NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

SCHEME OF INSTRUCTION AND SYLLABI

for

M.Tech Program in

WASTE MANAGEMENT

(Effective from 2021-22)

DEPARTMENT OF CIVIL ENGINEERING

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
Department of Civil Engineering

VISION

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

MISSION

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

Department of Civil Engineering:

Brief about the Department:

The Department of Civil Engineering was established in 1959, along with the setting up of the institute, that is, REC Warangal. The Department offers undergraduate and eight postgraduate programs in addition to Ph.D. The Department has highly committed faculty who are well qualified and are members of several national and international policy making and advisory bodies, including the BIS. The Department is a recognized QIP center since 1978 to offer Ph.D. programs to faculty of other institutes. The Department is known for its cutting-edge research and believes in disseminating the knowledge through publishing in highly reputed journals and patenting the research work.

The Department maintains excellent industry-institute linkages. Most of the students are placed in reputed companies, Government organizations, and Higher Educational Institutes in India and abroad. The alumni who are important stakeholders of the Department actively guide and provide valuable inputs. They constantly peer review the syllabus and curriculum to make students industry-ready.

The Civil Engineering Department, apart from Teaching and R&D, also does an enormous amount of consultancy, which adds up to the institutional internal revenue generation and involves faculty and students in challenging field problems. There are six centers of excellence in the Department, and most laboratories have state-of-the-art equipment.

The faculty of the Department are actively involved in sponsored projects and have prestigious projects like SPARC, BRICS, IMPRINT, DST, SERB, DBT, ARDB, to name a few. The Department takes pride in having conducted the highest number of GIAN and SPARC programs.

The Civil Engineering Department has MoUs with highly reputed organizations like NAAC, NCCBM, WALAMTARI, SCCL, INVENTA, PSI, among others, and has collaborations with several foreign universities and companies such as – Texas A&M, NCAR-Colorado, PTV Group Germany, etc.

List of Programs offered by the Department:

Program	Title of the Program
B.Tech.	Civil Engineering
M.Tech.	Engineering Structures
	Water Resource Engineering
	Geotechnical Engineering
	Transportation Engineering
	Remote Sensing and Geographical Information Systems
	Environmental Engineering
	Construction Technology and Management
	Waste Management
Ph.D.	Civil Engineering

Note: **Refer to the following weblink for Rules and Regulations of M.Tech. program:**
https://www.nitw.ac.in/main/MTechProgram/rulesandregulations/

DEPARTMENT OF CIVIL ENGINEERING
M.TECH. WASTE MANAGEMENT

Program Educational Objectives

PEO1	Apply knowledge of basic science and engineering to achieve waste management hierarchy and its significance in the socio-economic development
PEO2	Identify, formulate and design engineered solutions to waste management problems to cater needs of society
PEO3	Apply best waste management practices for securing ecologically sustainable development while promoting justifiable economic and social development
PEO4	Communicate and manage interdisciplinary teams in solving waste management problems.
PEO5	Demonstrate leadership qualities and exhibit professional ethics.

Program Articulation Matrix

Mission Statement	PEO1	PEO2	PEO3	PE04	PEO5
MS1	3	3	3	2	2
MS2	2	3	2	3	3

PROGRAM OUTCOMES: At the end of the program the student will be able to:

PO1	Engage in critical thinking and pursue investigations/research and development to solve waste management problems.
PO2	Communicate effectively, write and present technical reports on complex engineering activities by interacting with the engineering fraternity and with society at large.
PO3	Demonstrate higher level of professional skills to tackle multidisciplinary and complex problems related to waste management
PO4	Analyze and predict waste management parameters /variables to ensure effective delivery of waste management services
PO5	Design feasible solutions for waste management which are legally, ethically, socially and economically acceptable
PO6	Develop waste management strategies for tackling problems at local, regional and global scales

SCHEME OF INSTRUCTION

M.Tech. (Waste Management) Course Structure

M. Tech. I - Year I - Semester

S No	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	CE5801	Logistics in Waste Collection and Disposal	3	0	0	3	PCC
2	CE5802	Solid Waste Management	3	0	0	3	PCC
3	SM5006	Strategic Management	3	0	0	3	PCC
4		Elective – I	3	0	0	3	PEC
5		Elective – II	3	0	0	3	PEC
6		Elective – III	3	0	0	3	PEC
7	CE5304	Advanced Environmental Engineering Lab	0	1	2	2	PCC
8	CE5505	Geographical Information Systems Laboratory	0	1	2	2	PCC
9	CE5848	Seminar – I	0	0	2	1	SEM
		TOTAL	**18**	**2**	**6**	**23**	

M. Tech. I - Year II - Semester

S No	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	CE5851	Waste Processing Technologies	3	0	0	3	PCC
2	CE5852	Hazardous Waste Management	3	0	0	3	PCC
3	CE5853	Regulatory and Legal Framework for Waste Management	3	0	0	3	PCC
4		Elective – IV	3	0	0	3	PEC
5		Elective – V	3	0	0	3	PEC
6		Elective – VI	3	0	0	3	PEC
7	CE5854	Waste Characterization and Analysis Lab	0	1	2	2	PCC
8	CE5855	Waste Management Design Lab	0	1	2	2	PCC
9	CE5898	Seminar – II	0	0	2	1	SEM
		TOTAL	**20**	**2**	**6**	**23**	

M. Tech. II - Year I - Semester

S No	Course Code	Course Title	Credits	Cat. Code
		Industrial Training (8-10 Weeks) – Optional		
1	CE6847	Comprehensive Viva Voce	2	CVV
2	CE6849	Dissertation Part A	12	DW
		Total	14	

M. Tech. II - Year II - Semester

S No	Course Code	Course Title	Credits	Cat. Code
1	CE6899	Dissertation Part B	20	DW
		Total	20	

Credits Distribution

Cat. Code	Sem-I	Sem-II	Sem-III	Sem-IV	Total
PCC	13	13	0	0	26
PEC	9	9	0	0	18
SEM	1	1	0	0	02
CVV	0	0	2	0	02
DW			12	20	32
Total	23	23	14	20	**80**

Abbreviations:
PCC – Program Core Courses
PEC – Program Elective Courses
SEM – Seminar
CVV – Comprehensive Viva Voce
DW – Dissertation Work

Professional Elective Courses:

Semester	Elective Number	Course Code	Course Title
I	I, II, III	CE5811	Environmental Health and Safety
I	I, II, III	CE5812	Circular Economy for Sustainable Development
I	I, II, III	SM5071	Entrepreneurship in Waste Management
I	I, II, III	CH5115	Waste to Energy
I	I, II, III	CH5116	Green & Cleaner Technology
I	I, II, III	BT5116	Biotechnology for Waste Management
II	IV, V,VI	CE5861	Operation Research
II	IV, V, VI	CE5866	Landfill Design and Operation
II	IV, V, VI	BT 5174	Applied Environmental Microbiology
II	IV, V, VI	SM5051	Operations and Maintenance
II	IV, V, VI	SM5031	Marketing Management for Waste
II	IV, V, VI	CH5168	Advanced Physicochemical Treatment Technologies
II	IV, V, VI	CH5169	Energy Audit and Conservation

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.

