CURRICULUM & SYLLABI

M.Tech. ENVIRONMENTAL ENGINEERING

Effective from AY: 2024-25



NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

WARANGAL, TELANGANA

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Vision and Mission of the Institute

National Institute of Technology Warangal

VISION

Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.
- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.
- Fostering product-oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

Vision and Mission of the Department

CIVIL Engineering

VISION

To be a knowledge nerve center in civil engineering education, research, entrepreneurship and industry outreach services for creating sustainable infrastructure and enhancing quality of life.

MISSION

- Generate a specialized cadre of civil engineers by imparting quality education and training
- Attain international standards in teaching, research and consultancy with global linkages

Program: M.Tech. Environmental Engineering

Program Educational Objectives

PEO-1	Apply basic principles of environment and their significance in the socio-economic development
PEO-2	Identify, formulate and design engineered solutions to environmental problems related to air, water and land.
PEO-3	Apply best management practices for sustainable development.
PEO-4	Communicate and manage interdisciplinary teams in solving complex environmental engineering problems.
PEO-5	Demonstrate leadership qualities and exhibit professional ethics.

Program Articulation Matrix

PEO Mission Statements	PEO-1	PEO-2	PEO-3	PEO-4	PEO-5
Generate a specialized cadre of civil engineers by imparting quality education and training	3	3	3	2	2
Attain international standards in teaching, research and consultancy with global linkages	2	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Program: M.Tech. Environmental Engineering

Program Outcomes

PO-1	Engage in critical thinking and pursue investigations/research and development to solve practical problems.
PO-2	Communicate effectively, write and present technical reports on complex engineering activities by interacting with the engineering fraternity and with society at large.
PO-3	Demonstrate higher level of professional skills to tackle multidisciplinary and complex problems related to Environmental Engineering.
PO-4	Analyze and predict environmental parameters /variables using formulated methodologies and techniques.
PO-5	Design technically feasible solutions to environmental problems which are legally, ethically, socially and economically acceptable.
PO-6	To develop strategies for mitigating environmental problems at local, regional and global scales.

CURRICULUM
M.Tech. Environmental Engineering

1st Semester

S.No.	Code	Course Title	L-T-P	Credits
1	CE 36001	Environmental Chemistry and Microbiology	3-0-0	3
2	CE 36003	Water Supply Systems	3-0-0	3
3	CE 36005	Solid Waste Management	3-0-0	3
4	CE360XX	Professional Elective - I	3-0-0	3
5	CE360XX	Professional Elective - II	3-0-0	3
6	CE 36007	Advanced Environmental Engineering Lab	0-1-2	2
7	CE 36009	Waste Management Design Laboratory	0-1-2	2
			Total Credits	**19**

2nd Semester

S.No.	Code	Course Title	L-T-P	Credits
1	CE 36002	Air Pollution and Control	3-0-0	3
2	CE 36004	Wastewater Treatment Systems	3-0-0	3
3	CE360XX	Professional Elective – III	3-0-0	3
4	CE360XX	Professional Elective – IV	3-0-0	3
5	CE360XX	Professional Elective – V	3-0-0	3
6	CE 36006	Waste Characterization and Analysis Laboratory	0-1-2	2
7	CE 36008	Environmental Systems Design Laboratory	0-1-2	2
8	CE 36096	Minor Project	0-0-0	2
			Total Credits	**21**

3rd Semester

S.No.	Code	Course Title	L-T-P	Credits
1	CE 36089	Seminar and Technical Writing	0-0-0	2
2	CE 36091	Summer Internship/Research Experience	0-0-0	2
3	CE 36094	Comprehensive Viva Voce	0-0-0	2
4	CE 36097	Dissertation Part A	0-0-0	8
			Total Credits	**14**

4th Semester

S.No.	Code	Course Title	L-T-P	Credits
1	CE 36098	Dissertation Part B	0-0-0	12
			Total Credits	**12**

The Overall Credit Structure

Cat. Code	Sem-I	Sem-II	Sem-III	Sem-IV	Total
PCC	13	12	0	0	25
PEC	6	9	0	0	15
SEM	0	0	2	0	02
CVV	0	0	2	0	02
SIRE	0	0	2	0	02
MP	0	2	0	0	02
DW	0	0	8	12	20
Total	19	21	14	12	**68**

Abbreviations:

PCC– Program Core Courses
PEC – Program Elective Courses
SEM – Seminar and Technical Writing
SIRE – Summer Internship/Research Experience
MP – Minor Project
CVV – Comprehensive Viva Voce
DW – Dissertation Work

Professional Elective Courses:

Professional Elective- I		
S.No.	**Code**	**Course Title**
1	CE36021	Computational Methods for Environmental Engineering
2	CE36023	Ecology and Stream Pollution
3	CE36025	Noise Pollution and Control
Professional Elective- II		
4	CE36027	Environmental Fluid Mechanics
5	CE36029	Waste Processing Technologies
6	CE36031	Environmental Health and Safety

Professional Elective- III		
S.No.	**Code**	**Course Title**
1	CE36042	Industrial Waste Management
2	CE36044	Water Quality Modelling
3	CE36046	Life Cycle Analysis
Professional Elective- IV		
4	CE36048	Environmental Regulations and Management System
5	CE36050	Environmental Impact Assessment and Management
6	CE36052	Regulatory and Legal Framework for Waste Management
Professional Elective- V		
7	CE36054	Hazardous Waste Management
8	CE36056	Environmental Systems Engineering
9	CE36058	Circular Economy for Sustainable Development

Note: In addition to the above listed electives, a student can also register one elective per semester from other departments and two electives per semester from other specializations of the same department, based on suitability of timetable.

SYLLABI

M.Tech. Environmental Engineering

1st Semester

CE 36001 **3-0-0 (3)**

Environmental Chemistry and Microbiology

Pre-Requisites: **None**

Course Outcomes:

CO1	Apply fundamental chemical principles to environmental engineering problems
CO2	Analyze thermodynamic and kinetic processes in environmental systems
CO3	Evaluate and implement water and wastewater treatment techniques
CO4	Understand and apply microbiological concepts in environmental engineering
CO5	Integrate concepts of organic chemistry and environmental chemistry in pollution control

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

General Chemistry: Basic principles – chemical equations – formulation, balancing, and 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 and its effects on reactions.

Physical Chemistry: Thermodynamics – concepts of heat and work, enthalpy, entropy, free energy, temperature dependence of equilibrium constant; Membrane processes; Principles of solvent extraction; Electrochemistry; Chemical kinetics; Adsorption.

Equilibrium Chemistry: Equilibrium relationships -variation and 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 – general properties and environmental relevance of functional groups; Enzymes – classification, enzyme-catalyzed reactions, energy considerations; Biochemical reactions - 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: Surface and colloidal chemistry – fundamentals and environmental applications; Chemistry involved in water treatment; Atmospheric chemistry; Soil chemistry; Emerging pollutants.

Environmental Microbiology: Introduction of microbiology - classification and characterization of microorganisms, including viruses; Bacterial Morphology and structure - nutrient requirement and growth of bacteria; Microbiology of water and sewage; Plankton analysis; Analysis of specific microorganisms; Microbial metabolism; Microbiology of water, wastewater, soil and air.

