5th Semester

Syllabus

Course Title: Water Treatment and Supply Engineering	***Course Code: 20EV510***
Credits: 4	***Total Contact Hours (L:T:P): 52:0:0***
Type of Course: Theory	***Category: Professional core course***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Fluid mechanics

Course Objectives

The student acquires mastery in computing population and water demand, describes types of water supply schemes, water quality parameters and standards. Provides the knowledge on the principles, design of unit operations and processes in water distribution system. Exposes to the recent trends in water treatment and supply system.

Course Outcomes: After completing this course, students should be able to:

CO1:	Understand water quality standards and parameters and solve numerical problems related to population forecasting and basics of unit operations and processes
CO2:	Analyze the flow schemes, water demand calculation, peak factor, materials of pipes, and selection of pumps, water intake structures and pipe hydraulics.
CO3:	Design the various treatment units for water supply scheme.
CO4:	Gain an in-depth knowledge of water supply network system, quality aspects in distribution network small network through simple numerical problems and importance of use of appurtenances.
CO5:	Understands the need for advanced water treatment with automation in treatment, water economics and patented material.

Unit No.	Course Content	No. of Hours
1	**Introduction** Water Sources, need for water supply, schemes - types and objectives. Drinking water quality parameters, guidelines and standards – International, national, regional and local. Population forecasting methods, Selection of appropriate method and numerical problems. Rate of water supplies for urban and rural systems. Unit operations and processes, treatment flow-diagrams for different sources of water. Water supply norms.	**08**
2	**Pipe hydraulics** Water demand, design period, peak factor. Water Intakes- types and design aspects. Pipes and pipe materials, Pumps and pumping station. Hazen-William equation, Manning's equation, Cole Brooke-White equation, Darcy Weisbach equation Rising main economics, Hydraulic transients - numerical problems.	**12**

3	**Water treatment design** Design principles and criteria: aeration, Parshall flume, flash mixer, coagulation – flocculation systems, types of settling, sedimentation, tube settlers, pulsators, filtration, disinfection processes – numerical problems. Cross flow systems, Green flocculants. Miscellaneous treatment- Removal of hardness, fluoride, nitrate, arsenic, selenium and boron.	**14**
4	**Water supply and distribution** Appurtenances for collection and conveyance, gravity and pressure flows. Service reservoirs and service connection (ferrule). Selection of materials for water supply schemes. Distribution system - types. Hardy- cross and Newton-Raphson methods of pipe network analysis - Simple problems Intermittent residual chlorine boosting in the water distribution system, water quality in distribution system with special reference to bio films, Corrosion-prevention and control.	**10**
5	**Recent trends** Advanced water treatment, Automation in Water Supply and Smart Water Supply Systems, Package treatment units, implications of 24x7 supply, Water Economics & Pricing and application of nano materials package treatment units. Alum recovery in filter backwash. New underflow designs in filtration systems.	**08**

Text books

1. Howard S. Peavy, Donald R. Rowe, George T, (2015), "Environmental Engineering" - McGraw Hill International Edition. New York.
2. David Hendricks, (2010), "Fundamentals of Water Treatment Unit Processes": Physical, Chemical, and Biological, CRC Press.
3. Edward M. Motley, Guang Zhu, Syed R. Qasim, (2000), "Water Works Engineering": Planning, Design and Operation‖, Prentice Hall.
4. Viessman W, Hammer M. J., Perez E.M., Chandik P. A., (2011), "Water supply and pollution control" eighth edition, PHI Learning Private Ltd., New Delhi.
5. S. K. Garg, Environmental Engineering Vol.-I, (2019), "Water supply engineering" – M/s Khanna Publishers, New Delhi.
6. B. C. Punmia and Ashok Jain, (2010) "Environmental Engineering I-Water Supply Engineering" Laxmi Publications (P) Ltd., New Delhi.

Reference books

1. CPHEEO Manual on water supply and treatment engineering, Ministry of Urban Development, Government of India, New Delhi. (recent edition)
2. Mark. J Hammer, (2013), "Water & Wastewater Technology", John Wiley & Sons Inc., New York.