DETAILED SYLLABUS

M.Tech. (Waste Management)

CE5801	Logistics in Waste Collection and Disposal	3-0-0: 3

Pre-requisites**:** NONE

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

CO1	Plan logistics for waste collection and disposal
CO2	Formulate strategies for segregation of waste and waste reduction
CO3	Plan appropriate recycle facility for heterogeneous wastes
CO4	Plan and design waste collection systems

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

1. **Introduction to waste management logistics**, importance, methods of logistics, human components, technological components- waste handling equipment and technology, and managerial goals, steps in waste management logistics.
2. **Basics of GPS & GIS** - introduction, importance; GPS aided vehicle; GPS in India, US, Russia. variable cycle (multi-day, weekly, bi-weekly, monthly, quarterly),variable route start location, route optimization, scheduling, GPS tracking, mobile communications.
3. **Waste collection system and organization**: Environmental aspects of waste collection, role of public authority and private sector in waste collection, organizing collection of residential waste, fee schemes, public awareness programs.
4. **Source segregation and collection** - source-segregated waste, Purpose of source segregation, segregation criteria and guidance, segregation potential and efficiencies, systems for collecting segregated fraction
5. **Waste transfer stations:** waste delivery, waste transfer, transportation of the reloaded waste, siting and Design of waste transfer station, economical considerations, recycling solid wastes, materials recovery facilities

Learning Resources:

Text Books:

1. Integrated Solid Waste Management, Engineering Principles and Management Issues,Tchobanoglous G., Theisen H., and Vigil S.A. (2014)., 2nd Ed., McGraw-Hill, USA.
2. Solid Waste Engineering, Vesilind, P.A., and Worrell W. A. (2016), 2nd Ed., Cengage India.
3. Hand Book of Solid Waste Management, Tchobanoglous G., Frank Kreith., (2002)., 2nd Ed., McGraw Hill, USA.
4. Solid Waste Technology & Management, Thomas Christensen, (2011)., John wiley & sons, USA.

Reference Books:

1. Waste: A Handbook for Management, Letcher, T.M., Vallero, D.A. (2011)., 1st Ed, Academic Press, USA.
2. Waste Management Practices: Municipal, Hazardous and Industrial, John Pichtel (2014)., 2nd Ed., CRC Press, USA.
3. Solid Waste Management - Present and Future Challenges, Jagbir Singh, Ramanathan, AL., (2019)., I.K. International publishing House Pvt.Ltd., India.
4. Introduction to GPS- The Global Positioning System,Ahmed El Rabbany (2002):, Second Edition, Artech House Publishers, India.

Online Resources:

1. https://nptel.ac.in/content/storage2/courses/105106056/Introduction.pdf
2. https://nptel.ac.in/courses/105/103/105103205/

CE 5802	SOLID WASTE MANAGEMENT	3-0-0: 3

Pre-requisites**:** NONE

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

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 land fills – 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. Integrated Solid Waste Management, Engineering Principles and Management Issues, Tchobanoglous G, Theisen H and Vigil SA, McGraw Hill Education, 2014, Indian Edition

2. Waste Management Practices: Municipal, Hazardous and Industrial, John Pichtel, CRC Press, 2014, 2nd Edition

3. Solid Waste Engineering, Vesilind PA, Worrell W and Reinhart D, Brooks/Cole Thomson Learning Inc., 2010, 2nd Edition

Reference Books:

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

Online Resources:

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/

SM5006	STRATEGIC MANAGEMENT	3 – 0 – 0

Pre-requisites**:** NONE

Course Outcomes:

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

CO1	Apply conceptual, diagnostic and analytical skills in strategy formulation, implementation and control
CO2	Analyze the suitability of strategies to achieve valuable outcomes.
CO3	Appraise the resources and capabilities of the organization
CO4	Demonstrate the ability to think critically in relation to strategic decision through real-world scenarios.
CO5	Analyze the best practices in strategic waste management and relate to sustainable development goals

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Detailed Syllabus:

Introduction to Strategic Management: Concepts of Strategic management, strategic management process, vision, mission, objectives, goals, strategy; Environmental Appraisal- external, internal; resources & capabilities – SWOT analysis, concept of core competence and value chain analysis, PESTEL Analysis, Industry analysis; strategic issues of waste management.

Formulation of Strategy: Level of strategy formulation, Generic competitive strategies: cost leadership, and differentiation, framework for analyzing competition, competitive positioning of a firm.

Strategic alternatives and Choices: Grand strategies, business level strategies, horizontal, vertical integration, diversification. Strategic Choices- BCG matrix, G.E matrix portfolio analysis - Technology based versus mature industries, External growth strategy – Strategic Alliances, merger-acquisition, collaborative partnerships.

Implementation of Strategy: Elements of strategy implementation, structure, McKinsey's 7s framework Resources allocation, corporate leadership, personal values, organizational culture, Strategy evaluation and control – Balanced Scorecard.

Strategic waste management: Alignment with Sustainable Development goals; best practices in strategic waste management; challenges in strategic waste management.

(Case studies of related topics have to be discussed)

Learning Resources:

Text Books:

1. Strategic Management concepts,Fred R.D., Forest R.D., (2016)., 16th Ed, Pearson Education,USA..
2. Strategic Management,Hitt, M.A.,Hoskisson, R.E., Ireland, R.D., (2016)., Cengage Learning, India.

Reference Books:

1. Waste Management Strategy and Action Plan,IGES, UNEP, CCET. (2018), Phnom Penh 2018-2035. Phnom Penh, Cambodia.
2. Practical Guidebook on Strategic Planning in Municipal Waste Management, Kobus,Dariusz. (2003), Washington, D.C.: World Bank.

Online Resources:

1. **https://nptel.ac.in/courses/110/108/110108047/**

CE 5304	ADVANCED ENVIRONMENTAL ENGINEERING LABORATORY	0-1-2:2

Pre-requisites**:** NONE

Course Outcomes:

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

CO1	Learn sampling, and storage of water, wastewater and soil samples
CO2	Experience on lab scale physicochemical treatment processes
CO3	Expose to sophisticated environmental monitoring and 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. Chemistry for Environmental Engineering and Science, Sawyer, C. N., McCarty, P. L., and Perkin, G.F., 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

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

Online Resources:

www.vlab.co.in

CE 5505	GEOGRAPHICAL INFORMATION SYSTEMS LABORATORY	0-1-2: 2

Pre-requisites**:** NONE

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

CO1	Prepare different geospatial layers
CO2	Compute geometric measurements and perform spatial analysis
CO3	Create high-quality maps and associated graphics
CO4	Integrate different geospatial layers

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Detailed Syllabus:

1. Digitization of Points and Lines
2. Editing Map Elements
3. Attribute Data Entry and Manipulation
4. Cleaning, Building and Transformation
5. Data Analysis – Overlay, Buffer
6. Map Generation with Patterns and Legends
7. Buffer Analysis
8. Network Analysis

Learning Resources:

1. ArcGIS user manuals,
2. QGIS User Manuals

CE5851	Waste Processing Technologies	3-0-0: 3

Pre-requisites**:** NONE

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

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, Bio CNG, 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. Solid Waste Technology & Management,Thomas Christensen, (2011)., John wiley&sons, USA.
2. Waste Management Practices: Municipal, Hazardous and Industrial, John Pichtel (2014)., 2nd Ed., CRC Press, USA
3. Hand Book of Solid Waste Management, Tchobanoglous G., Frank Kreith., (2002)., 2nd Ed., McGraw Hill, USA.