Learning Resources:

Text Books:

1. Sawyer, C. N., McCarty, P. L., and Perkin, G.F.,Chemistry for Environmental Engineering and Science, McGraw Hill Education, 2017, 5th Edition
2. Pelczar, M.J.Michael, Chan, E.C.S., and Krieg, N.R, Microbiology, The McGraw-Hill Education, 2021, Indian edition

Reference Books:

1. Benefield D. L., Judkins F. J., Weand L. B., Process Chemistry for Water and Wastewater Treatment, Prentice Hall, 1982, 1st Edition
2. Tortora GJ, Funke BR, and Case CL, Microbiology: An Introduction, Pearson Education, 2019, 4th Edition

Other Suggested Readings:

1. NPTEL: Environmental Chemistry and Microbiology, IIT Kharagpur
2. NPTEL: Environmental Chemistry and Analysis, IIT Madras

CE 36003 **3-0-0 (3)**

Water Supply Systems

Pre-Requisites: **None**

Course Outcomes:

CO1	Plan water supply systems for a community
CO2	Analyze water quality and propose water treatment train
CO3	Design various components of a water treatment plant
CO4	Design advanced treatment systems for the removal of specific contaminants
CO5	Analyze and design water distribution systems
CO6	Plan an appropriate water reuse system

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 – Substantially**

Syllabus:

Need for Transport of water- Water quality- Planning of water supply systems

Intake structures, Selection of pipe materials, Water transmission main design- Gravity and pumping main; Selection of Pumps- Characteristics-Economics; Jointing, Laying and Maintenance, Water hammer 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- Distribution

Water reuse/recycle- Sludge thickening-Sludge dewatering systems-Sludge drying beds- Recent Advances.

Use of computer software in water transmission and water distribution systems.

Learning Resources:

Text books:

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., 2017

Reference Books:

1. Viessman Jr, Hammer J. M, Perez, E.M, and Chadik, P. A,Water Supply and Pollution Control, PHI Learning, New Delhi, 2009
2. WATER QUALITY& TREATMENT AWWA Hand book, McGraw Hill, 2011.
3. Larry W. Mays, Urban Water Supply Handbook, McGraw Hill, 2002.
4. Computer modelling of water distribution system, AWWA manual of water supply practice, 2005.

Other Suggested Readings:

1. https://onlinecourses.nptel.ac.in/noc20_ce23/preview
2. https://ocw.mit.edu/courses/urban-studies-and-planning/11-479j-water-and-sanitation-infrastructure-in-developing-countries-spring-2007/readings/hwts_paper.pdf
3. http://www.who.int/water_sanitation_health/dwq/WSH02.07.pdf

CE 36005 **3-0-0 (3)**

Solid Waste Management

Pre-requisites: **NONE**

Course Outcomes:

CO1	Identify various types of solid wastes and their sources
CO2	Examine the physical and chemical composition of wastes
CO3	Analyze the activities associated with the management of solid waste
CO4	Evaluate the techniques and methods used in recovery of materials and energy from solid wastes
CO5	Design a sanitary landfill for disposal of solid waste
CO6	Categorize and manage the hazardous waste

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

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; Integrated SW Management concepts

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.

Engineering Disposal of SW: Dumping of solid waste; sanitary landfills – site selection, design and operation of sanitary landfills – Leachate collection & treatment. Identify methods of solid waste disposal during a site visit and follow safety precautions.

Hazardous Waste Management: Introduction; Concern about Hazardous Waste Management; Characteristics of Hazardous Waste; Transportation and Disposal of Hazardous Waste; Industrial/biomedical waste, E- waste management.

Learning Resources:

Text Books:

1. Tchobanoglous G, Theisen H and Vigil SA, Integrated Solid Waste Management, Engineering Principles and Management Issues, McGraw Hill Education, 2014, Indian Edition
2. John Pichtel, Waste Management Practices: Municipal, Hazardous and Industrial, CRC Press, 2014, 2nd Edition

Reference Books:

1. Peavy, H.S, Rowe, D.R., and G. Tchobanoglous Environmental Engineering, , McGraw Hill Education, 2017, 1st Indian Edition
2. Tchobanoglous G and Kreith F, Handbook of Solid Waste Management, , McGraw-Hill Education, 2002, 2nd Edition
3. Qian X, Koerner R M and Gray D H, Geotechnical Aspects of Landfill Design and Construction, Prentice Hall, 2002, 1st Edition
4. LaGrega M.D., Buckingham P.L. and Evans J.C. Hazardous Waste Management, Waveland Pr Inc., 2010, Reissue Edition
5. Richard J. Watts, Hazardous Wastes - Sources, Pathways, Receptors, John Wiley and Sons, 1998, 1st Edition.
6. Vesilind PA, Worrell W and Reinhart D, Solid Waste Engineering, Brooks/Cole Thomson Learning Inc., 2010, 2nd Edition

Other Suggested Readings:

1. http://cpheeo.gov.in/cms/manual-on-municipal-solid-waste-management-2016.php
2. https://nptel.ac.in/courses/105/103/105103205/
3. https://nptel.ac.in/courses/120/108/120108005/
4. https://nptel.ac.in/courses/105/106/105106056/
5. https://nptel.ac.in/courses/105/105/105105160/
6. https://nptel.ac.in/courses/103/107/103107125/

CE 36007 **0-1-2 (2)**

Advanced Environmental Engineering Laboratory

Pre-requisites: NONE

Course Outcomes:

CO1	Sample and store water, wastewater and soil samples
CO2	Perform physicochemical treatment processes on lab scale
CO3	Perform environmental monitoring using sophisticated analytical instruments
CO4	Determine pollutant concentrations in air samples

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Experiment No.1: Estimation of Solids (TDS, DS, TSS, VS), Acidity, Alkalinity, Hardness, Chlorides and Fluorides

Experiment No.2: Determination of pH and Conductivity

Experiment No.3: Determination of Dissolved Oxygen

Experiment No.4: Estimation of Biochemical Oxygen Demand

Experiment No.5: Estimation of Chemical Oxygen Demand

Experiment No.6: Estimation of Nitrogen (Different Forms like Ammonia, Nitrite, Nitrate)

Experiment No.7: Estimation of Phosphates and Sulphates

Experiment No.8: Estimation of Residual Chlorine

Experiment No.9: Determination of Available Chlorine in bleaching powder

Experiment No.10: Conducting Break Point Chlorination Test

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 Heavy metals using spectrophotometer/MPAES

Experiment No.15: Estimation of suspended particulate matter, SO_x, NO_x and VOC in air.

Learning Resources:

Text Books:

1. Standard methods for the examination of water and wastewater, 21st Edition, Washington: APHA., 2012
2. Sawyer, C. N., McCarty, P. L., and Perkin, Chemistry for Environmental Engineering and Science, G.F., 5th edition McGraw-Hill Inc., 2002

Reference Books:

1. Industrial Waste Resource Guidelines Sampling and Analysis of Waters, Wastewaters, Soils and Wastes, EPA Victoria, 2009
2. A Guide to the Sampling and Analysis of Waters, Wastewaters, Soils and Wastes, Environment Protection Authority State Government of Victoria March 2000
3. B. Kotaiah and Dr. N. Kumara Swamy, Environmental Engineering Laboratory Manual, Charotar Publishing House Pvt. Ltd., 1st Ed., 2007

Other Suggested Readings:

1. www.vlab.co.in

CE36009 **0-1-2 (2)**

Waste Management Design Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand solid waste characterization and analysis
CO-2	Apply design principles of waste collection systems and routes
CO-3	Design composting and biogas plants
CO-4	Analyze and design incinerators
CO-5	Develop sanitary landfill designs

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	3	–	3	2	–
CO-2	3	–	3	–	3	–
CO-3	3	–	3	–	2	–
CO-4	3	3	3	3	–	–
CO-5	3	–	3	–	–	–

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Solid Waste Properties: Introduction to solid waste characterization; Estimate of moisture content and specific weight of solid waste samples; Approximate determination of chemical composition energy content of solid waste

Waste Generation and Collection Analysis: Material-balance analysis for assessing solid waste quantities; Statistical analysis of collected waste data; Selection of container size for commercial facility use; Analysis and layout design of waste collection systems and routes

Design of Composting Plants: Estimate the oxygen requirements for the aerobic conversion of solid waste; Design considerations for composting plants.

Design of Biogas Plants: Estimate of biogas produced from organic fraction of solid waste under anaerobic conditions; Design principles for biogas plants.

Design of Incinerators: Effects of excess air on temperature and composition of flue gases; Estimation of heat available in exhaust gases from solid waste combustion; Design considerations for incinerators.

