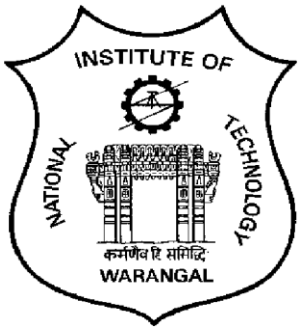
NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL



RULES AND REGULATIONS

SCHEME OF INSTRUCTION AND SYLLABI

FOR

M.TECH PROGRAM IN ENVIRONMENTAL ENGINEERING

Effective from 2016-17

DEPARTMENT OF CIVIL ENGINEERING

SCHEME OF INSTRUCTION

M.Tech. (Environmental Engineering) Course Structure

M. Tech. I - Year I - Semester

S No	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	CE5301	Environmental Chemistry and Microbiology	4	0	0	4	PCC
2	CE5302	Air Pollution and Control	4	0	0	4	PCC
3	CE5303	Environmental systems Engineering	4	0	0	4	PCC
4	CE5304	Advanced Water Supply Systems	4	0	0	4	PCC
5		Elective – I	3	0	0	3	DEC
6		Elective – II	3	0	0	3	DEC
7	CE5305	Environmental Engineering Lab	0	0	3	2	PCC
8	CE5306	Environmental Systems Design Lab	0	0	3	2	PCC
9	CE5341	Seminar – I	0	0	2	1	PCC
		TOTAL	**22**	**0**	**8**	**27**	

M. Tech. I - Year II - Semester

S No	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	CE5351	Wastewater Treatment Systems	4	0	0	4	PCC
2	CE5352	Solids and Hazardous Waste Management	4	0	0	4	PCC
3		Elective – III	3	0	0	3	DEC
4		Elective – IV	3	0	0	3	DEC
5		Elective – V	3	0	0	3	DEC
6		Elective – VI	3	0	0	3	DEC
7	CE5353	Environmental Microbiology Laboratory	0	0	3	2	PCC
	CE5354	GIS Laboratory	0	0	3	2	PCC
8	CE5391	Seminar – II	0	0	2	1	PCC
		TOTAL	**20**	**0**	**8**	**25**	

M. Tech. II - Year I - Semester

S No	Course Code	Course Title	Credits	Cat. Code
		Industrial Training (8-10 Weeks) – Optional		
1	CE6342	Comprehensive Viva Voce	2	PCC
2	CE6349	Dissertation Part A	6	PCC
		Total	8	

M. Tech. II - Year II - Semester

S No	Course Code	Course Title	Credits	Cat. Code
1	CE6399	Dissertation Part B	12	PCC
		Total	12	

List of Electives

I Year I Semester

CE5311	Ecology and Stream Pollution
CE5312	Environmental Impact Assessment and Management
CE5313	Cleaner Technologies
CE5314	Economics for Pollution Control
CE5315	Environmental Policy and Legislation
CE5316	Life Cycle Analysis
CE5317	Environmental Geotechnology
CE5511	Advanced Statistical Methods

I Year II Semester

CE5361	Industrial Waste Management
CE5362	Environmental Hydraulics and Hydrology
CE5363	Rural Water Supply and Environmental Sanitation
CE5364	Environmental Audit
CE5365	Bio-remediation
CE5366	Environmental Management Systems
CE5762	Urban Water Management
CE5765	Applications of RS and GIS in Water Resources and Environmental Engineering
CE5767	Applications of Soft Computing Techniques
CE5768	Water Quality Modeling
CE5770	Climate Systems

DETAILED SYLLABUS

CE5301	ENVIRONMENTAL CHEMISTRY AND MICROBIOLOGY	PCC	4 – 0 – 0	4 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the fundamentals aspects of chemistry valuable for solving environmental problems
CO2	Apply the principles of chemistry in the treatment processes of water and wastewater
CO3	Classify and analyze the microorganisms
CO4	Understand the processes in biological treatment systems

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	1	-	1	1	2	-	-	1
CO2	1	3	1	1	1	-	-	1
CO3	2	2	2	1	1	-	1	-
CO4	1	3	1	1	1	-	-	1

Detailed Syllabus:

General Chemistry:-Basic principles – chemical equations – types of chemical reactions - calculations from chemical equations; gas laws; Equilibrium and Le Chatelier's Principle – factors affecting chemical equilibrium - activity and activity coefficient - ionic strength.

Physical Chemistry:- Thermodynamics – heat and work – enthalpy – entropy – free energy – temperature dependence of equilibrium constant; membrane processes; principles of solvent extraction; ; electrochemistry; chemical kinetics; adsorption.

Equilibrium Chemistry:-Variations of Equilibrium relationships; ways of shifting chemical equilibrium; solutions to equilibrium problems -acid base equilibrium – solubility equilibrium – oxidation reduction equilibrium.

Organic Chemistry and Biochemistry:-Organic compounds of interest to environmental engineers, general properties of the functional groups of organic compounds; Enzymes, classification enzymes catalyzed reaction, energy considerations coupling of reaction; Breakdown and synthesis of carbohydrates, fats, proteins under aerobic and anaerobic reactions; CNP cycles under aerobic and anaerobic reactions;. Concepts of BOD, COD, TOC.

Environmental Chemistry:-Major water and wastewater quality parameters, Fundamentals of surface and colloidal chemistry; chemistry involved in water treatment procedure like coagulations – softening - fluoridation, defluoridation - iron and manganese removal – demineralization - analysis of pesticide and heavy metals; Atmospheric chemistry; soil

chemistry- Instrumentation for analysis of water and wastewater.

Environmental Microbiology:- Introduction of microbiology, classification and characterization of microorganisms, viruses; Morphology and structure of bacteria, nutrient requirement, growth of bacteria; Basic microbiology of water and sewage; Basic principals involved in the analysis of fecal indicator bacteria – coli forms and streptococci, plankton analysis, analysis of pseudomonas & streptococci; Pathways of aerobic and anaerobic metabolism, Energy transfer in metabolism; Kinetics of microbial growth.Microbiology of water, wastewater, soil and air.

Readings:

1. Sawyer, C. N., McCarty, P. L., and Perkin, G.F., Chemistry for Environmental Engineering and Science, 5thEd., McGraw-Hill Inc., 2002
2. Benefield D. L., Judkins F. J., Weand L. B., Process Chemistry for Water and Wastewater Treatment, 1st Ed., Prentice Hall, 1982
3. Bitton, G., Wastewater Microbiology, 3rd Ed., Wiley, 2005
4. Mitchell, R., and Gu, J.D., Environmental Microbiology, 2nd Ed., Wiley-Blackwell, 2010
5. Eugene Weiner R., Applications of EnvironmentalChemistry - A Practical Guide for Environmental Professionals, 1st Ed., Lewis Publishers, 2000

CE5302	AIR POLLUTION AND CONTROL	PCC	4 – 0 – 0	4 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Identify sampling techniques and analyze air quality.
CO2	Understand plume behaviour for different atmospheric stability conditions.
CO3	Assess concentration of pollutant at different receptor locations using plume dispersion modelling
CO4	Design air pollution control systems and evaluate their efficiency

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	3	1	1	-	1	1
CO2	3	2	2	-	1	-	1	-
CO3	3	2	3	-	2	2	1	1
CO4	2	2	1	-	1	2	1	1

Detailed Syllabus:

Air Pollution: Definition of Air Pollution - Sources & Classification of Air Pollutants - Effects of air pollution - Global effects - Air Quality and Emission standards - Sampling of Pollutants in ambient air - Stack sampling.

Meteorology And Air Pollution: Factors influencing air pollution, Wind rose, Mixing Depths, Lapse rates and dispersion - Atmospheric stability, Plume rise and dispersion, Prediction of air quality, Box model - Gaussian model - Dispersion coefficient - Application of tall chimney for Pollutant dispersion.