4. Integrated Solid Waste Management, Engineering Principles and Management Issues, Tchobanoglous G., Theisen H., and Vigil S.A. (2014)., 2nd Ed., McGraw-Hill, USA

Reference Books:

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

Online Resources:

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 5852	HAZARDOUS WASTE MANAGEMENT	3-0-0: 3

Pre-requisites**:** NONE

Course Outcomes:

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

CO1	Examine physical, chemical and biological characteristics of hazardous wastes
CO2	Analyze activities associated with the management of Hazardous wastes
CO3	Formulate and plan suitable treatment facility for handling hazardous wastes
CO4	Design a secured landfill for the disposal of Hazardous wastes

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Hazardous waste:

Hazardous waste definition, sources, identification and classification; Hazardous waste management in developing countries- Collection, handling, storage and transport, TSDF concept; Hazardous waste management rules and regulations

Hazardous waste treatment and disposal:

Hazardous waste treatment technologies: Physical, chemical, physico-chemical treatment, and thermal treatment;-Solidification, chemical fixation, encapsulation, pyrolysis and incineration. Hazardous waste disposal: Hazardous waste landfills- Site selections, design and operation. Hazardous waste reduction, recycling and reuse, remediation of hazardous waste contaminated sites

Management of different Hazardous wastes:

Nuclear waste: Characteristics – Types – Nuclear waste – Uranium mining and processing – Power reactors – Refinery and fuel fabrication wastes – spent fuel – Management of nuclear wastes – Decommissioning of Nuclear power reactors – Health and environmental effects

Biomedical waste: Introduction to biomedical wastes, sources, classification, collection, segregation, treatment and disposal. Biomedical waste management rules

E-waste: introduction, e-waste characteristics; e-waste generation, collection, transport, recycling and disposal methods; Effects of e-wastes on the society and environment. E-waste waste management rules

Plastic waste: Plastic Waste – Sources, Production, Global and Indian Context; Plastic Waste Management Practices – Plastic management- recycling, energy production, landfilling, other application.

Learning Resources:

Text Books:

1. Waste Management Practices: Municipal, Hazardous and Industrial, John Pichtel, CRC Press, 2014, 2nd Edition
2. Hazardous Waste Management, LaGrega M.D., Buckingham P.L. and Evans J.C., Waveland Pr Inc., 2010, Reissue Edition
3. Integrated Solid Waste Management, Engineering Principles and Management Issues, Tchobanoglous G, Theisen H and Vigil SA, McGraw Hill Education, 2014, Indian Edition

Reference Books:

1. Handbook of Solid Waste Management, Tchobanoglous G and Kreith F, McGraw-Hill Education, 2002, 2nd Edition
2. Geotechnical Aspects of Landfill Design and Construction, Qian X, Koerner R M and Gray D H, Prentice Hall, 2002, 1st Edition
3. Hazardous Wastes - Sources, Pathways, Receptors, Richard J. Watts, John Wiley and Sons, 1998, 1st Edition.

Online Resources:

1. http://cpheeo.gov.in/cms/manual-on-municipal-solid-waste-management-2016.php
2. https://nptel.ac.in/courses/105/106/105106056/
3. https://nptel.ac.in/courses/105/105/105105184/
4. https://nptel.ac.in/courses/105/105/105105169/
5. https://nptel.ac.in/courses/105/105/105105160/

CE5862	REGULATORY AND LEGAL FRAMEWORK FOR WASTE MANAGEMENT	3 – 0 – 0

Pre-requisites**:** NONE

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

CO1	Interpret the Regulatory and legal frameworks in waste management
CO2	Identify various components of Regulatory and legal frameworks in WM
CO3	Assess the challenges in the Regulatory and legal frameworks in WM
CO4	Formulate the frameworks for legal and regulatory requirements for emerging waste management scenarios

Course Articulation Matrix:

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

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

Reference Books:

1. Solid Waste Technology & Management, Thomas Christensen, (2011)., John Wiley & sons, USA.
2. Waste Management Practices: Municipal, Hazardous and Industrial, John Pichtel (2014)., 2nd Ed., CRC Press, USA
3. Integrated Solid Waste Management, Engineering Principles and Management Issues, Tchobanoglous G., Theisen H., and Vigil S.A. (2014)., 2nd Ed., McGraw-Hill, USA

Online Resources:

1. https://nptel.ac.in/content/storage2/courses/105106056/Introduction.pdf
2. https://wedocs.unep.org/bitstream/handle/20.500.11822/31379/IWM_Guidelines.pdf?sequence=1&isAllowed=y
3. http://moef.gov.in/wp-content/uploads/wssd/doc2/ch2.html
4. https://www.epa.gov/regulatory-information-topic/regulatory-and-guidance-information-topic-waste

CE 5854	WASTE CHARACTERIZATION AND ANALYSIS LAB	0-1-2: 2

Pre-requisites**:** NONE

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

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. *Solid Waste Technology & Management,* Thomas Christensen, (2011)., John wiley& sons, USA.
2. *Wastewater Engineering Treatment and Reuse,* Metcalf & Eddy, (2017), 4th Ed, McGraw Hill Inc, India.

Reference Books:

1. *Environmental Engineering,* Peavy, H.S, Rowe, D.R., and Tchobanoglous, G., (2017)., Indian ED, McGraw Hill Inc., India.
2. Handbook of Solid Waste Management, Tchobanoglous G and Kreith F, McGraw-Hill Education, 2002, 2nd Edition
3. Chemistry for Environmental Engineering and Science, Sawyer, C. N., McCarty, P. L., and Perkin, G.F., McGraw Hill Education,2017, 5th Edition

Online Resources:

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

CE 5855	WASTE MANAGEMENT DESIGN LAB	0-1-2: 2

Pre-requisites**:** NONE

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

CO1	Estimate the physical and chemical composition of solid waste
CO2	Analyze the waste collection system
CO3	Design waste transformation processes
CO4	Design waste containment systems as per regulatory standards

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

1. Estimate the moisture content and specific weight of solid waste sample
2. Determine the approximate chemical composition of a solid waste sample and estimate the energy content
3. Assess the solid waste quantities using material-balance analysis
4. Statistical analysis of solid waste collected data
5. Selection of container size for use at a commercial facility
6. Analysis of waste collection systems
7. Layout of collection route for a given area
8. Design of composting plants
    - Estimate the oxygen requirements for the aerobic conversion of solid waste
9. Design of Biogas plant
    - Estimate the amount of gas produced from the organic fraction of solid waste under anaerobic conditions
10. Design of an incinerator for the treatment of solid waste
    - Determination of the effects of excess air on temperature and composition of flue gases
    - Determine the heat available in the exhaust gases from the combustion of solid waste
    - Estimate the amount of energy produced from a solid waste energy conversion system
11. Design of sanitary landfill design
    - Estimate the chemical composition and the amount of gas that can be derived from the organic constituents of solid waste
12. Secured landfill design
13. Design of a combination of compost plant and landfill for municipal solid waste

management for a city

Learning Resources:

Text Books:

1. Integrated Solid Waste Management, Engineering Principles and Management Issues, Tchobanoglous G, Theisen H and Vigil SA, McGraw Hill Education, 2014, Indian Edition
2. Waste Management Practices: Municipal, Hazardous and Industrial, John Pichtel, CRC Press, 2014, 2nd Edition
3. Solid Waste Engineering, Vesilind PA, Worrell W and Reinhart D, Brooks/Cole Thomson Learning Inc., 2010, 2nd Edition

Reference Books:

1. Environmental Engineering, Peavy, H.S, Rowe, D.R., and G. Tchobanoglous, McGraw Hill Education, 2017, 1st Indian Edition
2. Handbook of Solid Waste Management, Tchobanoglous G and Kreith F, McGraw-Hill Education, 2002, 2nd Edition
3. Geotechnical Aspects of Landfill Design and Construction, Qian X, Koerner R M and Gray D H, Prentice Hall, 2002, 1st Edition

Online Resources:

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/

CE5811	ENVIRONMENTAL HEALTH AND SAFETY	3 – 0 – 0

Pre-requisites**:** NONE

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

CO1	Assimilate the goals and objectives of EHS
CO2	Apply safety protocols related to environment health and safety
CO3	Identify various activities in a working environment which affect EHS
CO4	Assess the EHS standards in a given working environment

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	2	2	3
CO2	1	2	2	2	-	2
CO3	1	3	2	2	1	1
CO4	1	1	1	2	2	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. Safety, Health and Environmental Auditing: A Practical Guide, Second Edition, CRC press, 2018.

2. Environmental Engineering: Environmental Health and Safety for Municipal Infrastructure, Land Use and Planning, and Industry, Sixth Edition. Nelson L. Nemerow, Franklin J. Agardy, Patrick J. Sullivan, Joseph A. Salvato ISBN: 978-0-470-08305-5.
3. Occupational and Environmental Safety and Health. Pedro M. Arezes, João S. Baptista, Mónica P. Barroso, Paula Carneiro, Patrício Cordeiro, Nélson Costa, Rui B. Melo, A. Sérgio Miguel, Gonçalo Perestrelo, Springer International Publishing, 2019.

Reference Books:

1. Health Safety and Environmental Legislation A Pocket Guide R. Day, J.A. Reader, 2003.
2. Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards: Updated Version (2011), National Research Council (US) Committee on Prudent Practices in the Laboratory. Washington (DC): National Academies Press (US); 2011.
3. Environment, Health and Safety Manual (2020), The university of North Carolina at chapel hill, North Carolina, USA.
4. Risk communication: a handbook for communicating environmental, safety, and health risks Lundgren, Regina E., McMakin, Andrea H, Wiley Publications, 2019.
5. Handbook of environmental health and safety. Herman Koren, CRC Press, 2002.

Online Resources:

1. https://www.coursera.org/lecture/construction-project-management/safety-health-and-environment-management-systems-Yn8K8
2. https://coursera.community/course-suggestions-51/occupational-health-and-safety-ohs-health-security-safety-and-environment-14930
3. https://www.edx.org/course/health-safety-and-wellness-in-mining?index=product&queryID=49f1844df4480f90f2b7894f712b88eb&position=3

CE 5812	CIRCULAR ECONOMY FOR SUSTAINABLE DEVELOPMENT	3-0-0: 3

Pre-requisites: NONE

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

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	PO7	PO8
CO1	3	-	1	1	2	-	-	-
CO2	2	1	2	-	1		1	**1**
CO3	1	2	1	-	1	2	1	-
CO4	2	-	-	1	-	2	-	2

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. The Circular Economy A User's Guide by Walter R Stahel. CRC Press 2019.
2. The Circular Economy Handbook: Realizing The Circular Advantage by Peter Lacy, Jessica Long, Wesley Spindler. 2020.
3. Waste to Wealth: The Circular Economy Advantage Peter Lacy, Jakob Rutqvist, 2015.

References

1. Towards Zero Waste: Circular Economy Boost, Waste to Resources María-Laura Franco-García, Jorge Carlos Carpio-Aguilar, Hans Bressers. Springer International Publishing 2019
2. Strategic Management and the Circular Economy Marcello Tonelli, Nicolo Cristoni, Routledge 2018.
3. Circular Economy: Global Perspective Sadhan Kumar Ghosh, Springer, 2020
4. The Circular Economy: A User's Guide Stahel, Walter R. Routledge 2019
5. An Introduction to Circular Economy Lerwen Liu, Seeram Ramakrishna, Springer Singapore 2021.

Online Resources:

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-Why-How-Where.pdf

SM5071	ENTREPRENEURSHIP IN WASTE MANAGEMENT	3 – 0 – 0

Pre-requisites**:** NONE

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

CO1	Assimilate the attitudes, values and processes for appropriate entrepreneurial behaviour.
CO2	Develop entrepreneurial opportunities to start fresh business or act as an entrepreneur within an existing organization
CO3	Formulate mechanisms to turn a new business concept into a sustainable business venture
CO4	Explore entrepreneurial leadership and management style.

Detailed Syllabus:

Introduction to Entrepreneurship, Practicing Entrepreneurship and its significance and contribution to the economy

Entrepreneurial Mindset, Supporting Social Entrepreneurship, Entrepreneurship and opportunities in Waste Management, Generating New Ideas, Using Design Thinking

Building Business Models, Planning a Waste Managing Enterprise, Human Resources and Infrastructure, Arranging and Managing Finance, Marketing and Pitching the idea

Government rules, Navigating Legal & IP Issues involved in Waste Management, Role of financial institutions

Innovations in waste management, Revenue models, Developing Networks, Challenges in Entrepreneurship, Learning from Failure

Case studies: Wealth from waste and entrepreneurs in India and other countries

Learning Resources:

Text Books:

1. *Entrepreneurship,*Hisrich, R.D., andPeters, M.P., Shepherd A.D., (2013)., 9th Ed., McGraw Hill, USA.

Reference Books:

1. *Entrepreneurship: Theory, Process, Practice,*Kuratko, D.F., (2017), 10th Ed., Cengage Learning Publishing, India.
2. *Innovation and Entrepreneurship,* Peter Drucker, (2012)., Routledge Publishers, England UK.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc21_ge06/preview

CH 5115	WASTE TO ENERGY	3-0-0: 3

Pre-requisites: None

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

CO1	Interpret technologies for generation of energy from solid waste
CO2	Select thermochemical conversion methods
CO3	Identify sources of energy from bio-chemical conversion
CO4	Analyse the environmental and health impact of waste to energy conversion

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Characterization of wastes, agricultural residues and wastes including animal wastes, industrial wastes, municipal solid wastes. Waste processing types and composition of various types of wastes, characterization of municipal solid waste, Industrial waste and biomedical waste, waste collection and transportation, waste processing-size reduction, separation, waste management hierarchy, waste minimization and recycling of municipal solid waste.

Thermochemical conversion: incineration, pyrolysis, gasification of waste using gasifiers, environmental and health impacts of incineration; strategies for reducing environmental impacts. Energy production from wastes through incineration, energy production through gasification of wastes. Energy production through pyrolysis and gasification of wastes, syngas utilization.