Design of Sanitary Landfills: Estimate of chemical composition and gas production from organic constituents of solid waste; Principles and design considerations for sanitary landfill design.

Project Presentations and Review: Presentation of design projects; Review and feedback sessions.

Final Project Submission and Evaluation: Submission of final design projects; Evaluation of design projects

Learning Resources:

Text Books:

1. Tchobanoglous G, Theisen H and Vigil SA, Integrated Solid Waste Management, Engineering Principles and Management Issues, McGraw Hill Education, 2014, Indian Edition
2. John Pichtel, Waste Management Practices: Municipal, Hazardous and Industrial, CRC Press, 2014, 2nd Edition

Reference Books:

1. Peavy, H.S., Rowe, D.R., and Tchobanoglous G., Environmental Engineering, McGraw Hill Education, 2017, 1st Indian Edition
2. Vesilind PA, Worrell W and Reinhart D, Solid Waste Engineering, Brooks/Cole Thomson Learning Inc., 2010, 2nd Edition

Other Suggested Readings:

1. Municipal Solid Waste Management Manual, 2016 (Part I; Part II; Part III)

2nd Semester

CE 36002 **3-0-0 (3)**

Air Pollution and Control

Pre-Requisites: **None**

Course Outcomes:

CO1	Identify sampling and analysis techniques for air quality assessment
CO2	Describe the plume behaviour for atmospheric stability conditions
CO3	Apply plume dispersion modelling and assess the concentrations
CO4	Design air pollution controlling devices

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Air Pollution: Definition - Sources & Classification of Air Pollutants - Effects of air pollution on humans, plants and materials- Global effects - Air Quality and NAAQS - National Clean air Programme- 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.

Learning Resources:

Text Books:

1. Khare M, Sharma P, Kota, S.H, Sumanth C, Air Pollution Science Engineering and Management Fundamentals, ISBN 9780367750527, CRC Press, 2024.
2. Noel, D. N., Air Pollution Control Engineering, ISBN 978-0070393677, Tata McGraw Hill Publishers, 1999.

Reference Books:

1 Colls, J., Abhishek T, Air Pollution: Measurement, Modeling and Mitigation, ISBN13: 978-0- 415-47932-5 CRC Press, 2009
2 Boubel, R.W., Fox, D.L., Turner, D.B. and Stern, A.C. Fundamentals of air pollution, 1994. 3rd Edition, Academic Press, New York

Other Suggested Readings:

1. https://nptel.ac.in/courses/105102089
2. https://indair-neeri.res.in/

CE 36004 **3-0-0 (3)**

Wastewater Treatment Systems

Pre-requisites: NONE

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

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. Quantity estimation

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.

Learning Resources:

Text books:

1. Metcalf and Eddy, Wastewater Engineering – Collection, Treatment, Disposal and Reuse, 5th Ed., McGraw Hill Pub. Co., 2014
2. Mackenzie L. Davis, Water and Wastewater Engineering: Design Principles and Practice McGraw Hill, 2010.

Reference Books:

1. Benefield L.D. and Randall C.D, Biological Process Designs for Wastewater Treatment, Prentice Hall Pub. Co., 1980
2. Udo Wiesmann, In Su Choi and Eva-Maria Dombrowski, Fundamentals of Biological Wastewater Treatment, , , 1st Ed., Wiley, 2007
3. Tchobanoglous, G. et al, Fifth Edition, Metcalf & Eddy, Inc. Wastewater Engineering: Treatment, Disposal, and Reuse, McGraw-Hill Publishers, New York, 2013.
4. Crittenden, J.C., et al. Water Treatment Principles and Design, 2nd Ed., Montgomery, Inc., John Wiley and Sons, New York, 2005.
5. Reynolds, T.D., Richards, P.A, Unit Operations and Processes in Environmental Engineering, PWS Publishing Company, Boston, 1996

Other Suggested Readings:

1. www.indair-neeri.res.inhttps://nptel.ac.in/courses/105/105/105105178/
2. https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-85-water-and-wastewater-treatment-engineering-spring-2006/lecture-notes/
3. https://onlinecourses.nptel.ac.in/noc21_ce25/preview

CE 36008 **0-1-2 (2)**

Waste Characterization and Analysis Laboratory

Pre-Requisites: **None**

Course Outcomes:

CO1	Characterize waste quantity and composition for the design of suitable treatment facility.
CO2	Classify waste as hazardous or non-hazardous waste according to regulations
CO3	Plan appropriate treatment facility for the waste
CO4	Estimate the energy potential of the waste

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

1. Sampling of a solid waste
2. Physical analysis of the waste material
    a. Picking analysis/quantifying material fractions as identifiable items.
    b. Particle size distribution.
    c. Moisture content.
    d. Densities. and chemical analysis
3. Chemical analysis of the waste material
    a. pH and alkalinity.
    b. Organic matter.
    c. Inorganics.
    d. Heating value/calorific value
4. Compressibility tests
5. Leaching tests
6. Respiration tests
7. Biochemical methane potential tests

Learning Resources:

Text Books:

1. Thomas Christensen, Solid Waste Technology & Management, John wiley&sons, USA, 2011.
2. Qasim SR, Zhu G, Wastewater treatment and reuse, theory and design examples, Principles and basic treatment, CRC press; 2017.

Reference Books:

1. Peavy, H.S, Rowe, D.R., and Tchobanoglous, Environmental Engineering, McGraw Hill, 2017.
2. Tchobanoglous G and Kreith F , Handbook of Solid Waste Management, McGraw-Hill, 2002, 2nd Edition
3. Sawyer, C. N, Chemistry for Environmental Engineering and Science ,McGraw Hill Education,2017, 5th Edition

Online Resources:

1. www.cpcb.nic.in
2. www.swachhbharat.mygov.in

CE 36008 **0-1-2 (2)**

Environmental Systems Design Laboratory

Pre-Requisites: **None**

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 – Substantially**

Syllabus:

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

Learning Resources:

Text Books:

1. Metcalf & Eddy, Waste water Engineering Treatment and Reuse, Inc., McGraw Hill Inc., New Delhi., 2003
2. Peavy, H.S, Rowe, D.R., and G. Tchobanoglous, Environmental Engineering, McGraw Hill Inc., New York., 1995

Reference Books:

1. Metcalf & Eddy, Wastewater Engineering Treatment and Reuse, McGraw Hill Education, 2017, 4th Edition
2. Thomas Christensen, John wiley& sons, Solid Waste Technology & Management, USA, 2011.

Other Suggested Readings:

www.epa.gov.in

CE 36096 **0-0-0 (2)**

Minor Project

Pre-Requisites: **None**

Course Outcomes:

CO1	Apply engineering principles to real-world projects
CO2	Plan and monitor project tasks individually or as a team
CO3	Demonstrate practical experience in project execution
CO4	Communicate project findings clearly through reports and presentations

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 – Substantially**

Description:

Students are expected to choose real world or relevant problems and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel will decide the suitability and worthiness of the project

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria.

Criteria	Description	Weightages
I	Identification of Problem Domain	Weightage for each criterion will be determined by the panel and will be informed to the students.
II	Study of Existing Systems and establishing clear objectives	
III	Planning of project and work distribution within the team	
IV	Proper Documentation and Technical Writing	
V	Presentation and Response to questions	

Evaluation Criteria-CO Mapping

CO Criteria	CO1	CO2	CO3	CO4
I	X			
II	X			
III		X	X	
IV				X
V				X

3rd Semester

CE 36089 **0-0-0 (2)**

Seminar and Technical Writing

Pre-requisites: NONE

Course Outcomes:

CO1	Consolidate ideas based on expert talks attended
CO2	Prepare a well-organized report employing elements of critical thinking and technical writing
CO3	Demonstrate the ability to describe, interpret and analyze the subject matter and develop competence in presenting

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2		2			3
CO2	2		2			3
CO3	2		2			3

1 - Slightly; 2 - Moderately; 3 – Substantially

Description:

In Seminar and Technical Writing, every student is expected to prepare a well-organized report based on one / all of the following:

1. by attending at least 5 expert lectures/ invited talks/ Seminar/ Popular lectures etc. organized by the institute/any of the departments, ideally in a specific domain or with the same theme.
2. prepare a business or marketing plan based on patent search

The student is expected to consolidate the ideas from these lectures/patent searches and may even include material from other sources to strengthen the content of the report. The student should prepare a well-organized report based on the above and present it to the panel constituted by the department, for evaluation.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria.