Control Of Particulate Pollutants: Properties of particulate pollution - Particle size distribution - Control mechanism - Dust removal equipment - Design and operation of settling chambers, cyclones, wet dust scrubbers, fabric filters & ESP.

Control Of Gaseous Pollutants: Process and equipment for the removal by chemical methods - Design and operation of absorption and adsorption equipment - Combustion and condensation equipment, fugitive gas emissions and control.

Automobile Pollution And Control: Sources, Theoretical Considerations, Operating conditions Vs Emissions, Pollution control Measures, Emission Standards.

Control Of Air Pollution: Zoning and site selection – Other Management controls, AP Legislation.

Readings:

1. Colls, J., Air Pollution: Measurement, Modeling and Mitigation, CRC Press, 2009
2. Noel, D. N., Air Pollution Control Engineering, Tata McGraw Hill Publishers, 1999
3. Stern, A.C., Fundamentals of Air Pollution, Academic Press, 1984

CE5303	ENVIRONMENTAL SYSTEMS ENGINEERING	PCC	4 – 0 – 0	4 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Analyze physical, chemical and biological processes in environmental systems.
CO2	Formulate and solve governing equations for pollutant transport.
CO3	Analyze engineered transport system.
CO4	Plan and analyze treatment systems.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	2	2	1	2	2	2	1
CO2	2	2	2	1	2	2	2	1
CO3	2	2	2	1	2	2	2	1
CO4	2	2	2	1	2	2	2	1

Detailed Syllabus:

Basic concepts of mole and mass concentration: notations and conventions, Review of mass balance concepts.

Diffusive transport: Diffusion and Fick's first law, Calculation of molecular diffusion coefficients in air and water

The constitutive transport equation: Derivation of general transport equation and special forms ie continuity and NS equations and similarity between equations of mass momentum and heat dispersion laws.

Theories of mass transport: two film theory, penetration and surface renewal theory, Boundary layer theory. Mass transport correlations

Transport in sheared reactors: Fluid shear and turbulence, transport in steady sheared fluids, turbulent sheared fluids, shear rates in mixed reactors

Particles and fractals: Introductions, particle size spectra, solid particles and fractal aggregate geometries, measuring and calculating fractal dimensions from particle size distributions.

Coagulation in natural and engineered systems: Introduction, general coagulation equations, factors affecting the stability of aquasols, coagulation kinetics, fractal coagulation models.

Finite difference and Finite volume procedures for solutions of partial differential equations of Mass, Momentum and Energy transport phenomenon

Readings:

1. Bruce E. Logan, Environmental Transport Processes, 2nd Ed., Wiley, 2012.
2. E.L. Cussler, Diffusion: Mass transfer in fluid systems, 3rd Ed., Cambridge University Press, 2007.
3. John S. Gulliver, Introduction to chemical transport in the environment, Cambridge University Press, 2007

CE5304	ADVANCED WATER SUPPLY SYSTEMS	PCC	4 – 0 – 0	4 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Estimate water demand
CO2	Analyze water quality
CO3	Design conventional water treatment systems
CO4	Design treatment systems for removal of dissolved solids
CO5	Analyze and design water distribution systems

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	-	-	1	-	2	-
CO2	3	2	-	1	1	-	2	-
CO3	3	3	-	1	2	2	1	1
CO4	3	3	-	1	2	2	1	1
CO5	3	2	-	1	1	2	1	1

Detailed Syllabus:

Need for Transport of water- Water quality- Planning of water supply systems –Intake structures, Selection ofpipe materials, Water transmission main design- Gravity and pumping main; Selection ofPumps- Characteristics-Economics; Jointing, Laying and Maintenance, Waterhammer analysis; Water distribution pipe networks- Design, analysis and optimization – Appurtenances –Corrosion prevention – Minimization of water losses – Leak detection- SCADA systems- Storage reservoirs- Water treatment: Screening – Mixing- Equalization – Sedimentation – Coagulation, Flocculation- Filtration– Back washing –Membrane separation- Reverse Osmosis- Nano filtration, Ultra filtration-Electro dialysis- -Specific contaminant removal systems- Disinfection- Water reuse/recycle- Sludge thickening-Sludge dewatering systems- Sludge drying beds- Recent Advances.

Use of computer software in water transmission and water distribution– LOOP, BRANCH, Canal ++ and GIS based software.

Readings:

1. Mackenzie L. Davis, Water and Wastewater Engineering: Design Principles and Practice,McGraw Hill, 2010.
2. Howard S. Peavy, Donald R. Rowe and George Tchobanoglous, Environmental Engineering, McGraw Hill., 1984
3. ViessmanJr, Hammer J. M, Perez, E.M, and Chadik, P. A, Water Supply and Pollution Control, PHI Learning, New Delhi, 2009
4. WATER QUALITY& TREATMENT, AWWA Hand book, McGraw Hill, 2011.

CE5305	ENVIRONMENTAL ENGINEERING LAB		0 – 0 – 3	2 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Identify and analyze physical parameters of water and wastewater.
CO2	Determine the concentration of Chlorides, Fluorides, Hardness, DO and other quality parameters.
CO3	Estimate BOD and COD of given wastewater samples.
CO4	Determine pollutant concentrations using AAS, Spectrophotometer, HPLC, Ion Analyser and flame photometer.
CO5	Determine pollutant concentrations in air samples.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	-	1	2	-	-	1
CO2	3	3	1	-	1	-	-	1
CO3	3	3	1	-	-	-	1	1
CO4	3	3	1	-	-	2	-	-
CO5	3	3	-	-	1	-	1	-

Detailed Syllabus:

Experiment No.1: Estimation of Solids (TDS/TDIS, TSS, VS), Acidity, Alkalinity, Hardness, Chlorides and Fluorides
Experiment No.2: Determination of pH and Conductivity
Experiment No.3: Estimation of Biochemical Oxygen Demand
Experiment No.4: Estimation of Chemical Oxygen Demand
Experiment No.5: Estimation of Nitrogen (Different Forms like Ammonia, Nitrite, Nitrate)
Experiment No.6: Estimation of Phosphates and Sulphates
Experiment No.7: Estimation of Residual Chlorine
Experiment No.8: Determination of Available Chlorine in bleaching powder
Experiment No.9: Conducting Break Point Chlorination Test
Experiment No.10: Determination of Dissolved Oxygen
Experiment No.11: Conducting Jar test for determining optimum dosage of coagulant
Experiment No.12: Estimation of Organic Compounds Using HPLC
Experiment No.13: Analysis of air samples using Gas Chromatograph
Experiment No.14: Determination of Heavymetalsusing Atomic Absorption spectrophotometer
Experiment No.15:Estimation of suspended particulate matter, SO_x, NO_x and VOC in air

Readings:

1. Standard methods for the examination of water and wastewater, 21st Edition, Washington: APHA., 2012
2. Sawyer, C. N., McCarty, P. L., and Perkin, G.F., Chemistry for Environmental Engineering and Science, 5th edition McGraw-Hill Inc., 2002
3. B. Kotaiah and Dr. N. Kumara Swamy, Environmental Engineering Laboratory Manual, Charotar Publishing House Pvt. Ltd., 1st Ed., 2007

CE5306	ENVIRONMENTAL SYSTEM DESIGN LAB		0 – 0 – 3	2 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Design stormwater sewers using precipitation data.
CO2	Design water supply mains and distribution system
CO3	Estimate the effect of water hammer in water supply pipelines and design the appurtanances
CO4	Determine kinetic parameters related to chemical and biological processes
CO5	Design air pollution control systems

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	-	1	-	1	-
CO2	3	3	-	2	2	2	-	-
CO3	3	2	2	-	-	-	-	-
CO4	3	2	2	-	1	-	1	-
CO5	3	3	-	1	-	2	-	-