Bio-chemical Conversion: Anaerobic digestion of sewage and municipal wastes, direct combustion of MSW-refuse derived solid fuel, industrial waste, agro residues, anaerobic digestion biogas production, and present status of technologies for conversion of waste into energy, design of waste to energy plants for cities, small townships and villages. Energy production from wastes through fermentation and trans esterification. Cultivation of algal biomass from wastewater and energy production from algae. Energy production from organic wastes through anaerobic digestion and fermentation, introduction to microbial fuel cells. Process analysis and reactor configurations for Methane production, Energy assessment, Bio-methanation from sludge digestion.

Energy production from waste plastics, gas clean-up Waste, Heat Recovery: Concept of conversion efficiency, energy waste, waste heat recovery classification, advantages and applications, commercially viable waste heat recovery devices.

Environmental and health impacts-case studies: Environmental and health impacts of waste to energy conversion, case studies of commercial waste to energy plants, waste to energy-potentials and constraints in India, eco-technological alternatives for waste to energy conversions.

Learning Resources:

Text Books:

1. Thermo-chemical Processing of Biomass: Conversion into Fuels, Chemicals and Power, Robert C. Brown, John Wiley and Sons, USA, 2019.
2. Introduction to Biomass Energy Conversions, Sergio Capareda, CRC Press, USA, 2013.
3. Dry Scrubbing Technologies for Flue Gas Desulfurization. (2012). Ohio Coal Development Office, United States: Springer US.

Reference Books:

1. Efficiency of Biomass Energy: An Exergy Approach to Biofuels, Power, and Biorefineries, Krzysztof J Ptasinski, John Wiley & Sons, USA, 2016.
2. Solid Waste Engineering, Vesilind, P.A., and Worrell W. A., Cengage India, 2016, 2nd Edition.

Online Resources:

1. https://nptel.ac.in/courses/103/107/103107125/

CH 5116	GREEN AND CLEANER TECHNOLOGIES	3-0-0: 3

Pre-requisites: None

Course Outcomes:

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

CO1	Estimate the carbon credits of various activities
CO2	Apply principles of energy efficient technologies.
CO3	Interpret the importance of green fuels and its impact on environment.
CO4	Identify the importance of life cycle assessment

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Greenhouse emissions, climate change and role of green and cleaner technologies, causes and effects. Diagnostics and baseline determination, climate change mitigation and adaptation strategy. Risk assessments & mitigation.

Carbon accounting, carbon market, carbon capture and storage, potential carbon sequestration (forest sinks).

Green Technology: definition, Importance, historical evolution, advantages and disadvantages of green technologies, factors affecting green technologies, role of Industry, government and institutions, industrial ecology, role of industrial ecology in green technology.

Principles of Green Technologies, reasons for Green Technology, resource minimization, waste minimization, concepts, green reactions solvent free reactions, catalyzed (heterogeneous/homogeneous) reactions, ultrasound mediated reactions, bio catalysts etc.

Materials for "Green" Systems: Green materials, including biomaterials, biopolymers, bioplastics, and composites. Green technologies for energy, green fuels, definition, benefits and challenges, comparison of green fuels with conventional fossil fuels with reference to environmental, economic and social impacts. Various technologies available for energy production: Wind, solar biofuels etc.

Principles of cleaner production, barriers, role of Industry, clean development mechanism, reuse, recovery, recycle, raw material substitution, wealth from waste, case studies. Overview of cleaner production assessment steps and skills, process flow diagram, material balance, cleaner production, option generation, technical and environmental feasibility analysis, economic valuation of alternatives. Bio CNG

Learning Resources:

Text Books:

1. Emerging green technologies, Matthew N. O. Sadiku, CRC Press, USA, 2020.
2. Green and Smart Technologies for Smart Cities, Pradeep Tomar, and Gurjit Kaur, CRC Press, USA, 2019.

Reference Books:

1. Handbook of Green Chemistry and Technology, Clark, J.H., and Macquarrie, D.J., John Wiley and Sons, USA, 2002.
2. Green Chemistry: Theory and Practice, Paul Anastas, and John Warner, Oxford University Press, USA, 2000.
3. Green Chemistry- An introductory Text, Mike Lancaster, Royal Society of Chemistry, UK, 2016, 3rd Edition.

Online resources:

1. https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-ch26/
2. https://nptel.ac.in/courses/103/107/103107125/

BT5116	Biotechnology for Waste Management	3-0-0: 3

Pre-requisites: None

Course Outcomes:

CO1	Identify salient aspects of biological processes for waste management.
CO2	Design of bioreactors for waste treatment.
CO3	Apply principles of bioremediation for handling waste.
CO4	Develop suitable biotechnological processes for hazardous waste management.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to waste management. Introduction to bioreactor, Microbial growth kinetics, Design of a bioreactors, Instrumentation and control, Aeration and agitation, Effluent treatment. Bio-industrial waste management. Strategies for sustainable waste management.

Bioreactors for wastewater treatment: – Aerobic System Biological processes for domestic and industrial wastewater treatments; Aerobic systems - activated sludge process, trickling filters, biological filters, rotating biological contractors (RBC), Fluidized bed reactor (FBR), expanded bed reactor, inverse fluidized bed biofilm reactor (IFBBR) packed bed reactors air-sparged reactors.

Bioremediation:- The characterization and bioremediation of contaminated sites, the superfund law, preliminary site assessment, site investigation techniques, and bioremediation technologies; and monitoring requirements. In-situ Bioremediation of Contaminated Ground Water; Phytoremediation of Contaminated Soil and Ground Water at Hazardous Waste Sites

Hazardous Waste Management: Introduction - Xenobiotic compounds, recalcitrance. Hazardous wastes - biodegradation of Xenobiotics. Biological detoxification - market for hazardous waste management, biotechnology application to hazardous waste management. Introduction to Solid, Hazardous, and Radioactive Waste Disposal and Containment. Design of Landfill, Municipal Solid Waste Landfills.

Learning Resources:

Text Books:

1. Introduction to Hazardous Waste Management, Clifton Vanguilder, Mercury Learning & Information 2011, 1st Edition.
2. Microbial biodegradation and bioremediation, Surajit Das, Elsevier, 2014, 1st Edition.

Reference Books:

1. Wastewater Engineering Treatment and Reuse, Metcalf & Eddy, McGraw Hill Inc, India, 2017, 4th Edition.
2. Environmental biotechnology: principles and applications. Rittmann, B. E., & McCarty, P. L., Tata McGraw-Hill Education, 2020, 2nd Edition.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc21_bt41/preview
2. https://onlinecourses.nptel.ac.in/noc19_ce32/preview

CE5861	OPERATION RESEARCH	3 – 0 – 0

Pre-requisites: None

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

CO1	Formulate and solve deterministic optimization models
CO2	Apply deterministic optimization techniques for resource allocation, scheduling, inventory control
CO3	Apply decision theory and stochastic optimization techniques for decision making under uncertainty
CO4	Formulate and solve optimization models for planning and design of waste management systems

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus

Modeling Techniques: Concepts of Systems Engineering, Types of mathematical models, Formulation of a prescriptive model, Overview of optimization techniques

Linear Programming, Graphical method, Simplex method, Sensitivity analysis, Dual LP, Transportation problem, Assignment problem, Integer Linear Programming

Dynamic Programming: Concepts of dynamic programming, Formulation of recursive equation, Resource allocation using DP, Capacity expansion, Inventory control

Nonlinear Optimization, Classical optimization techniques, Lagrange methods, Kuhn-Tucker conditions, steepest gradient technique and other gradient based search techniques, Overview of genetic algorithm

Decision Theory: Decision analysis, Decision making under risk and uncertainty, Markovian decision process, stochastic inventory control

Simulation: Types of simulation models, Monte-Carlo simulation, Applications of simulation

Other Optimization Techniques, Overview of Multi Objective Optimization Techniques, Fuzzy Optimization and Fuzzy Decision Making, New algorithms.