Criteria	Description	Weightages
I	Clarity on the topic	
II	List of lectures attended	
III	Report	
IV	Presentation	
V	Response to questions	

Evaluation Criteria-CO Mapping

CO Criteria	CO1	CO2	CO3
I	X		
II	X		
III		X	
IV			X
V			X

CE 36091 **0-0-0 (2)**

Summer Internship/Research Experience

Pre-requisites: NONE

Course Outcomes:

CO1	Apply engineering principles to real-world problems, gaining practical experience
CO2	Plan, manage and execute the work with ethical consideration
CO3	Review the social and environmental impact of the work
CO4	Communicate the learnings through report and presentation

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Description:

Every student has to undergo either a Summer Internship / Research project. The summer internship may be undergone in an Industry/Research organization or any premier academic Institution, including NIT Warangal for 6-8 weeks. The research project shall be registered under the guidance of any faculty member in the institute. The student is required to submit a report and present the work before an evaluation committee, nominated by the Head of the Department.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria.

Criteria	Description	Weightages
I	Relevance of the area of work	Weightage for each criterion will be determined by the panel and will be informed to the students.
II	Performance of the Task	
III	Crucial learnings from the work	
IV	Report Preparation	
V	Presentation and Response to questions	

Evaluation Criteria-CO Mapping

CO Criteria	CO1	CO2	CO3	CO4
I	X	-	-	-
II	-	-	-	-
III	-	-	X	-
IV	-	-	-	X
V	-	-	-	X

CE 36094 **0-0-0 (2)**

Comprehensive Viva Voce

Pre-requisites: **None**

Course Outcomes:

CO1	Comprehend the knowledge gained in the course work
CO2	Demonstrate the ability in problem solving
CO3	Communicate effectively using engineering terminology

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 – Substantially**

Description:

In Comprehensive viva-voce each student will be evaluated for their overall comprehension of the course work and laboratory training that they have undergone. The students will be expected to answer questions orally, write down simple equations, draw plots, schematics, write simple code etc. as questioned by the panel. Assessment will be done by the panel based on the student response.

CE 36097 **0-0-0 (8)**

Dissertation Part – A

Pre-Requisites: None

Course Outcomes:

CO-1	Define Research Problem Statement.
CO-2	Critically evaluate literature in chosen area of research & establish scope of work.
CO-3	Develop study / experimental methodology.
CO-4	Carryout pilot theoretical study/experiment.

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	2	2	1	3	---
CO-2	3	2	2	1	3	---
CO-3	3	2	2	1	3	---
CO-4	3	2	2	1	3	---

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

Students are required to search, collect and review various research articles published in chosen area of research. A student has to select a topic for his dissertation, based on his/her interest and the available facilities at the commencement of dissertation work. A student shall be required to submit a dissertation report on the research work carried out by him/her.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria.

Criteria	Description	Weightages
I	Identification of Problem Domain	Weightage for each criterion will be determined by the panel and will be informed to the students.
II	Study of Existing Systems and establishing clear objectives	
III	Planning of project and work distribution within the team	
IV	Proper Documentation and Technical Writing	
V	Presentation and Response to questions	

Learning Resources:

1. Journal Publications
2. Conference / Seminar Proceedings
3. Handbooks / Research Digests

4th Semester

CE 36098 **0-0-0 (12)**

Dissertation Part – B

Pre-requisites: **CE36097**

Course Outcomes:

CO1	Identify the materials and methods for carrying out experiments/develop a code.
CO2	Execute the research methodology with a concern for society, environment and ethics
CO3	Analyse, discuss and justify the results/trends and draw valid conclusions.
CO4	Prepare the report as per recommended format and present the work orally adhering to stipulated time.
CO5	Explore the possibility to publish/present a paper in peer reviewed journals/conference proceedings without plagiarism.

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 – Substantially**

Description:

Students are expected to choose real-world contemporary problem and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel will decide the suitability and worthiness of the project.

Dissertation Evaluation:

i. The dissertation shall be submitted as per the schedule given in the academic calendar.

ii. The dissertation supervisor will periodically review the progress of the student and finally give his/her assessment of the work done by the student.

iii. The Dissertation Part – B will be evaluated for 100 marks, with the following weightages:

Sub-component	**Weightage**
a) Periodic evaluation by Guide	40 marks
b) Mid-term review	20 marks
c) End Semester viva-voce examination	40 marks

iv. The midterm review will be conducted by a committee constituted by the Head of the Department. The end semester examination will be conducted by an External Examiner along with the evaluation committee constituted by the Head of the Department.
v. A student will be permitted to submit the dissertation only if he/she completes all the courses as required in the program.
vi. The marks may be distributed among various components like selection of topic, problem statement, literature review, methodology, oral and written presentation of the work done and performance in end semester examination.
vii. Dissertation and Viva-Voce: A student shall be required to submit a report on the Dissertation work carried out by him/her. The template for the dissertation report may be downloaded from (https://www.nitw.ac.in/main/PGForms/NITW/). The students are required to submit a report showing that the plagiarism is within 20%. Three/four bound copies along with a soft copy of the dissertation shall be submitted to the Head of the Department/Centre within the last date prescribed in the Academic Calendar for the purpose. Dissertation viva - voce will be held within the date fixed in the academic calendar and the grades will be finalized by the committee.
viii. If the performance of the student in Dissertation Part-B is not satisfactory, he/she will be awarded 'F' grade. The student has to repeat the dissertation work by registering in the next semester.
ix. Extension of dissertation work (Part-B) beyond the deadline of submission in very special case may be granted by the Dean (Academic) on recommendation of the department/center for a maximum period of 3 months and he/she will be awarded "I" Grade. The viva-voce has to be completed within the extension period. The student shall not be eligible either for award of scholarship during the extension period or any medal/prize. However, if the student had been absent on medical grounds and his/her dissertation had been extended, he/she may be eligible for award of medal or prize, if any. If the above-mentioned extension period encroaches into the next semester, the student will have to pay the tuition fee on par with full time student.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria as a continuation of Dissertation Part A.

Task	Description	Weightages
IV	Performance of the Task	Weightage for each criterion will be determined by the panel and will be informed to the students.
V	Dissertation Preparation	
VI	Review (Presentation & Understanding)	
VII	Viva-Voce	
VIII	Publications /Possibility of publication	

Evaluation Criteria-CO Mapping:

CO / Criteria	CO1	CO2	CO3	CO4	CO5
IV	X	X			
V				X	
VI			X		
VII				X	
VIII					X

Professional Electives

CE 36021 **3-0-0 (3)**

Computational Methods for Environmental Engineering

Pre-Requisites: **None**

Course Outcomes:

CO1	Apply numerical methods for the solution of non-linear equations in Environmental Engineering
CO2	Formulate and solve systems of linear algebraic equations for a system of reactors
CO3	Apply finite difference schemes for the solution of hydraulic and hydrologic models
CO4	Apply the method of characteristics for the solution of hydraulic transients in pipes and channels

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Modelling, Computers and Error Analysis: Mathematical modelling and Engineering problems, Computers and concept of computation, Approximations and Errors.

Solution of Non-linear equations: Bracketing methods- Bisection, False-Position, Open methods- Fixed point Iteration, Newton Raphson method, Secant method, Brent's method , Roots of polynomials,.

Linear Algebraic Equations: Gauss Elimination method and its drawbacks, Gauss-Jordan method, LU Decomposition method, Gauss-Siedel method.

