methods of its effective implementation and review. Functions and techniques of risk assessment, inspections and audits. Investigation of accidents- Principles of quality management systems in health and safety management. Relationship between quality manuals, safety policies and written risk assessments.

38Records and other documentation required by an organisation for health and safety. Industry specific EHS issues.

UNIT V EDUCATION AND TRAINING **9**

Requirements for and benefits of the provision of information, instruction, training and supervision. Factors to be considered in the development of effective training programmes. Principles and methods of effective training. Feedback and evaluation mechanism.

TOTAL : 45 PERIODS

REFERENCES

1. Environmental and Health and Safety Management by Nicholas P. Cheremisinoff and Madelyn L. Graffia, William Andrew Inc. NY, 1995
2. The Facility Manager's Guide to Environmental Health and Safety by Brian Gallant, Government Inst Publ., 2007.

3. Effective Environmental, Health, and Safety Management Using the Team Approach by Bill Taylor, Culinary and Hospitality Industry Publications Services 2005

MER067	**ADVANCED OXIDATION PROCESS**	**L**	**T**	**P**	**C**
	Total Contact Hours:45	**3**	**0**	**0**	**3**
	Prerequisite:Environmental Engineering I,II				
	Course Designed by : Department of Civil Engineering				

OBJECTIVES

To educate the students on the principles of various oxidation process needed for waste water treatment

COURSE OUTCOMES (COs)

CO1	To make them understand the fundamentals of AOPs for water and wastewater treatment
CO2	To understand about the various heterogeneous photocatalytic processes
CO3	To understand in detail about the homogeneous photocatalytic processes
CO4	To improve the knowledge on the various case studies and applications of semiconductor photolysis
CO5	To know about the industrial applications and economic assessment of AOTS

Mapping of Course Outcomes with Program outcomes (POs)
(H/M/L indicates strength of correlation) H-High, M-Medium, L-Low

1	COs/Pos	a	b	C	d	e
2	CO1		H		L	M
	CO2		M		H	L
	CO3	H			L	M
	CO4		M		L	H
	CO5		H		L	M
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
				√		
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

UNITI INTRODUCTION TO AOPs **8**

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

UNIT II HETEROGENEOUS PROCESS 10

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

UNIT III HOMOGENOUS AOPs 8

Ozone, electro-chemical oxidation, ultrasonication, UV – Photolysis, Hydrogen Peroxide and Ultraviolet Radiation (H_2O_2/UV), Fenton and Photo Fenton‟s Oxidation, chemical and nonchemical AOPs, advantages and disadvantages of homogeneous processes.

UNIT IV ENHANCEMENT OF QUANTUM YIELD 9

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

UNIT V INDUSTRIAL APPLICATIONS AND ECONOMIC ASSESSMENT OF AOTs 10

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

TOTAL: 45 PERIODS

REFERENCES:

1. Cao G., "Nanostructures & Nanomaterials: Synthesis, Properties & Applications", Imperial College Press, 2004.

2. Rose R. M., Shepard L. A.and Wulff J., “The Structure and Properties of Materials”, Wiley EasternLtd,

3. Simon Parsons, "Advanced oxidation processes for water and wastewater treatment", IWA Publishing, 2004

4. Thomas Oppenländer, "Photochemical Purification of Water and Air: Advanced Oxidation Processes (AOPs): Principles, Reaction Mechanisms, Reactor Concepts", Wiley-VCH Publishing, Published by, 2003

5. Marta.I.Litter, RobertsJ.Candal,J.Martin Meichtry,"Advanced Oxidation Technologies: Sustainable Solution for Environmental Trearment , CRC,Press, 2014.

MER068	**RESEARCH METHODOLOGY**	**L**	**T**	**P**	**C**
	Total Contact Hours:45	**3**	**0**	**0**	**3**
	Prerequisite: Professional Courses				
	Course Designed by : Department of Civil Engineering				

OBJECTIVES

- To Get adequate knowledge about research concepts
- To describe mathematical modeling and simulation
- To understand experimental modeling
- To get knowledge about the interpretation of result

COURSE OUTCOMES (COs)

CO1	To describe research concepts.
CO2	To Get adequate knowledge about mathematical modeling
CO3	To describe experimental modeling
CO4	To understand analysis of results
CO5	To know about report writing

Mapping of Course Outcomes with Program outcomes (POs)

(H/M/L indicates strength of correlation) H-High, M-Medium, L-Low

1	COs/Pos	a	b	c	d	e
2	CO1	H	M	L	M	M

	CO2	H	M	L	M	M
	CO3	H	M		M	M
	CO4	H	M	L	M	M
	CO5	H	M		M	M
3	Category	Professional Mathematics (PM)	Professional Core (PC)	Professional Elective (PE)	Open Elective (OE)	Project/ Term Paper Seminar/ Internship (PR)
					√	
4	Approval	37th , 38th& 39th Meeting of Academic Council, May 2015, Jan 2016 & April 2016				

I. RESEARCH CONCEPTS **9**

II. Concepts, meaning, objectives, motivation, types of research, approaches, research (Descriptive research, Conceptual, Theoretical, Applied & Experimental).

Formulation of Research Task – Literature Review, Importance & Methods, Sources, quantification of Cause Effect Relations, Discussions, Field Study, Critical Analysis of Generated Facts, Hypothetical proposals for future development and testing, selection of Research task.

II MATHEMATICAL MODELING AND SIMULATION **9**

Concepts of modeling, Classification of Mathematical Models, Modeling with Ordinary differential Equations, Difference Equations, Partial Differential equations, Graphs, Simulation, Process of formulation of Model based on Simulation.

III EXPERIMENTAL MODELING **9**

Definition of Experimental Design, Examples, and Single factor Experiments, Guidelines for designing experiments. Process Optimization and Designed experiments, Methods for study of

response surface, determining optimum combination of factors, Taguchi approach to parameter design.

IV ANALYSIS OF RESULTS 9

Parametric and Non-parametric, descriptive and Inferential data, types of data, collection of data (normal distribution, calculation of correlation coefficient), processing, analysis, error analysis, different methods, analysis of variance, significance of variance, analysis of covariance, multiple regression, testing linearity and non-linearity of model.

V REPORT WRITING 9

Types of reports, layout of research report, interpretation of results, style manual, layout and format, style of writing, typing, references, tables, figures, conclusion, appendices.

TEXT BOOKS

1. Wilkinson K. L, Bhandarkar P. L, „Formulation of Hypothesis", Himalaya Publication.
2. Schank Fr.,"Theories of Engineering Experiments", Tata Mc Graw Hill Publication.

REFERENCE BOOKS

1. Douglas Montgomery, "Design of Experiments", Statistical Consulting Services, 1990.
2. Douglas H. W. Allan, "Statistical Quality Control: An Introduction for Management", Reinhold Pub Corp, 1959.
3. Cochran and Cocks, „Experimental Design", John Willy & Sons.
4. John W. Besr and James V. Kahn, „Research in Education", PHI Publication.
5. Adler and Granovky, "Optimization of Engineering Experiments", Meer Publication.
6. S. S. Rao, „Optimization Theory and Application", Wiley Eastern Ltd., New Delhi, 1996.