Learning Resources:

Text Books:

1. *Operations Research,*Taha, H. A. (2017), , 10th Ed, Pearson Higher Education, USA.
2. *Introduction to Operations Research,* Hiller, F. S., Lieberman, G. J., Nag, B., Basu, P., (2017), , McGraw Hill Publications, USA.

Reference books:

1. *Civil and Environmental Systems Engineering,* Revelle, C.S., Whitlatch, E.E., and Wright, J.R. (2013), , Pearson Education Inc., USA.

2. *Introduction to Operations Research Techniques,*Daellenbach, H. G. and George, J. A. (1978), ,Allyn and Bacon Inc., Boston.
3. *Introduction to Operations Research – A Computer Oriented Algorithmic Approach,*Gillett, B. E. (1989), , Tata McGraw Hill Publishers, India.

Online Resources:

1. https://nptel.ac.in/courses/111/107/111107128/

CE5866	LANDFILL DESIGN AND OPERATION	3– 0 – 0

Pre-requisites: None

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

CO1	Identify salient aspects of landfills
CO2	Suggest suitable site and configuration for landfills
CO3	Plan and design the major components of landfill as per regulatory standards
CO4	Operate and monitor landfills

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus

Introduction: Landfill principle, Landfill classification, types and methods, Landfill's role in sustainable waste management, Waste and landfill fundamentals.

Siting and regulatory requirements: Size of the landfill, Traffic and Access, Site-specific Information, Site Hydrology, Permits, Other Regulatory Issues, Additional Regulatory Requirements for Bioreactor Landfills and secured Landfill

Typical landfill configurations: Cell Layout, Water Table, Aquifers, and Bedrock, Landfill foundation and slope stability, Site development plan

Key aspects of design and construction: Preparation of landfill sub-base, Liner design, Leachate management, Landfill gas management, daily, intermediate and final cover design, Stormwater management, Bioreactor landfill design, Secured landfill design, Landfill Construction

Landfill operation: Waste acceptance at landfills, Waste filling and compaction, Bioreactor Landfill Operations, Tools and Techniques for Landfill Monitoring, Gas collection and utilisation.

Post-construction monitoring: Leachate monitoring and leakage detection, Groundwater monitoring, Landfill gas migration, Stability of the final cover

Landfill Closure and Post Closure: Elements of closure and Post-closure process, Closure considerations for sustainable landfills, Determination of End of post-closure care, Landfill reclamation and reuse, Final site use and configuration

Learning Resources:

Text Books:

1. Sustainable Practices for Landfill Design and Operation,Townsend, T.G., Powell, J., Jain, P., Xu, Q., Tolaymat, T., and Reinhart, D. (2015), Springer, USA.
2. Integrated Solid Waste Management, Engineering Principles and Management Issues,Tchobanoglous G., Theisen H., and Vigil S.A. (2014)., 2nd Ed., McGraw-Hill, USA.

Reference Books:

1. Waste Management Practices: Municipal, Hazardous and Industrial,John Pichtel (2014)., 2nd Ed., CRC Press, USA
2. Geotechnical Aspects of Landfill Design and Construction,Qian X., Koerner R.M., and Gray D.H., (2002)., 1st Ed., Prentice Hall, USA.
3. Manual on Municipal Solid Waste Management,CPHEEO,(2016)., Ministry of Urban Development, India.

Online Resources:

1. https://nptel.ac.in/content/storage2/courses/105106052/downloads/Lecture-40.pdf
2. https://nptel.ac.in/content/storage2/courses/105103025/pdf/pdf3.pdf
3. https://www.epa.gov/landfills/basic-information-about-landfills
4. http://cpheeo.gov.in/upload/uploadfiles/files/annex17.pdf

BT 5174	APPLIED ENVIRONMENTAL MICROBIOLOGY	3-0-0: 3

Pre-requisites: None

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

CO1	Describe environmental challenges by developing a fundamental understanding of the microbial communities and processes in natural and built environments.
CO2	Predict the effect of environmental parameters and operational factors on performance.
CO3	Understand the role of microbes in biological processes in different ecosystems.
CO4	Explain the microbial ecosystem and role of mix culture microbes in the biological wastewater treatment process.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction; cell elements and composition Cell and its composition, cytoplasmic membrane Prokaryotic cell division Microbes and their environmental niches Historical roots of microbiology Nucleic acids and amino acids DNA structure, replication, and manipulation Protein and its structure Regulation Microbial nutrition Microscopy: Light microscopy, 3D Imaging, AFM, Confocal scanning laser microscopy.

Microbial energetics and diversity Stoichiometry and bioenergetics Oxidation-reduction NAD, energy-rich compounds and energy storage Mathematics of microbial growth Glycolysis Respiration Citric-acid cycle Catabolic Alternatives Phototrophy, Chemolithotrophy, anaerobic respiration (Nitrate and Sulfate reduction; Acetogenesis; Methanogenesis; Metal, Chlorate, and organic electron acceptors)

Microbial metabolism and functional diversity of bacteria Prokaryotic diversity Classical taxonomy Origin of life Tree of life Major catabolic pathways Catalysis and enzymes Energy conservation Sugars and polysaccharides, amino acids, nucleotides, lipids

Microbial ecosystems Population, guilds, and communities Environments and microenvironments Microbial growth on surfaces Environmental effects on microbial growth Environmental genomics and microbial ecology; genetic exchange Environmental genomics Microbial ecology Horizontal and vertical gene transfer: Replication, Transformation Transduction

Bioremediation and wastewater microbiology, Bioremediation and examples, Acid mine drainage, Enhanced metal recovery, Wastewater microbiology

Drinking water microbiology, drinking water microbiome and treatment, Microbial instability, Water borne microbial diseases

Solid waste microbiology and antimicrobial resistance, Landfills, Leachate, Anaerobic degradation phases, Antimicrobial resistance

Learning Resources:

Text Books:

1. Environmental Microbiology, Ian L. Pepper, Charles P. Gerba and Terry J Gentry, Academic Press, 2014, 1st Edition.
2. Environmental Microbiology, Ralph Mitchell, Ji-Dong Gu, Wiley-Blackwell, 2010, 2nd Edition.

Reference Books:

1. Environmental Biotechnology: Principles and Applications, Bruce E. Rittmann, and Perry L. McCarty, McGraw-Hill, 2017, 2nd Edition.
2. Brock Biology of Microorganisms, Madigan, M, Bender K. S, Buckley D.H, Sattley W. M, and Stahl D.A. Brock, Pearson, 2020, 16th Edition.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc21_ce07/preview
2. https://nptel.ac.in/courses/105/107/105107173/

SM 5051	Operations and Maintenance	3-0-0: 3

Pre-requisites: None

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

CO1	Interpret the operations involved in waste management methods and techniques.
CO2	Examine the government regulations and initiatives in waste maintenance.
CO3	Explain the importance of hygiene and safety in waste management.
CO4	Identify various operational maintenance issues of waste management and its solutions.