Ordinary differential equations: Nature of problems, boundary and initial equations, Euler's method, modified Euler's method, Predictor-Corrector methods, Runge-Kutta methods, Boundary value problems, Applications for reservoir routing, gradually varied flow problems, pipe networks.

Partial differential equations: Classification, nature of problems, Concepts of finite difference method, finite difference schemes, Solution of parabolic equations, pollutant transport, Solution of elliptical equations, solution of Laplace equation and Poisson equation, flow through porous media, Solution of hyperbolic equation, method of characteristics, unsteady flow through open channels, propagation of waves, Concepts of finite volume method.

Learning Resources:

Text Books:

1. Chapra, Steven C., and Canale, Raymond P., Numerical methods for engineers, McGraw Hill Education, 2021, 8th Edition
2. Hoffman, J.D., Numerical Methods for Engineers and Scientists, CRC Press, Special Indian Edition, 2011

Reference Books:

1. Applied Numerical Methods for Engineering, Schilling, R.J., and S.L. Harris, CENGAGE Learning, India Edition, 2007
2. Abbot, M.A. and Vervey, Computational Hydraulics, Elsevier Publications, 1996.
3. Moukalled, F., Mangani, L., Darwish, M., The Finite Volume Method in Computational Fluid Dynamics, Springer International Publishing, 2015.

Other Suggested Readings:

1. https://nptel.ac.in/courses/112/105/112105045/

CE 36023 **3-0-0 (3)**

Ecology and Stream Pollution

Pre-Requisites: **None**

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 – Substantially**

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

Learning Resources:

Text Books:

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. Monson, Russell K. (Ed.), Ecology and the Environment, Springer Publications, 2014.

Reference Books:

1. Frank R. Spellman and Joanne Drinan, Stream Ecology and Self Purification: An Introduction, 2nd Ed., CRC Press, 2001
2. Peavy, H.S, Rowe, D.R., and G. Tchobanoglous, Environmental Engineering, McGraw Hill Education, 2017, 1st Indian Edition
3. Welch, E.D. Ecological Effects of Wastewater, Cambridge University Press, 1992

Other Suggested Readings

1. https://nptel.ac.in/courses/127/106/127106004//
2. https://nptel.ac.in/content/storage2/courses/122103039/pdf/mod6.pdf
3. https://www.jstor.org/stable/25030232

CE 36025 **3-0-0 (3)**

Noise Pollution and Control

Pre-Requisites: **None**

Course Outcomes:

CO1	Classify the type and sources of noise pollution in urban areas
CO2	Assess and analyze noise levels from different sources
CO3	Identify suitable noise control measures to reduce noise
CO4	Plan strategies for control of noise from different sources to meet regulatory standards

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 – Substantially**

Syllabus:

Introduction: Sources of noise pollution – Properties and Measurements of Noise – Noise Propogation; sound measurement; Noise level meters – types, components, Noise Power level, Intensity level, Pressure level – Relationships -– Weighted networks – Combined Noise – Octave Band – Noise spectrum – Equivalent Noise – Day and night time –Standards, Equations and Application.

Characteristics and Effects of noise: Characterization of Noise from Construction, Mining, Transportation and Industrial Activities, Airport Noise – General Control Measures – Effects of noise pollution – auditory effects, non-auditory effects - Performance effects - Behavioral Effects.

Noise Abatement and Control: Noise Menace – Noise mitigation – Prevention and Control of Noise Pollution in Industries– Control of noise at source, control of transmission - Personal protection - Control of other types of Noise Sound Absorbent – Noise Pollution Analyzer

Acoustics of Noise: Acoustic materials – Industrial Noise Control – effects of noise on workers efficiency -Acoustic quieting - mechanical isolation technique, acoustical absorption, constrained layer damping – OSHA Noise standards – public education – other non-legislative measures – Auditorium Designing – Anti Noise Devices.

Regulation: Legislation of Noise and the Administrative Function – Planning for Noise Reduction – Noise levels standards in India - Acceptable Noise levels in Residential Areas - IS Standards - Vehiclular Nosie levels and the Law –The Aircraft Act 1934 (Related to noise only), Factories Act 1948 (Related to noise only), The Environmental Protection Act 1986 – Noise pollution (regulation and control) Rules, 2000.

Learning Resources:

Text Books:

1. S.P. Singal Noise Pollution and Control Strategy -, Alpha Publishers, 2005
2. Peterson and Gross .E Jr., Hand Book of Noise Measurement, 7th Edn, 2003.

Reference Books:

1. Antony Milne, David & Charles Noise Pollution: Impact and Counter Measures, PLC, 2009.
2. Harris, David A Noise Control Manual - Guidelines for Problem-Solving in the Industrial / Commercial Acoustical Environment, , Spinger 1991
3. Lawrence K. Wang (Editor), Norman C. Pereira, Yung Tse Hung, Advanced Air and Noise Pollution Control: Volume 2 (Handbook of Environmental Engineering), Humana Press, 2004.

Online Resources:

1. https://nptel.ac.in/courses/112/104/112104227/
2. https://nptel.ac.in/noc/courses/noc17/SEM2/noc17-me32/
3. https://onlinecourses.nptel.ac.in/noc19_me72/preview
4. https://www.legalserviceindia.com/articles/noip.htm
5. https://cpcb.nic.in/noise-pollution/
6. http://cpcbenvis.nic.in/noisepollution/noise_rules_2000.pdf

CE 36027 **3-0-0 (3)**

Environmental Fluid Mechanics

Pre-requisites: NONE

Course Outcomes:

CO1	Formulate momentum, energy and mass transport models
CO2	Solve diffusion-dispersion equations
CO3	Derive and solve basic equations of flow through porous medium
CO4	Solve analytically transport equations of momentum, heat, gases, and volatile organic chemicals across the air/water interface
CO5	Design multiport diffusers and submerged discharges

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Basic concepts of fluid mechanics: conservation laws, continuity equation, momentum equation, Application of momentum and energy equations

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

Exchange Processes at the Air/Water Interface: Exchange of Gases, Measurement of Gas Mass Transfer Coefficients.

Topics in Stratified Flow: Buoyancy and Stability Considerations, Internal Waves, Mixing, Double-Diffusive Convection, Mixed-Layer Modeling.

Dynamics of Effluents: Jets and Plumes, Submerged Discharges and Multiport Diffuser Design, Surface Buoyant Discharges

Sediment Transport: Hydraulic Properties of Sediments, Bed-Load Calculations, Suspended Sediment Calculations, Particle Interactions, Particle-Associated Contaminant Transport.

Remediation Issues: Soil and Aquifer Remediation, Bioremediation, Remediation of Surface waters

Learning Resources:

Text Books:

1. Rubin, H and Atkinson, J, Marcel and Deckker, Environmental Fluid Mechanics, , 2001.
2. Cussler, E. L, Diffusion: Mass transfer in fluid systems, Cambridge University Press, 3rd Ed., 2007.