Course Outcomes	Program Outcomes												PSO's		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	2	2	2	3	3	3	2	2	2	1	1	2	2	3
CO2	3	3	3	3	3	2	3	2	1	1	1	1	3	3	3
CO3	3	3	3	3	3	3	3	2	1	1	1	1	3	3	3
CO4	3	3	3	3	3	3	3	2	1	1	1	1	3	3	3
CO5	3	3	3	3	3	3	3	3	1	1	3	3	3	3	2

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Atmospheric Environmental Engineering	*Course Code: 20EV520*
Credits : 4	*Total Contact Hours(L:T:P): 52:0:0*
Type of Course: Theory	*Category: Professional core course*
CIE Marks: 50	*SEE Marks: 100*

Pre-requisite: Elements of Environmental Engineering

Course Objectives

The course covers the air pollution sources, its classification, effects and measurement of air pollutants. The course emphasizes on air quality standards, meteorological parameters which influence dilution and dispersion of pollutants. The course highlights the need for understanding and applying various mathematical models to assess the fate and transport of pollutants, as well air and noise pollution control technologies and regulations.

Course Outcomes: After completing this course, students should be able to:

CO1:	Explain the composition and structure of atmosphere, classify the sources of air pollution and describe the types of emission inventory and need for source apportionment studies
CO2:	Discuss the influence of meteorological factors on dispersion of air pollutants and grasp the basics of modeling and stability class
CO3:	Analyze the plume behavior and describe various air pollution monitoring methods
CO4:	Paraphrase the effects of air pollution and remember the regulations governing air quality
CO5:	Explain the basic mechanisms involved, working principles and design aspects air and noise pollution control

Unit No.	Course Content	No. of Hours
1	**Introduction:** Composition and Structure of atmosphere, scales of air pollution – local, regional and global. Sources of air Pollutants: Natural and Anthropogenic, Units of measurements of air pollutants and conversions Classification of air Pollutants: Point, area, line source, volume primary and secondary pollutants, photochemical oxidants with examples. Emission inventory and source apportionment.	**10**
2	**Air Pollution Meteorology** Role of meteorology in air pollution. Meteorological factors – Solar radiation, temperature, lapse rate, wind velocity profile, humidity, precipitation, Maximum/ Mean mixing depths, atmospheric stability conditions, wind rose diagram. **Models:** Gaussian and box model Inversion – types, plume behavior under different atmospheric stability conditions, Pasquil – Gifford atmospheric stability classification. Effect of topography on pollutant dispersion, land/ sea breeze effects	**12**

3	**Atmospheric Dispersion of Stack Emissions** Plume rise, effective stack height, plume rise formulations, guidelines for fixing stack height, problems on plume rise calculations. **Measurement of Air Pollutants** Criteria for station selection, Measurement of various gaseous (CO, VOC, NOx, SO_x, etc) pollutants, particulate matter and microbial, sampling devices, sampling train, sampling methods/ techniques, stack sampling techniques. Indoor air quality and IAQ standards. Bio-aerosols.	**10**
4	**Effects of Air Pollution** Effect of air pollutants on human, plants and animals, materials and structure/ monuments. acid rain, wet deposition, greenhouse effect, global warming, ozone depletion, visibility reduction and haze formation Air Pollution, prevention and control Regulations Air pollution laws/ acts, air quality and emission standards, air pollution indices - determination of air pollution index by different methods.	**10**
5	**Air Pollution Control Equipment** General methods, control by process changes Particulate Matter Control – settling chambers, inertial separators, cyclones, fabric filters, scrubbers, wet collectors, and electrostatic precipitators, Numerical Problems Control of gaseous pollutants – adsorption, absorption, combustion and condensation. Noise pollution – Sources, effects, attenuation, governing equations and standards.	**10**

Text books

1. Wark, K. Warner, C. F. and Davis, W. T. (1981), "Air Pollution its Origin and Control", Harper& Row Publishers, New York.
2. Boubel, R. W., Donald, L. F, Turner, D. B. and Stern, A. C. (2006)," Fundamentals of Air Pollution" Academic Press, New York.