Detailed Syllabus:

Design problem 1: Analysis of Precipitation Data
Design problem 2: Analysis of Distribution Networks
Design problem 3: Design of water Treatment plant
Design problem 4: Design of Wastewater Treatment plant
Design problem 5: Design of Air Pollution Control Devices
Design problem 6: Determination of Rate Constants and Ultimate BOD
Design problem 7: Kinetics of Biological Processes
Design problem 8 :Kinetics of Chemical Processes
Design problem 9 :Design integrated solid waste management system

Readings:

Metcalf & Eddy, Inc., Waste water Engineering Treatment and Reuse, McGraw Hill Inc., New Delhi., 2003

Peavy, H.S, Rowe, D.R., and G. Tchobanoglous ,Environmental Engineering, McGraw Hill Inc., New York., 1995

CE5311	ECOLOGY AND STREAM POLLUTION	DEC	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand fundamental concepts of ecology.
CO2	Identify components of ecosystems and their interrelationships.
CO3	Understand importance of stream water chemistry in assessment of fate of pollutants.
CO4	Assess self purification capacity of receiving waters.
CO5	Model the pollutant transport processes in water bodies.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	1	1	2	1	2	-	2	1
CO2	1	1	2	1	2	-	2	1
CO3	3	2	2	2	2	1	2	-
CO4	3	2	2	1	2	1	2	1
CO5	3	2	2	1	3	2	3	1

Detailed syllabus:

Introduction To Ecosystems: Development and evolution of ecosystems – Principles and concepts – Energy flow and material cycling – Nutrient cycles- productivity – Classification of ecotechnology – ecological engineering- Classification of systems – Structural and functional interactions of environmental systems – Mechanisms of steady-state maintenance in open and closed systems- Modeling and ecotechnology – Classification of ecological models – Applications- Ecological economics- Self-organizing design and processes.

Introduction To Fluvial Ecosystems: Fluvial Ecosystem Diversity- The Water Cycle – Stream flow- Flow Variation- The Stream Channel- Sediments and their Transport- Fluvial Processes along the River Continuum

Stream water Chemistry: Dissolved Gases -Major Dissolved Constituents of River Water-Variability in ionic concentrations -The dissolved load -Chemical classification of river water-The Bicarbonate Buffer System-Influence of Chemical Factors on the Biota-Variation in ionic concentration-Salinization -Effects of acidity on stream ecosystems

Water Quality: Water quality models – Historical development – Non point source pollution- Mass balance equation – Streeter - Phelps Equation – Modification to Streeter – Phelps Equation – Waste load allocations – Dissolved oxygen in Rivers and estuaries; Lake Water Quality Models; Models for Nitrogen, Bacteria, Phosphate and toxicants - Ground Water Quality Modeling - Contaminant solute transport equation,

Numerical methods- legislations for water quality.

Readings:

1. Tebutt T.H.Y., Principles of Water Quality Control, 5th Ed., Pergamon Press, 1998
2. Thomann V. R., and Mueller A. J., Principles of Surface Water Quality Modelling and Control, Prentice Hall, 1997
3. Welch, E.D., Ecological Effects of Wastewater, Cambridge University Press, 1992
4. Frank R. Spellman and Joanne Drinan, Stream Ecology and Self Purification: An Introduction, 2nd Ed., CRC Press, 2001

CE5312	ENVIRONMENTAL IMPACT ASSESSMENT AND MANAGEMENT	DEC	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Identify environmental attributes for the EIA study.
CO2	Identify methodology and prepare EIA reports.
CO3	Specify methods for prediction of the impacts.
CO4	Formulate environmental management plans.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	2	2	2	3	-	2	1
CO2	2	1	1	1	3	-	2	1
CO3	2	2	3	1	3	-	2	1
CO4	2	2	2	2	2	2	2	1

Detailed syllabus:

Introduction: Definitions - Environmental Inventory, Standards, Indices - Environmental attributes—Air, Water Noise, Land Economic; Cultural and detailed discussions of individual parameters of each attributes; methods for Prediction and assessment of impacts air - water - soil - noise - biological - cultural - social - economic environments - Standards and guidelines for evaluation.

EIA - EIA Terminology - Need for EIA - Evolution of EIA - Concepts of EIA - Merits and demerits of EIA - Procedures - Screening, Scoping baseline data, Impact prediction - Stake holders of EIA - Public Participation in Decision making - Projects requiring Environmental Clearance -

EIA methodologies - Criteria for Selection -Impact identification, measurement, interpretation and Evaluation - Impact Communication - Adhoc Methods, Checklists Methods, matrices , Networks and Overlays Methods - Cost-Benefit Analysis - Rapid EIA and Comprehensive EIA - General Framework for Environmental Impact Assessment, Characterization and site assessment.

EMP and Monitoring - Document Planning - Scope and Baseline conditions - Construction Stage Impacts - Environmental Management Plan - Identification of significant or Unacceptable Impacts - Environmental Mitigation Plans - Relief and rehabilitation - Environmental Legislation and Audit - Concept of Environmental Risk Analysis and Life Cycle Assessment - Legal and regulatory Aspects in India.

EIA Case Studies of Developmental Projects : Preparation of EIA for developmental projects - Factors to be considered in making assessment decisions, Water Resources Project, Pharmaceutical industry, thermal plant, Mining, Nuclear fuel complex, Highway project, Sewage treatment plant, CETP, Treatment Storage Disposal Facility, Municipal Solid waste processing plant, Tannery industry. Software for rapid EIA.

Readings:

1. Canter, L.W., Environmental Impact Assessment, McGraw Hill Pub. Co., 1997
2. David P. Lawrence, Environmental Impact Assessment: Practical Solutions to Recurrent Problems, John Wiley & Sons, 2003
3. Hosetti, B. B., Kumar A, Eds, Environmental Impact Assessment & Management, Daya Publishing House, 1998
4. UNESCO, Methodological Guidelines for the Integrated Environmental Evaluation of Water Resources Development, UNESCO/UNEP, Paris, 1987
5. Anjaneyulu.Y., and Manickam. V., Environmental Impact Assessment Methodologies, B.S. Publications, Hyderabad, 2007
6. Wathern.P., Environmental Impact Assessment- Theory and Practice, Routledge Publishers, London, 2004

CE5313	CLEANER TECHNOLOGIES	DEC	3 – 0 – 0	0 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand current developments and problems in the society for clean technologies.
CO2	Apply concepts of thermodynamics in arriving at clean technologies.
CO3	Plan engineered conditions for improved waste management.
CO4	Design hazardous waste management treatment and disposal options.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	-	2	2	2	1	1
CO2	3	2	2	2	2	-	2	1
CO3	2	1	-	3	2	1	2	1
CO4	2	3	1	3	1	2	2	2

Detailed Syllabus:

Introduction

Industrial Society- an overview; Resource Limitations - forests, water, air, soil, material resources; Environmental Problems - local problems such as population, energy, water, pollution etc, global problems such as global warming, climate change, ozone layer depletion, greenhouse effect etc; Sustainable development - principles, environmental, economic and social dimensions of sustainable development by focusing on changing patterns of consumption, production and distribution resources

Thermodynamics

Definitions; Earth as a thermodynamic system; Thermodynamics of the technosystem; Thermodynamics and energy in society; Thermodynamics and environmental pollution; thermodynamically sustainable development.