Reference Books:

1. Gualtieri and Mihailovic, Fluid Mechanics of Environmental Interfaces, Taylor and Francis, 2008
2. Kundu and Cohen, Fluid Mechanics, Academic Press, 2012
3. Chow, V.T., Open Channel Flows, , McGraw Hill, 2010

Other Suggested Readings

1.https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-061-transport-processes-in-the-environment-fall-2008/lecture-notes/

CE 36029 **3-0-0 (3)**

Waste Processing Technologies

Pre-Requisites: **None**

Course Outcomes:

CO1	Identify waste processing methods for different types of wastes
CO2	Plan recovery of materials and energy from solid wastes
CO3	Design waste processing systems as per regulatory standards
CO4	Integrate emerging technologies in waste Management

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Waste Generation and Characterization: Types and sources of solid wastes: Residential Waste, Commercial and Institutional Waste, Industrial Waste, Construction and Demolition Waste, an overview of various techniques for evaluation of parameters, Selection of Appropriate Technologies for waste treatment, legislations for waste management

Processing and Treatment of Solid Waste: Mechanical Treatment Material Recovery Facility, Recycling and Recovery, Types of Material Recovery Facilities Design of Material Recovery Facilities. Processing and Treatment of Solid Waste:

Biological Treatment: Biological methods for waste processing: Composting, Biomethanation, Biodeisel, Biohydrogen, Mechanical Biological Stabilization Processing and Treatment of Solid Waste:

Thermal Treatment: Incineration, Residues and its utilisation, co-combustion, Pyrolysis, Gasification, Refuse Derived Fuel, solid recovered fuel

Emerging Technologies in Waste Management: Technologies Under Development, Bio-fuels and bio-chemicals, Technologies for Smart Waste Collection, use of SCADA systems for waste management, technical options for Construction and Demolition Waste Management

Learning Resources:

Text Books:

1. Thomas Christensen., Solid Waste Technology & Management, John wiley & sons, USA, 2011.
2. John Pichtel., Waste Management Practices: Municipal, Hazardous and Industrial, 2nd Ed., CRC Press, USA , 2014.

Reference Books:

1. Vesilind, P.A., and Worrell W. A., Solid Waste Engineering, 2nd Ed., Cengage India, 2016.
2. Peavy, H.S, Rowe, D.R., and Tchobanoglous, G., Environmental Engineering, Indian ED, McGraw Hill Inc., India, 2017.
3. Qian X, Koerner RM and Gray DH., Geotechnical Aspects of Landfill Design and Construction, 1st Ed., Prentice Hall, USA., 2002.
3. CPHEEO., Manual on Municipal Solid Waste Management, Ministry of Urban Development, India, 2016.
4. Tchobanoglous G., Frank Kreith., Hand Book of Solid Waste Management, 2nd Ed., McGraw Hill, USA, 2002.
5. Tchobanoglous G., Theisen H., and Vigil S.A., Integrated Solid Waste Management, Engineering Principles and Management Issues, 2nd Ed., McGraw-Hill, USA, 2014.

Other Suggested Readings

1. https://nptel.ac.in/courses/120/108/120108005/
2. https://nptel.ac.in/noc/courses/noc18/SEM2/noc18-ce25/
3. https://nptel.ac.in/courses/105/106/105106056/

CE 36031 **3-0-0 (3)**

Environment Health and Safety

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand salient aspects of environment health and safety
CO-2	Implement safety protocols related to environment health and safety
CO-3	Identify various activities in a working environment that affect health and safety
CO-4	Implement occupational safety policies

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	3	2	1	1	3	1
CO-2	3	3	3	3	2	2
CO-3	3	1	2	1	3	2
CO-4	3	2	2	2	3	2

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

EHS Management System: Purpose and responsibility, EHS Program Goals and Objectives, EHS Program, EHS Committees, Workplace Inspections, EHS Self-Inspection Checklists, Introduction to Environmental Compliance

Injury, Illness, and Near Miss: Reporting Incidents, Personal Injuries, and Near Misses, Incident Investigation of Injuries, Illnesses, and Near Misses Workers, Lost-Time Injuries and Illnesses, Return to Work Program, First Aid, Travel Immunization Program

Fire Safety: Emergency Planning and Evacuation, Fire Emergency Procedure, Reporting Fires, Life Safety: Exitways, Life Safety Policy, Life Safety: Public Assemblies, Portable Fire Extinguishers, Storage and Use of Flammable and Combustible Liquids, Sign and Tag Requirements for Accident Prevention, Fire and Life Safety Coordination, Managing Fire Alarms, Life Safety: Electrical Equipment, Exterior Open Flame, Policy on Fire Protection System Impairments, False Alarm Ordinance, Building Emergency Coordinators

Occupational Safety Policies: Industrial Hygiene Program Requirements, Medical Surveillance, Hearing Conservation Program, Use of Chemical Carcinogens, Chemical Waste Disposal, OSHA Bloodborne Pathogens Standard, OSHA Laboratory Standard, Use of Biohazardous Agents, Product or Device Alert/Recall, Personal Protective Equipment, Eye and Face Protection, Eye Protection for Chemistry Lab Courses, Foot Protection, Compliance with Laboratory Safety Standards, Respiratory Protection Program, Laboratory Ventilation Policy, Clearance of Laboratories Where Hazardous Materials Have Been Used, Indoor Air Quality Policy

Learning Resources:

Text Books:

1. National Research Council (US), Committee on Prudent Practices in the Laboratory (2011). *Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards, updated version*, National Academies Press, USA.
2. *Environment, Health and Safety Manual* (2020), The university of North Carolina at chapel hill, North Carolina, USA.

Reference Books:

1. Tortora GJ, Funke BR, and Case CL, Microbiology: An Introduction, Pearson Education, 2019, 4th Edition

Other Suggested Readings:

1. https://archive.nptel.ac.in/courses/103/106/103106071/
2. https://onlinecourses.nptel.ac.in/noc20_ch38/preview

CE 36042 **3-0-0 (3)**

Industrial Waste Management

Pre-Requisites: **None**

Course Outcomes:

CO1	Assess characteristics of industrial wastewaters and their impacts when disposed
CO2	Explore suitable pretreatment techniques
CO3	Identify suitable advanced wastewater treatment options
CO4	Evaluate wastewater characteristics and suggest treatment strategies for different industries

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 – Substantially**

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 – Strength Reduction – Volume Reduction – Equalization and Proportioning- Neutralization - Segregation - Process Changes - Salvaging - By product Recovery.

Advanced Wastewater Treatment: Necessity – Treatment Techniques - Removal of Solids - Reverse Osmosis, Ion Exchange, Electro dialysis, Solvent Extraction, Floatation.- Removal of Refractory Organics - Removal of Nitrogen and Phosphorus – Wastewater disinfection

Major Industrial Effluents: Sources, Characteristics and Treatment Strategies. Food Industries: Sugar, Dairy, Distilleries

Chemical and other Industries: Paper and Pulp, Tanneries, Textiles, Fertilizers, Pharmaceuticals, Cement, Steel and refineries.

Learning Resources:

Text Books:

1. Metcalf & Eddy, Wastewater Engineering Treatment and Reuse, , McGraw Hill Education, 2017, 4th Edition
2. Numerow, N.L., Liquid Waste from Industry – Theories, Practice and Treatment, Addison Wesley, 1971
3. Rao, M.N., and Dutta, A.K., Wastewater Treatment, IBH Publ., 1995

Reference Books:

1. Industrial Wastewater Management, Treatment and Disposal, WEF Manual of practice No. FD-3, 3rd Ed., WEF Press and McGraw Hill, 2008
2. Patwardhan, A.D., Industrial Waste Water Treatment, PHI Learning, 2009
3. Vivek Ranade, Vinay Bhandari, Industrial Wastewater Treatment, Recycling and Reuse, Elsevier Publications, 2014.

Other Suggested Readings

1. https://nptel.ac.in/courses/105/106/105106119/
2. http://nptelvideos.com/video.php?id=1118
3. https://www.youtube.com/watch?v=in3GSRuooRs

CE 36044 **3-0-0 (3)**

Water Quality Modeling

Pre-Requisites: **None**

Course Outcomes:

CO1	Assess water quality parameters and their importance
CO2	Identify water quality monitoring strategies and suitable approaches for monitoring water quality
CO3	Formulate mathematical models to assess water quality
CO4	Assess water quality indices and formulate water quality management/ plans for restoration

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 – Substantially**

Syllabus:

Introduction: Water Quality, Objectives and Standards, Water quality characteristics, sampling and analysis, Analytical methods, Automated analysis and remote monitoring. Water Pollution, Sources of Pollution, Nature of pollutants, Existing Approaches for Control/Abatement of Water Quality Degradation, Water Quality Monitoring in River Basins and lakes.