Reference books

1. Crawford, M. (1980), "Air pollution Control Theory", THM Edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
2. Noel De Nevers, (2000), "Air Pollution Control Engineering", International Edition. McGraw Hill International.

Course Outcomes	**Program Outcomes**												**PSO's**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	2	2	2	2	3	3	3	2	2	2	1	1	2	2	3
CO2	3	3	3	2	3	2	3	2	1	1	1	1	3	3	3
CO3	2	3	3	3	3	3	3	2	1	1	1	1	3	3	2
CO4	3	3	3	3	3	3	2	2	1	1	1	1	3	2	3
CO5	3	3	3	2	3	2	3	3	1	1	3	3	3	3	2

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Municipal and Bio-Medical Waste Management	***Course Code: 20EV530***
Credits: 4	***Total Contact Hours (L:T:P):39:13:0***
Type of Course: Theory	***Category: Professional core course***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Elements of Environmental Engineering-Sources and characterization

Course Objectives

The student will have a thorough understanding of key functional elements in municipal solid waste management including waste minimization concepts. The course also provides a comprehensive knowledge on biomedical waste management practices incorporating the role of private public partnerships.

Course Outcomes: After completing this course, students should be able to:

CO1:	Identify improper practices of solid waste disposal and their environmental implications. Understands the basic engineering principles of solid waste management.
CO2:	Understand the need for economics in collection and transportation of solid waste and clearly describes various types of collection systems and able to analyze system dynamics.
CO3:	Appreciate the management concepts, stresses on 4R approach, PPP model and community involvement for effective management of municipal solid and biomedical waste
CO4:	Develop a concise idea on various conventional and Advanced treatment options for both municipal and bio-medical waste
CO5:	Understand and apply the design aspects of engineered disposal options and apply the gained knowledge to solve numerical examples.

Unit No.	Course Content	No. of Hours
1	**Introduction:** Objectives, principles, functional elements of municipal solid waste (MSW) management system – major problems. Environmental implications of open dumping of MSW, MSW rules, C&D waste – management & handling. Engineering Principles: Waste projection along with population projection, waste generation rates, source segregation, frequency, storage and refuse collection, processing at source, physical and chemical composition, quantity of waste, engineering properties of MSW.	**7:3**
2	**Collection and Transport:** Access and point of collection, primary and secondary collection – economics. Equipment types, personnel, route - optimization, Solid Waste Transport Means and Methods, Separation and Processing: Unit operation for component separation, Material recovery facilities (MRF), 5R concepts for dry waste components	**9:3**

3	**Biomedical Wastes:** (BMW) Health care systems, sources, categories, generation and handling of BMW. Segregation, BMW (Management and Handling) Rules, Radio-active waste containment, Treatment methods, disposal options. Community based waste management, waste as a resource concept, public private partnership (PPP) in MSW and BMW management. Integrated Solid Waste Management (ISWM) – steps, hierarchy and components.	**9:3**
4	**Treatment Options for MSW:** Composting, vermi-composting, bio-gasification, thermal processing – combustion, incineration, pyrolysis, - types and design criteria, plasma technique. Centralized and decentralized treatment technologies-benefits. Aerobic and Anaerobic Digestion - definition, stages and factors affecting anaerobic digestion, Pretreatment and co-digestion for enhancement of biogas production.	**8:2**
5	**Disposal Options:** Engineered sanitary landfill design – regulatory criteria, gases and leachate control, leachate treatment technology, opportunity costs, siting considerations and design problems. Secured landfill facility (SLF) for centralized system.	**6:2**

Text books

1. Tchobanoglous G., Theisen H., and Vigil S., (2019), "Integrated Solid Waste Management – Engineering Principles and Management Issues", McGraw Hill Inc., New York.
2. Flintoff F., (1976), "Management of Solid Wastes in Developing Countries", WHO Regional Publications, South East Asia, New Delhi.
3. Peavy, H.S., Rowe, D.R., and Tchobanoglous, G., (2015), "Environmental Engineering", McGraw Hill Book Co.