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Concepts and Principles: Fundamental principles, operating strategy, responsibilities of waste generators, responsibilities of the municipality, NGOs, municipal collection of solid wastes and special wastes, political will, community mobilization, resolving bottlenecks, addressing environmental hygiene and safety.

Transportation: Waste **c**ollection routes, mode of transportations, vehicles used for collecting waste, economy in transportation, waste optimization of transport routes, routing and scheduling, Replacing, repairing, track recording of vehicles, machinery, safety of transport workers. Maintenance of vehicles.

Waste Processing: Operation and maintenance of waste transfer stations: role of transfer stations, transfer station design, site design plan, transfer technology, transfer station operations, operations and maintenance plans, facility operating hours, interacting with the public, waste screening. Emergency situations, record keeping. Environmental issues, safety issues.

Society: Role of community landfill site, daily operations, access control, control of windblown debris, control of fire. Release to the receiving environment, troubleshooting and resolving safety, service, and operational issues maintain and distribute waste management related information on a daily basis. Waste management equipment, life cycles.

Learning Resources:

Text Books:

1. Management of Municipal Solid Waste, Central Pollution Control Board., (2004)., Ministry of Environment and Forests, New Delhi, India

Reference Books:

1. Waste transfer Stations (2002). A Manual for Decision Making, EPA, United States environmental protection agency.

Online Resources:

1. https://nptel.ac.in/courses/105/103/105103205/
2. https://nptel.ac.in/courses/105/106/105106056/

SM5031	MARKETING MANAGEMENT FOR WASTE	3 – 0 – 0

Pre-requisites: None

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

CO1	Assimilate the concepts and issues of waste marketing
CO2	Apply contemporary marketing theories to the demands of business
CO3	Demonstrate the ability to analyze marketing problems and opportunities using a variety of strategies and tactics
CO4	Interpret the importance of integrated marketing communication and its elements

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Introduction to Marketing Management, Core Concepts of Marketing, Marketing Orientations, Meaning and definition of Solid Waste Markets, Issues in Waste Marketing

Marketing Environment, Marketing Research, Marketing Mix, Marketing Strategy: evolving Waste Marketing Strategy

Product Life Cycle, Pricing of the Product / Service, Pricing Strategies, Determinants of Price, Branding the product, Product features, Types or levels of products, Value creation in product, Value chain analysis, Waste recycling options.

Consumer Behaviour, Segmentation, Targeting and Positioning, Solid Waste Distribution systems, Channels of distribution

Sales teams and targets, Integrated Marketing communications, Role of Social Media, Promotion mix elements, Role of contemporary modes of marketing communications, CRM and International Marketing.

Learning Resources:

Text Books:

1. Marketing Management,Kotler, P., Keller, K.L., (2011)., 14th Ed, Pearson, USA.

Reference Books:

1. Principles of Marketing, Philip T. Kotler, Gary Armstrong, PrafullaAgnihotri, (2018), Pearson Education, USA.
2. Marketing Management, Ramaswamy and Namakumari,(2018), Sage Publishing,USA.

Online Resources:

1. https://nptel.ac.in/courses/120/108/120108005/
2. https://nptel.ac.in/courses/105/105/105105160/

CH 5168	ADVANCED PHYSICOCHEMICAL TREATMENT TECHNOLOGIES	3–0–0:3

Pre-requisites: None

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

CO1	Assimilate the principles of advanced physico-chemical processes
CO2	Apply ozonation for sludge management
CO3	Apply electrochemical technologies for wastewater treatment
CO4	Employ sonochemistry for pollutant removal

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Pressurized Ozonation: Oxyozosynthesis Sludge Management System, Oxyozosynthesis Wastewater Reclamation System**:** Ozonation and Oxygenation Process. Continuous oxygenation–ozonation, Noncontinuous oxygenation–ozonation. Formation and generation of ozone by various methods.

Requirements for ozonation equipment: Feed Gas Equipment, ozone generators and ozone contactors. In-line contactor for water treatment, Film layer purifying chamber (FLPC) contactor for water treatment, Multicompartment turbine ozone contactor. Diffuser ozone contactor properties of ozone, hyperbaric reactor vessel. Diffuser contactor for water and wastewater treatment. Properties of Ozone.

Oxygen generation systems: The traditional cryogenic air separation (CAS), The pressure-swing adsorption (PSA). CAS system for oxygen production, PSA system for oxygen production, Ozonation Systems, Removal of Pollutants from Waste by Ozonation. Particle Removal Processes. Economical Aspects of Ozonation. Application of Ozone in Combined Processes.

Electrochemical Wastewater Treatment Processes: Reactors for metal recovery,rotating cylinder electrode. Fluidized bed reactor, tumbling bed electrodes. Fixed bed reactor, Design of a Reno cell. Electrode Materials, Application Areas.

Electrocoagulation: Basic concepts and theory of coagulation and flocculation with hydrolyzing metal salts. Reactions in electrofloculation, Effect of Charge Loading, NaCl, pH Effect, Temperature, and Power Supply. Comparison of electrocoagulation and chemical coagulation.

Electroflotation: Electrocoagulation unit with cylindrical electrodes, Effect of pH, Temperature, Alternative electrode arrangement for electroflotation. A typical electro flotation unit design. Applications.

Electro-oxidation: Indirect EO Processes, Direct Anodic Oxidation, Typical Designs.

Ultrasound-assisted electrochemical treatment - of wastewaters: Principles of sonochemistry. Sonochemical destruction methods of organic pollutants. Sonoelectrochemical degradation.

Sewage sludge electro-dewatering - Sludge conditioning, Mechanical dewatering processes, Electro-dewatering process.

Learning Resources:

Text Books:

1. Advanced Physicochemical Treatment Technologies, Lawrence K. Yung-Tse Hung, Nazih K. Shammas, Humana Press, New Jersey, 2007.

Reference Books:

1. Zonation of Drinking Water and of Wastewater, Christiane Gottschalk, Judy Ann Libra, Adrian Saupe, Wiley-VCH, 2000.
2. Advanced water treatment electrochemical methods, Sillanpaa, Mika, Elsevier, 2020.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc19_ce32/preview

CH 5169	ENERGY AUDIT AND CONSERVATION	3-0-0: 3

Pre-requisites: None

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

CO1	Implement energy audit for a process plant
CO2	Plan energy conservation strategies
CO3	Evaluate the suitability of renewable energy resources
CO4	Analyze the energy utilization of a process equipment

Course Articulation Matrix:

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

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Energy Scenario: Energy use patterns, energy resources, Oil - a critical resource, economic and environmental consideration, Future scenario.

Heat & work: First & second law of thermodynamics, Heat Engines.

Energy Audit: Energy conversion, Energy index, Energy consumption representation - pie chart, Sankey diagram & load profile, general audit, detailed audit, waste heat recovery.

Targeting and Conservation: Energy utilization and conversion – thermal efficiency, Heat Exchangers – heat recovery, Air conditioners – supply and removal of heat.

Use of alternate energy: Solar energy, Wind energy, Nuclear energy, Biomass, Geothermal energy, Future Energy Alternatives.