Water quality modeling: Modelling and Monitoring, Evolution of Water Quality Models, Types of Water Quality Models, Streeter Phelps Model, Non-Point Source Pollution, Modelling Approaches For Modeling Non-point Sources, River Water Quality Models and Lake Quality Models, Water quality indices

Water Quality Management: Overview of Water Quality Management, Water Quality degradation, Flow Augmentation, environmental flows in rivers, water quality restoration, Regulatory Provisions Pertaining to Water Quality Management, Water quality indices and Legal Aspects of Water quality management, Public and Private Sector Involvement

Management Practices for pollution control - Technology based approach - Water quality based approach - Control of point sources - Control of nonpoint sources- BMPs to control NPS Pollution, Optimization in Water Quality Management, Management plan case studies, Rivers, Lakes, reservoirs and Ground water.

Learning Resources:

Text Books:

1. Chapra, S.C., Surface Water Quality Modelling, ISBN-13: 978-1577666059; ISBN-10: 1577666054, Waveland Press, 2008
2. Sincero, A.P. and Sincero, G.A. Environmental Engineering - A Design Approach, (1999) Prentice Hall of India, N Delhi
3. Thomann, R.V., Mueller, J.A., Principles of Surface Water Quality Modelling and Control, (1987), Harper and Row Publishers

Reference Books:

1. Chin, David A., Water Quality Engineering in Natural Systems, (2006), Wiley – Interscience.
2. Marcello Benedini, George Tsakiris, Water Quality Modelling for Rivers and Streams,. Springer Science & Business Media, 2013.
3. Eckenfelder, Principles of Water Quality Management, , ISBN 978-94-011-7117-5, Elsevier, 1980

Other Suggested Readings

1. https://www.epa.gov/waterdata/surface-water-quality-modeling
2. https://www.youtube.com/watch?v=sItfGlg4sz0

CE 36046 **3-0-0 (3)**

Life Cycle Analysis

Pre-requisites: NONE

Course Outcomes:

CO1	Interpret the concept of Life cycle thinking and framework of Life cycle assessment.
CO2	Assimilate the computational structure behind LCA software packages
CO3	Write report/paper based on a LCA study
CO4	Predict the environmental impacts of a product

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction: Life Cycle Assessment concepts.

A brief history of Life-cycle Inventory analysis: overview of methodology, three components, Identifying 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.

Term Project Proposal, Process Based LCA, Software Demo: SimaPro Part-1, LCA Software Demo: SimaPro Part 2, LCA Software Demo: GREET, LCA Software Demo: BEES (Construction Materials)

Learning Resources:

Text Books:

1. Ciambrone , D.F, Environmental Life Cycle Analysis,., (2019)., Taylor and Francis Group, UK.
2. Jeroen Guinee, Handbook on Life Cycle Assessment: Operational guide to the ISO standards, , (2014).,Springer, USA.

Reference Books:

1. Hauschild, M. Z., Rosenbaum, R. K., & Olsen, S. I, Life Cycle Assessment - Theory and Practice, (Eds.) (2018). . Springer. https://doi.org/10.1007/978-3-319-56475-3

Other Suggested Readings

1. www.openlca.org
2. www.ecoinvent.org
3. www.gabi-software.com

CE 36048 **3-0-0 (3)**

Environmental Regulations and Management System

Pre-requisites: **NONE**

Course Outcomes:

CO1	Identify the importance of Management System and the process
CO2	Develop the strategic Environmental Management System to achieve cleaner production and pollution control
CO3	Identify the requisites for Environmental auditing and Documentation
CO4	Formulate environmental management System for various industries

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 – Substantially**

Syllabus:

Environmental Management System: Environmental management system - What is an EMS? Costs and Benefits of an EMS, Principles, problems and strategies; Review of political, ecological and remedial actions. Future strategies; multidisciplinary environmental strategies, the human, planning, decision-making and management dimensions. EMS in India

Develop an EMS: Plan, Do, Check and Act. Plan - Planning, including identifying environmental aspects and establishing goals, Do - Implementing, including training and operational controls, Act Reviewing, including progress reviews and acting to make needed changes to the EMS, Check Checking, including monitoring and corrective action

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

Standardization: Introduction to ISO and ISO 14001-2004, 2015, ISO 9001-2015, EMAS regulations, Wider application of system based approach. Local infrastructure development and environmental management: A system approach, Regional environmental management system, Conversion plan development and implementation strategies, Environmental management systems in local government**.** Twelve-step transition process from ISO 14001:2004 to 2015 revision

Environmental Audit and Applications: Environmental management system audits as per ISO 19011-2011 vs 2018 – Principles of auditing, Types of Audits, objective of Audit, Principle areas of environmental auditing, Benefits of Environmental Audit Environmental Audit Activities Roles and qualifications of auditors - Environmental performance indicators and their evaluation – Nonconformance – Corrective and preventive actions -compliance audits – waste audits and waste minimization planning – Environmental statement - Due diligence audit , Applications of EMS.

Case Studies: Waste Audits and Pollution Prevention opportunities in Textile, Sugar, Pulp & Paper, Electroplating, Mining, petroleum refining, Tanning industry, Dairy, Cement, Chemical industries, etc.

Learning Resources:

Text Books:

1. Vijay Kulkarni and Ramachandra T.V., Environmental Management, 2006. Commonwealth of Learning, Canada and Indian Institute of Science, Bangalore.
2. Parvesh, A newsletter from ENVIS Centre, Environmental Management System- February 2001, CPCB, India

Reference Books:

1. Hillary, R., Environmental Management Systems and Cleaner Production, Wiley Publishers, 1997
2. Christopher Sheldon and Mark Yoxon, Earthscan Installing Environmental management Systems – a step by step guide, Publications Ltd, London, 1999
3. ISO 14001/14004, ISO 9001, ISO 19011: Environmental management standards, International Organisation for Standardisation,
4. https://www.epa.gov/ems - Environmental Management Systems (EMS)
5. Ann Arbor, Environmental Management Systems: An Implementation Guide for Small and Medium-Sized Organizations, Second Edition, NSF International, , Michigan, January 2001

Other Suggested Readings

1. https://nptel.ac.in/courses/120/108/120108004/

CE 36050 **3-0-0 (3)**

Environmental Impact Assessment and Management

Pre-requisites: NONE

Course Outcomes:

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.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 - Substantially

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.

Learning Resources:

Text books:

1. Canter, L.W., Environmental Impact Assessment, McGraw Hill Pub. Co., 1997
2. Jain, R.K., Urban, L.V., Stracy, G.S., Environmental Impact Analysis, Van Nostrand Reinhold Co., New York, 1991.
3. Anjaneyulu.Y., and Manickam. V., Environmental Impact Assessment Methodologies, B.S. Publications, Hyderabad, 2007.

Reference Books:

3. Barthwal, R. R.Environmental Impact Assessment, ,New Age International Publishers, 2002
4. Rau, J.G. and Wooten, D.C, Environmental Impact Assessment,., McGraw Hill Pub. Co., New York, 1996.
5. Wathern.P., Environmental Impact Assessment- Theory and Practice, Routledge Publishers, London, 2004.
6. Hosetti, B. B, Environmental Impact Assessment & Management, , Kumar A, Eds, Daya Publishing House, 1998
7. UNESCO, Methodological Guidelines for the Integrated Environmental Evaluation of Water Resources Development, UNESCO/UNEP, Paris, 1987
8. EIA Notification 2016

Other Suggested Readings:

1. MEVE-001: Environmental Impact Assessment for Environmental Health – Course (swayam2.ac.in)
2. 120108004.pdf (nptel.ac.in)
3. environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/ommodel2.html
4. environmentclearance.nic.in/writereaddata/Form-1A/HomeLinks/ommodel3.html

CE 36052 **3-0-0 (3)**

Regulatory and Legal Frameworks for Waste Management

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the Regulatory and legal frameworks in waste management
CO-2	Identify various components of Regulatory and legal frameworks in WM
CO-3	Assess the challenges in the Regulatory and legal frameworks in WM
CO-4	Formulate the frameworks for legal and regulatory requirements for emerging waste management scenarios

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	3	2	2	3	3
CO-2	2	2	2	2	3	3
CO-3	3	2	3	2	2	3
CO-4	2	2	2	2	2	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction: Overview of waste management in India, importance of legal and regulatory frameworks, Difference between Regulatory and Legal frameworks, Legal Landmarks in the History of Waste management in India, Institutional framework on solid waste management in India.