Energy

The global energy situation; The energy system; Fossil energy, fuel cells; Renewable energy- biomass, photovoltaic, solar thermal, wind energy, future of renewable energy production, fusion; Net energy analysis- energy breeders

Engineering

Separation, supercritical extraction, membranes, reverse osmosis, ultrafiltration, electrodialysis, pervaporation, liquid membranes, adsorption, parametric pumping, biosorbents; Process development, centralization/decentralization/integration, engineering; photochemistry; Thermochemistry; Energy saving; Energy storage

Industrial and Hazardous Waste

Industrial waste types, characteristics of industrial wastes, pollutionfrom major industries, effects of industrial effluents, cleaner

production, treatmenttechnologies; Hazardouswastes definition, sources of hazardous waste, transportation, -treatment and disposal methods and processes

System Analysis, Materials & Products
Flexible processes; Ecodesign; Material recycling; Biodegradable materials - degradation mechanisms, test methods, structural factors influencing biodegradability, microbial polymers, other natural polymers, synthetic and decomposable polymers, mixtures of decomposable and non-decomposable materials.

Readings:

1. Allan Johansson, Clean Technology, 1st edition CRC Press, 1992
2. Aswathanarayana U., Harikrishnan T., and Kadher-Mohien S. T.**,** Green Energy Technology, Economics and Policy, CRC Press, 2012
3. Bernard Ganne and YvelineLecler, Pollution Prevention Handbook, CRC Press, 1995
4. T.T.Shen,IndustrialPollutionPrevention,Springer,1999.
5. Blackman, William C. Basic hazardous waste management, 3rd edition, CRC Press, 2001

CE5314	ECONOMICS FOR POLLUTION CONTROL	DEC	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand economical impacts of environmental projects.
CO2	Perform Cost - Benefit analysis for environmental projects.
CO3	Analyze economics of waste management and recycling.
CO4	Understand the influence of industrial and economic policies on pollution control.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	2	2	2	2	1	1	1
CO2	2	2	-	1	2	1	2	1
CO3	2	-	-	3	2	-	-	1
CO4	2	-	-	-	3	-	-	1

Detailed syllabus:

The Economic Approach: Introduction -The Human–Environment Relationship- Environmental Problems and Economic Efficiency- Property Rights- Externalities as a Source of Market Failure- An Efficient Role for Government.

Ethics, Economics and the Environment: Introduction- Naturalist moral philosophies- Libertarian moral philosophy- Utilitarianism- Criticisms of utilitarianism- Inter temporal distribution

Evaluating Trade-Offs: Benefit–Cost Analysis: Normative Criteria for Decision Making- Evaluating Predefined Options: Benefit–Cost Analysis- Finding the Optimal Outcome- Relating Optimality to Efficiency- Applying the Concepts- Valuation of environment.

Recyclable Resources: An Efficient Allocation of Recyclable Resources- Factors Mitigating Resource Scarcity- Market Imperfections- Disposal Cost and Efficiency- The Disposal Decision- Corrective Public Policies

Economics Of Pollution Control: Introduction- A Pollutant Taxonomy -Defining the Efficient Allocation of Pollution- Stock Pollutants- Fund Pollutants-Market Allocation of Pollution-Efficient Policy Responses- Cost-Effective Policies for Uniformly Mixed Fund Pollutants -Defining a Cost-Effective Allocation- Cost-Effective Pollution-Control Policies -Cost-Effective Policies for Non-uniformly Mixed Surface Pollutants- The Single-Receptor Case- The Many-Receptors Case- Other Policy Dimensions- The Revenue Effect- Responses to Changes in the Regulatory Environment- Price Volatility-

Instrument Choice under Uncertainty- Product Charges: An Indirect Form of Environmental Taxation, Polluter pays principle, intangible costs of pollution.

Readings:

1. Dixon, J., Economic Analysis of Environmental Impacts, Earthscan Publications, 1994
2. Tietenberg Tom and Lyne Lewis, Environmental Economics and policy, Pearson Higher Education, 2009
3. Tietenberg Tom and Lyne Lewis, Environment and Natural Resources Economics, Prentice Hall, 2011
4. Turner, R.K., Pearce, D., and Batman, I, Environmental Economics, The Johns Hopkins University Press, 1993

CE5315	ENVIRONMENTAL POLICY AND LEGISLATION	DEC	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Describe national and international policy issues related to environmental media.
CO2	Understand existing environmental laws and regulation.
CO3	Assess influence of policy decisions on the environment.
CO4	Apply knowledge of environmental analysis in planning and policy making.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	2	-	2	2	-	-	1
CO2	2	2	-	2	2	1	-	1
CO3	2	2	-	1	2	-	-	1
CO4	2	1	-	1	1	2	-	2

Detailed syllabus:

Introduction: Economics and Environmental Policy

Theory of externalities: Relevance. Externalities: definitions, significant types, and optimal pricing conditions, formal analysis

Uncertainity and choice of policy instruments: price or quantity controls. Market imperfections and the number of participants.

Detrimental externalities, and nonconvexities in the production set, optimal pricing of exhaustible resources

Introduction to design of Environmental policy. Efficiency without optimality: the charges and standard approaches

Marketable emission permits for the protection of the environment. Stochastic influences, direct controls, and taxes.Taxesvs subsidies: a partial analysis. Environment protection and the distribution of income

International environmental issues, National and local standards for environmental quality

Readings:

1. Baumol, W. J. and Oates, W. E. “The theory of environmental policy”, Cambridge: Cambridge University Press, 1988

2. Dixon, J. Economic Analysis of Environmental Impacts. London: Earthscan Publications, 1994
3. Mehta, S.; Mundle, S. and Sankar, U. Incentives and regulation for pollution control. Sage Publishers, 1997
4. Bohm, P. and Russell, C. "Comparative analysis of alternative policy instruments", in Allen Kneese, V. and Sweeney, J.L. (eds.) Handbook of natural resource and energy economics. North Holland, 1985

CE5316	LIFE CYCLE ANALYSIS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Perform life cycle inventory analysis of products.
CO2	Develop strategies to bring energy efficiency in all stages of the product development cycle.
CO3	Formulate plans for comprehensive environmental protection, in order to comply with environmental laws.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	1	2	1	3	-	2	1
CO2	3	1	-	-	2	-	1	2
CO3	3	2	-	2	2	2	2	2

Detailed Syllabus:

Introduction, Life Cycle Assessment concepts.

A brief history of Life-cycle Inventory analysis, overview of methodology, Three components, Indentifying and setting boundaries for life-cycle stages, issues that apply to all stages, Applications of inventory analysis

Procedural framework of Life-cycle inventory: Introduction, define the purpose and scope of inventory

General issues in Inventory analysis: Introduction, Using Templates, Data issues, special case boundary issues

Issues Applicable to specific life cycle stages: Introduction, Raw Material acquisition stage, Manufacturing stage, Use/Reuse/Maintenance stage, Recycle/Waste Management stage.

Readings:

1. Ciambrone , D.F., Environmental Life Cycle Analysis, CRC Press, 1997
2. Handbook on Life Cycle Assessment : Operational guide to the ISO standards, Kluwer Academic Publishers, 2004

CE5317	ENVIRONMENTAL GEOTECHNOLOGY	DEC	3 – 0 – 0	0 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the fundamentals of soil behavior under varied environmental conditions
CO2	Identify contaminant transport mechanisms in soils.
CO3	Specify site investigation techniques in the characterization of the contaminated site
CO4	Understand the principles of various remediation techniques.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	2	2	1	1	1
CO2	3	2	3	2	2	1	2	2
CO3	3	2	1	1	1		1	1
CO4	2	3	2	3	2	2	1	2

Detailed syllabus:

Soil system: Soil formation, soil minerology, soil structure, soil-water-pollutant interaction, soil composition and engineering properties, determination of soil composition.

Mass Transport and Transfer of contaminants: Mass transport and transfer mechanisms, Governing equation for mass transport, Solutions for special cases of mass transport, Non-aqueous – Phase Liquids in soils

Site characterization: Site investigation approach, phase investigations, Geophysical techniques, hydro-geological investigations, hydro-geochemical investigations, geochemical data collection and analysis.