Pinch Analysis and Process Heat Integration, Energy Management, Key Performance Indicators and Energy Dashboards Case Studies: Energy conservation in alcohol industry, fertilizer industry, and pulp and paper industry, Energy conservation in different units of refinery like FCCU, HCU and ADU.

Learning Resources:

Text Books:

1. Energy Management, Murphy W.R. and Mckay G., Elsevier, 2007.
2. Energy: Its Use and the Environment, Hinrichs R. A. and Kleinbach M. H., Cengage Learning, 2012.
3. Guide to Energy Management, Capehart B. L., Turner W. C. and Kennedy W. J., Keinnedu Fairmant press, 2011, 7th Edition.

Reference Books:

1. Non-conventional Energy Sources, Rai G. D., Khanna Publishers, New Delhi, 2010.
2. Energy Management and Efficiency for the process industries, A.P Rossiter, B.P Jones, AIChE, Wiley, 2015.

Online Resources:

1. https://nptel.ac.in/courses/112/105/112105221/ (Energy conservation and waste heat recovery, Prof. Prasanta Kumar Das, Prof. A Bhattacharya, IIT Kharagpur)

CE5848	Seminar – I	0 – 0 – 2:1

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Identify and chose appropriate topic of relevance.
CO2	Assimilate literature on technical articles.
CO3	Write technical report.
CO4	Design and develop presentation on a given technical topic.
CO5	Deliver technical presentation on a specified topic.

Course Articulation Matrix:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	*3*	*2*		*1*		
CO2	*3*	*2*		*2*		
CO3	*2*	*3*		*2*		
CO4	*2*	*2*		*2*		
CO5	*2*	*3*		*2*		

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

There is no specific syllabus for this course. However, student can choose any topic, of his choice, pertaining to Transportation Engineering. Topic should be a relevant and currently researched one. Students are advised to refer articles published in current journals in the area of Waste Management for choosing their seminar topics. Student should review minimum of 5 to 6 research papers relevant to the topic chosen, in addition to standard textbooks, handbooks, etc. Students are required to prepare a seminar report, in the standard format and give presentation to the Seminar Assessment Committee (SAC) in the presence of their classmates. It is mandatory for all the students to attend the presentations of their classmates.

Learning Resources:

Text Books:

Reference Books:

1. Research Articles / Reports available on Internet
2. Journals
3. Textbooks and Handbooks

Online Resources:

1. Guidelines for the Preparation and Delivery of a Seminar Presentation: http://www2.cs.uregina.ca/~hilder/cs499-900/Presentation%20Guidelines.pdf
2. Guidelines on Seminar Presentation:http://foodsci.rutgers.edu/gsa/SeminarGaudelines.pdf
3. http://onlinepubs.trb.org/onlinepubs/circulars/ec194.pdf
4. Instructor Resources: Seminar Proposal Guidelines, SAE International; http://www.sae.org/training/seminars/instructorzone/proposalguidelines.pdf

CE5898	Seminar – II	0 – 0 – 2:1

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Identify and chose appropriate topic of relevance.
CO2	Assimilate literature on technical articles.
CO3	Write technical report.
CO4	*Design and develop presentation on a given technical topic.*
CO5	*Deliver technical presentation on a specified topic.*

Course Articulation Matrix:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	*3*	*2*		*1*		
CO2	*3*	*2*		*2*		
CO3	*2*	*3*		*2*		
CO4	*2*	*2*		*2*		
CO5	*2*	*3*		*2*		

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

There is no specific syllabus for this course. However, student can choose any topic, of his choice, pertaining to Transportation Engineering. Topic should be a relevant and currently researched one. Students are advised to refer articles published in current journals in the area of Waste Management for choosing their seminar topics. Student should review minimum of 5 to 6 research papers relevant to the topic chosen, in addition to standard textbooks, handbooks, etc. Students are required to prepare a seminar report, in the standard format and give presentation to the Seminar Assessment Committee (SAC) in the presence of their classmates. It is mandatory for all the students to attend the presentations of their classmates.

Learning Resources:

Text Books:

Reference Books:

1. Research Articles / Reports available on Internet
2. Journals
3. Textbooks and Handbooks

Online Resources:

1. Guidelines for the Preparation and Delivery of a Seminar Presentation: http://www2.cs.uregina.ca/~hilder/cs499-900/Presentation%20Guidelines.pdf
2. Guidelines on Seminar Presentation:http://foodsci.rutgers.edu/gsa/SeminarGaudelines.pdf
3. http://onlinepubs.trb.org/onlinepubs/circulars/ec194.pdf
4. Instructor Resources: Seminar Proposal Guidelines, SAE International; http://www.sae.org/training/seminars/instructorzone/proposalguidelines.pdf

CE6847	Comprehensive Viva	0 – 0 – 0:2

Pre-requisites: Both I & II Semester course work of I Year should be completed.

Course Outcomes:

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

CO1	Assimilate knowledge of different courses studied.
CO2	Develop overall comprehension about Transportation Engineering.
CO3	Analyse real life transportation problems with theoretical knowledge learned.
CO4	Interpret and Articulate solutions to real life transportation problems.

Course Articulation Matrix:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	*2*	*2*	*2*			*1*
CO2	*2*	*2*	*2*			*1*
CO3	*2*	*3*	*2*			*2*
CO4	*1*	*2*	*3*			*1*

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

Entire course of study (All the required courses studied) up to II Semester of I Year.

Learning Resources:

Text Books:

1. Reading Material of all the courses.

Reference Books:

1. Case Studies / Consultancy Reports.

Online Resources:

CE6849	Dissertation Part – A	0 – 0 – 0:12

Pre-Requisites: Both I & II Semester course work of I Year should be completed.

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

CO1	Appraise Research Problem Statement.
CO2	Evaluate literature critically in chosen area of research & establish Scope of work.
CO3	Develop Study Methodology.
CO4	Plan and carryout pilot study.

Course Articulation Matrix:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1			*1*	*3*		*3*
CO2			*1*	*3*		*3*
CO3	*2*	*2*	*2*	*3*		*3*
CO4	*3*	*3*	*1*	*3*		*3*

Note: 1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

There is no prescribed syllabus. 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/her 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.

Learning Resources:

Text Books:

1. Writing Your Dissertation, Derek Swetnam, Oxford, UK, 2004, Third Edition.

Reference Books:

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

Online Resources:

CE6899	Dissertation Part – B	0 – 0 – 0: 20

Pre-requisites:

1. Both I & II Semester course work of I Year should be completed.
2. CE6849: Dissertation Part A

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

CO1	Appraise Research Problem Statement.
CO2	Evaluate literature critically in chosen area of research & Establish Scope of work.
CO3	Formulate Study Methodology.
CO4	Compile data base with appropriate field studies/laboratory tests.
CO5	Develop appropriate models and discuss solutions.

Course Articulation Matrix:

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

1: Slightly; 2: Moderately; 3: Substantially

Syllabus:

There is no prescribed syllabus. 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/her 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.

Learning Resources:

Text Books:

1. Writing Your Dissertation, Derek Swetnam, Oxford, UK, 2004, Third Edition.

Reference Books:

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

Online Resources:

NOTE: Refer to the following link for the guidelines to prepare dissertation report:
https://www.nitw.ac.in/main/PGForms/NITW/