Reference books

1. Sasikumar K. and Sanoop Gopi Krishna, (2009), "Solid Waste Management", Eastern Economy Edition, PHI, New Delhi
2. CPHEEO manual on Municipal Solid Waste Management (2016)
3. Bhide and Sundareshan, (1985), "Solid Waste Management in Developing Countries", UN publications.

Course Outcomes	Program Outcomes												PSO's		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	2	2	2	2	3	3	3	1	2	2	1	1	2	2	3
CO2	3	3	3	3	3	2	3	2	1	1	1	1	3	3	3
CO3	2	3	2	1	3	3	3	2	1	1	1	1	1	1	3
CO4	3	3	3	3	1	3	3	2	1	1	1	1	3	2	3
CO5	3	3	2	2	3	3	1	3	1	1	3	3	2	3	2

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Remote Sensing and GIS in Environmental Engineering	***Course Code: 20EV540***
Credits : 4	***Total Contact Hours: (L:T:P): 39:13:0***
Type of Course: Theory	***Category: Professional core course***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Engineering physics, Survey Engineering

Course Objectives

The student will have a thorough understanding on Remote Sensing and GIS applications in Environmental engineering.

Course Outcomes: After completing this course, students should be able to:

CO1:	Explain the fundamentals and principles of remote sensing (RS) and remote sensing systems including EM spectrum, resolutions and RS satellites.
CO2:	Discuss spatial data acquisition, compare manual interpretation and digital image processing
CO3:	Explain and illustrate with examples the importance and need of GIS in environmental resources management. Explain the concepts of co-ordinates and projection systems and differentiate between raster and vector data models.
CO4:	Identify sources of input data, explain possible errors in input data and their correction techniques, explain basic vector and raster spatial data analysis and their applicability
CO5:	Explain basics of Web GIS, plan and organize the input data for a given application, choose and perform appropriate spatial analysis, and assess the environmental implications of environmental related issues.

Unit No.	Course Content	No. of Hours
1	**Basics of Remote Sensing** Basic concepts of remote sensing, electromagnetic radiation – sources, spectrum and radiation laws, passive and active remote sensing, energy interactions - atmosphere and earth's surface features, spectral reflectance curves **Remote Sensing Systems** Ideal RS system, platforms and orbits, resolutions - spatial, spectral, radiometric, and temporal resolutions, multi-spectral RS, basics of thermal and hyper-spectral sensing, remote sensing satellites – features and applications	**12:2**
2	**Data Acquisition, Visual Image Interpretation and Digital Image Processing** Types of remotely sensed data products, Elements of visual image interpretation, Image processing - pre-processing, registration, enhancement, spatial filtering, transformation, classification, Concept of ground trothing. Cloud data analysis.	**7:3**

3	**Introduction to Geographical Information System (GIS)** Origin and importance of GIS, Maps – scale and elements, coordinate and projection systems, linkage of remote sensing to GIS **Data Models and Structures** Spatial data models – raster, vector; spatial and attribute data.	**6:2**
4	**Spatial Data Input and Editing** Methods of data input: keyboard, manual digitizing, scanning and automatic digitizing, GPS, data editing: sources and correction of errors, concept of topology. **Spatial Analysis** Raster and vector overlay analysis, terrain modelling, buffering and neighborhood function, basics of network analysis	**8:2**
5	**Introduction to Web GIS and hands-on to GIS software** **Applications of RS and GIS** Measurement, Monitoring, Mapping and Modelling applications in air, water, land system management (example with case studies - Watershed management, rainfall-runoff modelling, flood mapping, groundwater vulnerability modelling, optimal routing of solid wastes collection system of an urban area, environmental monitoring, environmental siting and zoning atlas development).	**6:4**

Text books

1. Lillesand, T. M., Kiefer, R. W., Chipman, J. W., (2017), "Remote Sensing and Image Interpretation", 5th Edition, John Wiley & Sons
2. Anji Reddy, (2019), "Text Book of Remote Sensing and Geographical Information Systems", 3rd Edition, B. S. Publications, Hyderabad
3. Burrough, P. A., and McDonnell, R. A., (2015), "Principles of Geographical Information Systems", 2nd Edition, Oxford University Press.