Remediation Technologies: Treatment approaches, Basis for treatment technology selection, in-situ treatment techniques & principles, ex-situ treatment techniques & principles, Natural attenuation principles, waste containment systems.

Readings:

1. Mitchell, J.K. and Soga, K., Fundamentals of Soil Behaviour, John Wiley & Sons, Inc., New Jersey., 2005
2. Reddy, L.N. and Inyang. H. I., Geoenvironmental Engineering –Principles and Applications, Marcel Dekker, Inc., New York., 2000

3. Mohamed, A.M.O. and Antia, H.E., Geoenvironmental Engineering, Elsevier, Netherlands., 1998
4. Hsai_Yang Fang and Daniels, J.L. Introductory Geotechnical Engineering an Environmental Perspective, Taylor & Francis, Oxon., 2006
5. Daniel, D. E., Geotechnical Practice for Waste Disposal, Chapman and Hall, 1993
6. Yong, R. N., Geoenvironmental Engineering: Contaminated Soils, Pollutant Fate and Mitigation", CRC press LLC, Florida., 2001

CE 5511	ADVANCED STATISTICAL METHODS	DEC	3-0-0	3 Credits

Prerequisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Understand and solve the problems using the advanced statistical approaches
CO2	Identify the statistical methods for solving geospatial problems
CO3	Apply the advanced statistical methods for image processing
CO4	Use geo-statistics for studying spatially varying phenomena

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	2	1	3	1			
CO2	3	2	1	3	2	1		
CO3	1	2	3	1				
CO4	1	3	2	2	2	1		

Detailed Syllabus:

Basic Statistics: Sources of Data, Organization of Data, The Histogram, Measures of central tendency, Mean Deviation, Standard Deviation, Correlation, Coefficient of correlation, Rank correlation, Regression.

Multivariate Data: Vector random variables, sample estimate of centroid, standard deviation, SSCP, dispersion, variance, covariance, correlation matrices.

Multiple Regression: Multiple parameter estimation by method of least squares, tests of significance use of dummy variables, problems associated with multi co-linearity, heteroscadasticity

Probability: equally likely, mutually exclusive events, definitions of probability, additions & multiplication theorems of probability and problems based on them.

Bayesian approach, distributions; Poisson, normal, Erlang, Gamma and Weibull probability distributions.

Geostatistics- Pattern Analysis, Measures of Arrangements & dispersion, Auto Correlation, Semiveriogram, Kriging

Reading:

1. Gupta, S.C. and Kapoor, V.K., “Fundamentals of Mathematics Statistics”, Sultan Chand and Sons, 2001.
2. Johnson, R.J., “Miller and Freund’s Probability and Statistics for Engineers” 6th Edition, Prentice Hall of India, 2002.
3. Jay L.Devore, “Probability and statistics for Engineering and the Sciences”, Thomson and Duxbbury, 2002.

4. Sarma, D.D. “Geostatistics with Applications in Earth Sciences”, Capital Publishing Company, 2002.
5. Cooley W.W and LohnesP.R .- Multivariate Data Analysis**,** John Wiley and Sons,1971.

CE5351	WASTEWATER TREATMENT SYSTEMS	PCC	4 – 0 – 0	4 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Identify and assess the characteristics of wastewater and their impacts
CO2	Plan and design the components of wastewater treatment systems
CO3	Understand underlying principles of processes involved in secondary wastewater treatment systems.
CO4	Design sludge treatment and disposal methods.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	1	-	2	-	1	-
CO2	3	3	1	-	1	-	1	1
CO3	2	2	-	-	1	1	-	-
CO4	3	3	1	-	1	2	-	1

Detailed Syllabus:

Introduction: Wastewater Sources and flow rates, Characteristics, Standards of Disposal, Treatment Objective and Strategies, Sanitary sewer design, Head works and Preliminary design, Layouts of Primary, Secondary and Advanced Treatment Units.

Design Of Preliminary and Primary Treatment Operations: Screens, Grit Chambers, Skimming Tank, Primary and Secondary Sedimentation Tanks.

Biological Treatment Processes: Types, Kinetics of Plug Flow and Completely Mixed Systems for aerobic and anaerobic systems.

Attached Growth Processes: Trickling Filters (Standard Rate, High Rate), Biofilters, Practices, Features and Design, Operational Difficulties and Remedial Measures, Rotating Biological Contactors.

Suspended Growth Processes: Activated Sludge Process, Modifications and Design Equations, Process Design Criteria, Oxygen and Nutrient Requirements - Classification and Design of Oxidation Ponds, Lagoons, Root Zone Treatment Systems, Membrane bio reactors, fluidized bed reactors, Hybrid Systems.

Sludge Treatment And Disposal: Sludge Thickening, Aerobic and Anaerobic Sludge Digestion Processes, Design of Digester Tank, Sludge Dewatering, Ultimate Disposal, Other Methods of Sludge Treatment.

Readings:

1. Metcalf and Eddy, *Wastewater Engineering – Collection, Treatment, Disposal and Reuse*, 4th Ed., McGraw Hill Pub. Co., 2003

2.Mackenzie L. Davis, Water and Wastewater Engineering: Design Principles and Practice,McGraw Hill, 2010.

3. Benefield L.D. and Randall C.D., *Biological Process Designs for Wastewater Treatment*, Prentice Hall Pub. Co., 1980

4. UdoWiesmann, In Su Choi and Eva-Maria Dombrowski, *Fundamentals of Biological Wastewater Treatment*, 1st Ed., Wiley, 2007

CE5352	SOLID AND HAZARDOUS WASTE MANAGEMENT	PCC	4 – 0 – 0	4 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Examine physical and chemical composition of hazardous wastes
CO2	Analyze activities associated with the management of solid waste.
CO3	Understand method to recover materials, conserve products, and to generate energy from solid and hazardous wastes.
CO4	Design and locate waste containment systems as per regulatory standards.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	3	2	1	-	-	-
CO2	2	2	1	2	1	-	-	1
CO3	3	2	1	2	1	1	-	1
CO4	3	3	2	3	1	2	-	1

Detailed Syllabus:

Solid Waste: Definitions, Characteristics, and Perspectives
Types of solid wastes, sources of solid wastes, properties of solid wastes, solid waste management: an overview

Engineering Systems for Solid Waste Management
Solid waste generation; on-site handling, storage and processing; collection of solid wastes; transfer and transport; processing techniques; ultimate disposal

Engineering Systems for Resource and Energy Recovery
Processing techniques; RRR approach, materials-recovery systems; recovery of biological conversion products; recovery of thermal conversion products; recovery of energy from conversion products; materials and energy recovery systems.

Hazardous Waste Management
Introduction; Concern about Hazardous Waste Management; Industrial/biomedical waste, Characteristics of Hazardous Waste; Transportation and Disposal of Hazardous Waste; Control of Hazardous Waste

Readings:

1. Tchobanoglous G, Theisen H and Vigil SA , Integrated Solid Waste Management, Engineering Principles and Management Issues' McGraw-Hill, 1993
2. Vesilind PA, Worrell W and Reinhart D, Solid Waste Engineering' Brooks/Cole

Thomson Learning Inc., 2002
3. Peavy, H.S, Rowe, D.R., and G. Tchobanoglous, Environmental Engineering, McGraw Hill Inc., N.York, 1985
4. G. Tchobanoglous., Frank Kreith ,Hand Book of Solid Waste Management, McGrawHill, Inc., N.York., 2002
5. Qian X, Koerner RM and Gray DH, Geotechnical Aspects of Landfill Design and Construction, Prentice Hall, 2002

CE5361	INDUSTRIAL WASTE MANAGEMENT	DEC	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Sample and analyze the characteristics of industrial wastewaters.
CO2	Analyze the effects of disposal of industrial wastes
CO3	Identify and design treatment options for handling industrial wastewater.
CO4	Identify and design treatment options for handling industrial wastewater.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	1	2	2	-	-	-
CO2	2	-	2	2	2	-	1	1
CO3	2	3	2	2	1	1	2	1
CO4	2	2	1	2	2	2	1	2

Detailed Syllabus:

Introduction:
General Characteristics of Industrial Effluents, Effects on Environment - ISI tolerance limits for discharging industrial effluents into surface water, into public sewers, onto land for irrigation and marine environment- Toxic chemicals from industry, Zero waste approach.