Waste Management Laws in India: The Environmental Protection Act, The Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008, The Plastic Waste (Management and Handling) Rules, 2011, Bio-Medical Waste (Management and Handling) Rules, 1998, The E- Waste (Management and Handling) Rules, 2011, The Batteries (Management and Handling) Rules, 2001.

Solid waste management rules 2016: Source segregation of waste and Duties of waste generator, Introduction of the concept of partnership in Swachh Bharat, Collection and disposal of sanitary waste, Collect back scheme for packaging waste, User fee and spot fine, Promotion of marketing and utilization of compost, Promotion of waste to energy, Criteria and standards for waste treatment facility and pollution control, Management of waste in hilly areas, Duties of constitutional bodies and Ministries

Regulatory and Legal policy making in Waste Management: Waste management protocol during epidemics, Circular economy in waste management, Role of global economy, Stake holder engagement, Best practices in India and Abroad- Case studies

Learning Resources:

Text Books:

1. "National Environment Policy, 2006", Ministry of Environment and Forests, Government of India, Approved by the Union Cabinet on 18 May, 2006

Reference Books:

1.“Municipal solid waste management Manual Part 1,2 & 3”(2016), Central public health and environmental engineering organization, Ministry of Urban Development, Government of India.

Other Suggested Readings:

1. http://www.digimat.in/nptel/courses/video/127106137/L21.html

CE 36054 **3-0-0 (3)**

Hazardous Waste Management

Pre-Requisites: **None**

Course Outcomes:

CO-1	Understand the definition, sources, identification, and classification of hazardous waste
CO-2	Apply best practices for the collection, handling, storage, and transport of hazardous waste, including the TSDF concept and relevant regulations
CO-3	Analyze and evaluate various hazardous waste treatment and disposal technologies, including physical, chemical, physico-chemical and thermal methods
CO-4	Assess management practices for plastic waste, e-wase, biomedical waste, and nuclear waste, focusing on recycling, disposal methods, and their environmental impacts
CO-5	Evaluate waste reduction, recycling and reuse strategies, and remediation techniques for contaminated sites

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	1	2	2	2	1
CO-2	3	2	3	2	2	1
CO-3	3	2	3	3	3	2
CO-4	2	2	3	3	2	2
CO-5	3	2	2	3	3	3

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to Hazardous Waste: Definition and sources; Identification and classification; Management in developing countries; Collection, handling, storage and transport; TSDF concept; Rules and regulations

Hazardous Waste Treatment and Disposal: Treatment technologies – physical treatment, chemical treatment, physico-chemical treatment, thermal treatment; Specific techniques – solidification and chemical fixation, encapsulation, pyrolysis and incineration; Disposal - hazardous waste landfills, waste reduction, recycling and reuse, remediation of contaminated sites

Plastic Waste: Overview – sources and production, global and Indian Context; Management practices - recycling, energy production, landfilling, other applications.

E-Waste: Introduction - E-waste characteristics; Generation and management – collection and transport, recycling and disposal; Effects on society and environment; E-waste management rules

Biomedical Waste: Introduction – definition and sources of biomedical waste; Classification and management – collection and segregation, treatment and disposal; Management rules

Nuclear Waste: Characteristics and types; Sources - uranium mining and processing, Power reactors, refinery and fuel fabrication, spent fuel; Management – waste management techniques, decommissioning of reactors; Health and environmental effects

Learning Resources:

Text Books:

1. John Pichtel, Waste Management Practices: Municipal, Hazardous and Industrial, CRC Press, 2014, 2nd Edition
2. LaGrega M.D., Buckingham P.L. and Evans J.C.,Hazardous Waste Management, Waveland Pr Inc., 2010, Reissue Edition

Reference Books:

1. Tchobanoglous G, Theisen H and Vigil SA, Integrated Solid Waste Management, Engineering Principles and Management Issues, McGraw Hill Education, 2014, Indian Edition
2. Richard J. Watts, Hazardous Wastes - Sources, Pathways, Receptors, John Wiley and Sons, 1998, 1st Edition.

Other Suggested Readings:

1. Hazardous and other Wastes (Management & Transboundary Movement) Rules, 2016
2. NPTEL: Plastic Waste Management; Electronic waste management-Issues and Challenges, IIT Kharagpur

CE 36056 **3-0-0 (3)**

Environmental Systems Engineering

Pre-requisites: NONE

Course Outcomes:

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

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

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.

Learning Resources:

Text Books:

1. Bruce E. Logan, 2nd Ed., Environmental Transport Processes, Wiley, 2012
2. John S. Gulliver, Introduction to chemical transport in the environment, Cambridge University Press, 2007

Reference Books:

1. Diffusion: Mass transfer in fluid systems, E.L. Cussler, 3rd Ed., Cambridge University Press, 2007.
2. S. Trapp and M. Matthies, Chemodynamics and Environmental Modeling, Springer, 1998
3. Crank, J., Mathematics of Diffusion, 2nd Edition, Oxford University Press, 1975

Other Suggested Readings

1. https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-061-transport-processes-in-the-environment-fall-2008/lecture-notes/

CE 36058 **3-0-0 (3)**

Circular Economy for Sustainable Development

Pre-Requisites: **None**

Course Outcomes:

CO1	Apply the concept of circular economy to environmental engineering problems
CO2	Understand the concept of sustainable development
CO3	Apply the principles of circularity and their application to sustainable development
CO4	Apply complexity aspects of circular economy for sustainable development

Course Articulation Matrix:

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

1 - Slightly; **2 - Moderately;** **3 - Substantially**

Syllabus:

Introduction to circular economy: Purpose of circular economy, Circular sustainability, Challenges for circular economy

Concept of sustainable development: Sustainable processes technologies and Critical assessment on current sustainable technologies. Circular bioeconomy, Circular Business Models. Circular business models to create economic and social value.

Circular economy policy framework: universal circular economy policy gals, role of governments and networks and how policies and sharing best practices can enable the circular economy.

Circular economy towards zero waste: circular economy and waste sector, waste management in the context of circular economy

Learning Resources:

Text Books:

1. Walter R Stahe, The Circular Economy A User's Guide, Taylor & Francis, 2019, First edition
2. Peter Lacy, The Circular Economy Handbook: Realizing the Circular Advantage, Palgrave Macmillan, 2020, first edition
3. Lacy P, Rutqvist J, Waste to wealth: The circular economy advantage, Palgrave Macmillan, 2015, first edition

Reference Books:

1. Franco-García, María-Laura, Jorge Carlos Carpio-Aguilar, and Hans Bressers, Towards Zero Waste: Circular Economy Boost, Waste to Resources, Springer International, 2019

2. Marcello Tonelli, Nicolò Cristoni, Strategic Management and the Circular Economy, Taylor & Francis2018, 1st Edition
3. Sadhan Kumar Ghosh, Circular Economy: Global Perspective, Springer, 2020, first edition
4. Lerwen Liu, Seeram Ramakrishna, The Circular Economy: A User's Guide Stahel, Walter R. Routledge 2019 5. An Introduction to Circular Economy, Springer Singapore 2021.

Other Suggested Readings

1. https://www.coursera.org/learn/circular-economy
2. https://www.edx.org/course/circular-economy-an-introduction
3. https://www.coursera.org/learn/sustainable-digital-innovation
4. https://online-learning.harvard.edu/course/introduction-circular-economy?delta=0
5. https://www.oecd.org/cfe/regionaldevelopment/Ekins-2019-Circular-Economy-What-WhyHowWhere.pdf