Pretreatment Of Industrial Wastewater:
Necessity of pretreatment - Equalization - Seggregation - Process Changes - Salvaging - By product Recovery. Removal by Reverse Osmosis, Ion Exchange, Electrodialysis, Solvent Extraction, Floatation.- Removal of Refractory Organics - Removal of Nitrogen and Phosphorus.

Major Industrial Effluents:
Sources, Characteristics and Treatment.
Food Industries: Sugar, Dairy, Distilleries
Chemical and other Industries*:* Paper and Pulp, Tanneries, Textiles, Fertilizers, Pharmaceuticals, Cement, Steeland refineries.

Readings:

1. Industrial Wastewater Management, Treatment and Disposal, WEF Manual of practice No. FD-3, 3rd Ed., WEF Press and McGrawHill, 2008
2. Numerow, N.L., Liquid Waste from Industry – Theories, Practice and Treatment, Addison-Wesley, 1971
3. Patwardhan, A.D., Industrial Waste Water Treatment, PHI Learning, 2009 Rao,

M.N., and Dutta, A.K., Wastewater Treatment, IBH Publ., 1995

CE5362	ENVIRONMENTAL HYDRAULICS AND HYDROLOGY	DEC	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Formulate momentum, energy and mass transport models.
CO2	Solve diffusion-dispersion equations.
CO3	Apply basic flow equations for steady and unsteady flows in open channels.
CO4	Derive and solve basic equations of flow through porous medium.
CO5	Formulate forecasting models for operation of hydrologic systems.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	1	2	3	2	2	-	3	1
CO2	2	2	3	2	1	1	2	1
CO3	2	2	2	1	2	1	2	1
CO4	2	2	3	2	2	1	2	1
CO5	1	2	1	2	1	-	2	1

Detailed syllabus:

Basic concepts of open channel flows, conservation laws, continuity equation, momentum equation, Application of momentum and energy equations

Critical flow, its properties and application; location of critical flow and its computation

Uniform flow, flow resistance, equations of flow resistance, computation of normal depth, Gradually varied flow, governing equations classification of water surface profiles

Rapidly varied flow, application of conservation laws, channel transition, supercritical flow, Hydraulic Jump

Hydrologic cycle and its interaction with human activity, Hydrologic processes, Hydrologic analysis, Hydrologic statistics.

Transport processes, diffusion phenomena, Fick's Ist and IInd Laws of diffusion, Advection diffusion equation, Turbulent diffusion and dispersion mixing in rivers

Porous medium flow, Approximation of Dupuit, Contaminant transport, Saltwater intrusion into aquifers, Non aqueous phase liquid (NAPL) in groundwater, aspects of

numerical modelling

Readings:

1. Kundu and Cohen, Fluid Mechanics, Academic Press, 2012
2. Cussler, E. L, Diffusion: Mass transfer in fluid systems, 3rd Ed., Cambridge University Press, 2007.
3. Chow, V.T. , Open channel flows, McGraw Hill, 2010
4. Chow, V.T. , Applied Hydrology, McGraw Hill, 2010

CE5363	RURAL WATER SUPPLY AND ENVIORNMENTAL SANITATION	DEC	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Identify the problems pertaining to rural water supply and sanitation.
CO2	Design water supply and sanitation system for rural community.
CO3	Design low cost waste management systems for rural areas.
CO4	Plan and design an effluent disposal mechanism.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	1	2	1	-	-	-
CO2	3	3	1	2	1	1	1	1
CO3	3	3	1	2	1	1	2	1
CO4	3	3	1	2	1	1	1	1

Detailed syllabus:

Rural Water Supply: Issues of rural water supply –Various techniques for rural water supply- merits- National rural drinking water program- rural water quality monitoring and surveillance- operation and maintenance of rural water supplies

Low Cost Water Treatment: Introduction – Epidemiological aspects of water quality- methods for low cost water treatment - Specific contaminant removal systems

Rural Sanitation: Introduction to rural sanitation- Community and sanitary latrines - Planning of wastewater collection system in rural areas- Treatment and Disposal of wastewater - Compact and simple wastewater treatment units and systems in rural areas- stabilization ponds - septic tanks - Imhoff tank- soak pits- low cost excreta disposal systems- Effluent disposal.

Solid Waste Management: Disposal of Solid Wastes- Composting- land filling- incineration- Biogas plants - Rural health - Other specific issues and problems encountered in rural sanitation.

Readings:

1. Eulers, V.M., and Steel, E.W., Municipal and Rural Sanitation, 6th Ed., McGraw Hill Book Company, 1965
2. Park, J.E., and Park, K., Text Book of Preventive and Social Medicine, BanarsidasBhanot, 1972
3. Wright, F.B., Rural Water Supply and Sanitation, E. Robert Krieger Publishing

Company, Huntington, New York, 1977
4. Juuti, P., Tapio S. K., and Vuorinen H., Environmental History of Water: Global Views on Community Water Supply and Sanitation, IWA Publishing (Intl Water Assoc), 2007

CE5364	ENVIRONMNENTAL AUDIT	DEC	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand background and importance of environmental auditing.
CO2	Identify safety and health aspects of environmental systems.
CO3	Apply key auditing tools and techniques for quantitative assessment
CO4	Prepare environmental audit reports.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	-	1	1	2	2	-	2	1
CO2	1	1	1	2	2	-	2	2
CO3	2	2	1	2	2	1	2	-
CO4	2	1	-	2	2	-	1	2

Detailed Syllabus:

Elements of a good Safety, Health and Environmental Systems. Concepts of Management systems
Auditing: Principles, Management audit, Specialist audit, Operational audits. Purpose and benefit. What makes a good auditor. The standard, Preparation
Protocols and checklist.The Entry meeting. Area familiarization and Audit observation skills
The formal and informal discussion, Statistical significance, The importance of verification and the audit trail
Observations and Non Compliance, Documentary review, Convergence and The exit meeting, Audit uniformity and credibility
Reporting- Quantitative assessment, Reporting- Qualitative assessment

Readings:

1. Heil Humphrey and Mark Hardley, Environmental Auditing, Palladian Law Pub, 2000.
2. Simon W. Pain, Safety, Health and Environmental Auditing: A practical guide, CRC Press, 2010

CE5365	BIO-REMEDIATION	DEC	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand fundamental principles of bioremediation processes
CO2	Identify bioremediation processes for different pollutants.
CO3	Design process for enhancing biodegradation.
CO4	Identify ethical, environmental, societal and safety issues related to bioremediation using genetically engineered microorganisms.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	2	2	2	2	1	1	-
CO2	3	2	1	2	2	-	1	1
CO3	3	3	2	3	2	1	1	1
CO4	1	-	1	-	2	2	1	3

Detailed syllabus:

Fundamental Aspects of Environmental Microbiology; Structure and Functions of Procaryotic Cells -Structure and Functions of Eucaryotic Cells Taxonomy of Microorganisms: Bacteria- Algae, Fungi and Protozoa -Study of Microbial Structure - Light Microscopy -Dark-field and Phase-contrast Microscopy -Electron Microscopy - Environmental Significance of Bacteria, Fungi, and Algae -Microbial Metabolism, Growth and Biokinetics - Microbial Nutrition and Metabolism - Microbial Growth and Energy - Enzymes and Their structures - Biokinetic Models - Batch and Continuous Chemostat Studies - Determination of Biokinetic Parameters

Microbiology Reactions- Suspended Growth Reactors - Biofilm Reactors - Batch Reactors - Completely Stirred Tank Reactors - Plug Flow Reactors - Reactors in Series - Engineering Design of Reactors

Bioflim Processes - Trickling Filters and Biological Towers -Rotating Biological Contactors - Granular Media Filters - Fluidized-bed Reactors -Hybrid Biofllm Processes

Bioremediation for Soil Environment - Environment of Soil Microorganisms -Soil Organic Matter and Characteristics -Soil Microorganisms Association with Plants - Pesticides and Microorganisms -Petroleum Hydrocarbons and Microorganisms -Industrial solvents and Microorganisms -Biotechnologies for Ex-Situ Remediation of Soil - Biotechnologies for in-Situ Remediation of Soil - Phytoremediation Technology for Soil Decontamination

Biotreatment of Metals- Microbial Transformation of Metals -Biological Treatment Technologies for Metals Remediation -Bioleaching and Biobenificiation - Bioaccumulation -Oxidation/Reduction Processes -Biological Methylation -Case studies

Emerging Environmental Biotechnologies - Phytoremediation -Sequestering Carbon

Dioxide -Biomonitoring -Application of Microbial Enzymes -Biomembrane Reactors

Readings:

1. Ergas, S.J., Chang, D.P.Y., Schreoder, E.D., and Eweis J.B., Bioremediation Principles , WCB/McGraw-Hill, 1998
2. Rittmann, B.E., and McCarty, P.L., Environmental Biotechnology : Principles and Applications, McGraw Hill, 2001

CE5366	ENVIRONMENTAL MANAGEMENT SYSTEMs	DEC	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Identify the complex environmental issues and their impact on business and industry.
CO2	Specify strategies and polices used to promote cleaner production in industry.
CO3	Identify mitigation methods for minimising the environmental risk due to anthropogenic activities.
CO4	Describe criteria and process for implementing Environmental Management systems.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	2	2	2	2	1	1	-
CO2	3	2	1	2	2	-	1	1
CO3	3	3	2	3	2	1	1	1
CO4	1	-	1	-	2	2	1	3

Detailed syllabus:

Environmental Management Standards
Development, trade and environment linkages – Environmental guidelines – Business and Citizen Charters for Sustainable Production and Consumption - National policies on environment, abatement of pollution and conservation of resources - Environmental quality objectives – Environmental standards - Concentration and Mass standards- Effluent and stream standards – Emission and ambient standards -Minimum national standards - Measuring performance evaluation: Indicators, Benchmarking - Systems approach to environmental management

Preventive Environmental Management
Pollution control vis a vis Pollution Prevention - Opportunities and Barriers – Cleaner production and Clean technology, closing the loops, zero discharge technologies - source reduction, raw material substitution, toxic use reduction and elimination, process modification – Cleaner Production Assessment- Material or resource balance – CP option generation and feasibility analysis

Environmental Management System
EMAS, ISO 14000 - EMS as per ISO 14001– benefits and barriers of EMS – Concept of continual improvement and pollution prevention - environmental policy – initial

environmental review – aspect and impact analysis – legal and other requirements- objectives and targets – environmental management programs – structure and responsibility – training awareness and competence- communication – documentation and document control – operational control – monitoring and measurement – management review.

Environmental Audit and Applications
Environmental management system audits as per ISO 19011- – Roles and qualifications of auditors - Environmental performance indicators and their evaluation – Non conformance – Corrective and preventive actions -compliance audits – waste audits and waste minimization planning – Environmental statement - Due diligence audit - Applications of EMS , Waste Audits and Pollution Prevention opportunities in Textile , Sugar, Pulp & Paper, Electroplating, Mining, petroleum refining, Tanning industry, Dairy, Cement, Chemical industries, etc.

Readings:

1. Hillary, R., Environmental Management Systems and Cleaner Production, Wiley Publishers, 1997
2. Christopher Sheldon and Mark Yoxon, Installing Environmental management Systems – a step by step guide, Earthscan Publications Ltd, London, 1999
3. ISO 14001/14004: Environmental management systems – Requirements and Guidelines – International Organisation for Standardisation, 2014
4. Environmental Management Systems: An Implementation Guide for Small and Medium-Sized Organizations, Second Edition, NSF International, Ann Arbor, Michigan, January 2001

CE5762	URBAN WATER MANAGEMENT	DEC	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Identify factors affecting urban hydrological cycle
CO2	Estimate urban water demand and urban stormwater quantity
CO3	Plan and design stormwater control and disposal systems
CO4	Develop integrated urban water management system

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	1	2	2	2	-	2	1
CO2	3	2	2	2	2	-	2	1
CO3	3	3	1	2	2	2	2	1
CO4	3	2	1	1	2	2	2	2

Detailed syllabus:

General introduction to urbanisation and its effect on water cycle – urban hydrological cycle – trends in urbanisation – Effect of urbanisation on hydrology.
Urban Hydrological cycle – time of concentration – importance of short duration of rainfall and runoff data – methods of estimation of time of concentration for design of urban drainage systems.
Master drainage plans – issues to be concentrated upon – typical content of an urban drainage master plan – interrelation between water resources investigation and urban planning processes – planning objectives – comprehensive planning – use of models in planning.
Basic approaches to urban drainage – runoff quantity and quality – wastewater and stormwater reuse – major and minor systems.
Elements of drainage systems – open channel – underground drains – appurtenances – pumping – source control.
Stormwater Analysis Calculation of runoff and peak – Design of storm water network systems.
Best Management Practices – Detention and retention facilities – Swales-constructed wetlands.
Operation and maintenance of urban drainage system – interaction between stormwater management and solid waste management, Various model available for stormwater management.
Legal aspects

Readings:

1. Geiger W. F., J Marsalek, W. J. Rawls and F. C. Zuidema, Manual on Drainage in Urbanised area – 2 volumes, UNESCO, 1987
2. Hall M J , Urban Hydrology, Elsevier Applied Science Publisher, 1984
3. Stahre P and Urbonas B , Stormwater Detention for Drainage, Water Quality and CSO Management, Prentice Hall, 1990
4. Wanielista M P and Eaglin ,Hydrology – Quantity and Quality Analysis, Wiley and Sons, 1997

CE5765	APPLICATIONS OF RS AND GIS IN WATER RESOURCES AND ENVIRONMENTAL ENGINEERING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to**:**

CO1	Apply basic principles of remote sensing for resource mapping and evaluation
CO2	Develop geospatial database of water resources and environmental engineering systems
CO3	Apply GIS models for hydrological simulation
CO4	Apply GIS models for planning environmental engineering systems

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	1	1	1	2	-	2	-
CO2	2	1	2	2	2	1	3	1
CO3	2	-	2	1	1	2	2	2
CO4	2	2	2	2	2	2	3	1

Detailed syllabus:

Surface-Water Hydrologic Data, Spatial techniques for Surface-Water Hydrology Modeling, Surface-Water Hydrology Models, ArcSWAT model and its applications; Groundwater Data, Ground water Models and spatial techniques for Groundwater Modeling and Visualization, The ArcHydro Data Model.

Geospatial techniques for planning and design of Water-Supply and Irrigation Systems, Spatial Database Development for Wastewater and Storm water Systems, GIS-Based Wastewater Collection System Design and Management Applications, GIS-Based Decision-Support Systems for Wastewater and Storm water Systems.

Geospatial technologies for Water Resources Monitoring and Forecasting; Spatial Decision-Support Systems in River Basin Management; Spatial systems for floodplain mapping and management.

Spatial techniques for Water Quality Monitoring and Modeling, GIS for Water-Quality Database Development, GIS for Water-Quality Management Decision Support

Taxonomy of Environmental Models in the Spatial Sciences.Geographic Data for Environmental Modeling and Assessment.Applications of Remote Sensing and

Geographic Information Systems in Wildlife Mapping and Modeling. Land Use Planning and Environmental Impact Assessment Using Geographic Information Systems.

Readings:

1. Lynn E. Johnson, Geographic Information Systems in Water Resources Engineering, CRC Press, 2008.
2. Praveen Kumar, Mike Folk, Momcilo Markus and Jay C. Alameda, Hydroinformatics: Data Integrative Approaches in Computation, Analysis, and Modeling, CRC Press, 2005.
3. Allan Brimicombe, GIS, Environmental Modeling and Engineering, Second Edition, CRC Press, 2009.
4. Andrew Skidmore (Editor, Environmental Modelling with GIS and Remote Sensing, CRC Press), 2002

CE5767	APPLICATIONS OF SOFT COMPUTING TECHNIQUES	DEC	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Understand the characteristics of Soft Computing Techniques
CO2	Develop neural network models with applications in Civil Engineering
CO3	Apply fuzzy logic and fuzzy reasoning for decision making
CO4	Apply genetic algorithm for simple optimization problems

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	1	2	2	1	1	1	3	1
CO2	2	2	2	1	1	1	3	1
CO3	2	2	2	1	1	1	3	1
CO4	2	2	2	1	1	1	3	1

Detailed syllabus:

Need for soft computing techniques, components of soft computing.
Artificial Neural Networks (ANN), Types of ANN, Learning algorithms, Applications of ANN, Information and uncertainty, Chance versus ambiguity.
Classical sets and fuzzy sets, Logic and reasoning, Fuzzy set operations and fuzzy relations, Membership Functions, Fuzzy Systems, Decision Making with Fuzzy Information, Fuzzy Classification and Pattern Recognition, Neuro-Fuzzy Systems.
Evolutionary computing, Genetic algorithm, Hybrid soft computing techniques, Applications in Civil Engineering.

Readings:

1. Haykin, Neural Networks: A Comprehensive Foundation, Prentice Hall India, New Delhi, 2008
2. Jang, J.R, Sun Chuen-tsai, and MizutaniEiji, Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, PHI Learning, 2009
3. Rajasekaran, S., and VijayalakshmiPai, G.A., Neural Networks, Fuzzy Logic and Genetic Algorithms – Synthesis and Applications, Prentice-Hall India, New Delhi, 2003
4. Sivanandam, S N and S N Deepa, Principles of Soft Computing, Wiley India, 2013
5. Karray, Fakhreddin O. and Clarence De Silva, Soft Computing and Intelligent Systems Design – Theory, Tools and Applications, Pearson Education Ltd., 2013

CE5768	WATER QUALITY MODELING	DEC	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	
CO2	
CO3	
CO4	

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1								
CO2								
CO3								
CO4								

Detailed syllabus:

Basic water quality characteristics, Physical, chemical and biological phenomenon, Reaction kinetics, Mathematical models of physical systems, completely and incompletely mixed systems, Natural transport systems, Transport of contaminants in environment, sources of pollution, water quality modelling in rivers, lakes and groundwater systems

READING:

1. Chin, David A., (2006),“Water Quality Engineering in Natural Systems”, Wiley – Interscience.
2. Sincero, A.P. and Sincero, G.A. (1999) "Environmental Engineering - A Design Approach", Prentice Hall of India, N Delhi
3. Thomann, R.V., Mueller, J.A., (1987), “Principles of Surface Water Quality Modelling and Control”, Harper and Row Publishers

CE5770	CLIMATE SYSTEMS	DEC	3 – 0 – 0	3 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	
CO2	
CO3	
CO4	

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1								
CO2								
CO3								
CO4								

Detailed syllabus:

Earth Climate and its historic evolution, climate change and its reasons, Climate classification, composition of the atmosphere, atmospheric thermodynamics and kinetic theory of gases, energy balance, greenhouse effect, transport processes in atmosphere, Reynolds transport theorem, atmospheric pressure and wind, atmospheric water and its circulation, precipitation formation processes, large scale circulations, monsoons, tropical cyclones and other disturbances, land surface atmosphere interaction, surface energy balance, evapotranspiration

READING:

Lutgens, Frederick K. ,Tarbuck, Edward J. (2010), The Atmosphere: An Introduction to Meteorology, PHI Publications

C. Donald Athens, (2011), Essentials of Meteorology, Thompson Brooks/ Cole, CENGAGE Learning

Andrew Gettelman, Richard B. Rood (2016), Demystifying Climate Models – A Users' Guide to Earth System Models, Springer Open

CE5353	ENVIRONMENTAL MICROBIOLOGY LABORATORY	PCC	0 – 0 – 3	2 Credits

Pre-requisites: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Microscopic examination of microbes from soil, water and air
CO2	Isolation of microorganisms
CO3	Understanding bacterial staining and cultural techniques
CO4	Quantitative estimation of microbes

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1								
CO2								
CO3								
CO4								

Detailed Syllabus:

1. Isolation of microorganisms from soil, water and air
2. Microscopic examination of microbes
3. Preparation of bacterial smear
4. Bacterial staining techniques
5. Culturing techniques
6. Plate count test and MPN test
7. Microbial growth curve

CE 5354	GIS LABORATORY	PCC	0-0-3	2 Credits

Prerequisites: None

Course Outcomes: At the end of the course, the student will be able to:

CO1	Prepare the different geospatial layers
CO2	Compute geometric measurements and perform spatial analysis
CO3	Create high-quality maps and associated graphics

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	3	2	2	1	1	1	1
CO2	1	2	1	3		1	2	1
CO3	1	2	2	2	1	1	2	1

Detailed Syllabus:

Digitization of Points and Lines
Editing Map Elements
Attribute Data Entry and Manipulation
Cleaning, Building and Transformation
Data Analysis – Overlay, Buffer
Map Generation with Patterns and Legends
Buffer Analysis
Network Analysis

Reading:

1. ArcGIS 10.1 user manuals, 2013
2. ERDAS Imagine 2013 user manual

CE5341 and CE5391	Seminar – I and Seminar – II	PCC	0 – 0 – 2 & 0 – 0 – 2	1 Credits & 1 Credits

Pre-requisite: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Select a topic relevant to planning, analysis and design of a Environmental Engineering systems
CO2	Undertake a critical review of the literature on the chosen topic
CO3	Prepare and present a technical report

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	2	2	1	2	1
CO2	2	1	1	1	1	3	2	3
CO3	1	-	-	-	-	2	-	3

CE6342	Comprehensive Viva	PCC	0 – 0 – 0	2 Credits

Pre-requisite: NONE

Course Outcomes: At the end of the course the student will be able to:

CO1	Assimilate knowledge of different courses studied
CO2	Develop overall comprehension about Environmental Engineering
CO3	Analyze real life environmental problems with theoretical knowledge learned
CO4	Interpret and articulate solutions to real life environmental problems

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	2	3	3	2	2	2	2	1
CO2	2	3	3	2	2	2	2	1
CO3	2	3	3	2	2	2	2	1
CO4	2	3	3	2	2	2	2	1

CE6349 and CE6399	**Dissertation Part – A & Dissertation Part – B**	**PCC**	**0 – 0 – 0 & 0 – 0 – 0**	**6 Credits & 12 Credits**

Course Outcomes: At the end of the course the student will be able to:

CO1	Identify and define a topic relevant to planning, analysis and design of a environmental engineering systems based on the social, economical and environmental considerations
CO2	Make a critical review of the available literature on the topic
CO3	Conduct independent research to formulate and solve the chosen problem
CO4	Prepare technical report on the study carried out and publish the results