Reference books

1. Longley, P. A., Goodchild, M. F., Maguire, D. J., and Rhind, D. W., (2011), "Geographical Information Systems: Principles, Techniques, Management and Applications", 2nd Edition, John Wiley & Sons.
2. Michael N. Demas, (2000), "Fundamentals of GIS" John Wiley and Sons. Inc.

Course Outcomes	Program Outcomes												PSO's		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	1	1	1	2	2	2	2	1	1	1	2	2	1	1
CO2	3	2	3	2	2	2	2	2	1	2	1	3	3	2	2
CO3	3	1	1	1	2	2	2	2	1	1	1	2	2	1	1
CO4	3	2	3	2	2	2	2	2	1	2	1	3	3	2	2
CO5	3	3	2	2	2	3	2	2	2	2	2	3	3	3	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Energy and Environment	***Course Code: 20EV551***
Credits: 03	***Total Contact Hours (L:T:P): 39:0:0***
Type of Course: Theory	***Category: Professional Elective Course -1***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Elements of Electrical Engineering, Elements of Environmental Engineering

Course Objectives

The course imparts knowledge on different types of energy sources, energy scenario, alternative energy resources and associated environmental impacts.

Course Outcomes: After completing this course, students should be able to:

CO1:	The student will have a thorough understanding and ability to recognize environmental resources, energy necessity and energy crisis. Have the ability to distinguish between renewable and non-renewable energy.
CO2:	The student will learn thoroughly hydroelectric and tidal energy production along with their impacts on environment.
CO3:	The student appreciates the necessity and implications of solar and wind energy in the present context and develops know-how of energy production.
CO4:	Imbibes the basic knowledge on geothermal and nuclear energy aspects and will be able to assess the environmental effects.
CO5:	Acquires knowledge on the availability, uses and generation of natural and biogas as energy supplements and will be able to identify appropriate methods for societal use and current knowledge on hybrid systems.

Unit No.	Course Content	No. of Hours
1	**Introduction to Energy Sources**: Global Energy- policy factors for sustainable energy systems. Indian Energy Scenario: Energy Consumption, needs and crisis. **Biomass:** Introduction; First, second and third generation feed stock and related technologies. Biomass conversion technologies - wet and dry processes – implication on economics	**07**
2	**Hydropower:** Site selection for hydroelectric power plants, classification, Mechanism of hydro energy production, Components and classification of hydro power plants. **Tidal Energy:** Tides and waves as source of renewable energy, Tides and tidal energy production, World and Indian tidal energy scenario, OTEC (Ocean Thermal Electric Conversion).	**07**

3	**Solar Energy:** Solar constants, physical principles of conversion. Concentrators - associated Environmental impacts, Solar energy economics – Photo Voltaic Cell calculation, financing – subsidy policies, and regulations. Solar vehicles and economic and environmental implications. **Wind Energy:** basic principles, components of wind energy conversion system. Energy production from wind, Wind energy computation.	**08**
4	**Geo-thermal Energy:** Geo-thermal sources, uses, types and arrangement for hybrid plants **Nuclear Energy:** reactor mechanism. Breeding reactors, types of nuclear waste and disposal, environmental impacts. **Natural gas:** Res**ource**s, composition, classification and comparison of different gas turbine power plants and environmental impacts. Co-generation and tri-generation, waste to energy approaches - incineration, pyrolysis and gasification. **Energy Audit** - Purpose, methodological approaches. Audit methods employed in energy intensive industries.	**10**
5	**Recent Trends**: Hybrid energy system, Energy from biomass wastes, energy forecasting tool (LEAP) Alternative Energy in Transport – fuels, electric vehicles. Green initiatives. Fuel cells: Types, fuel processing, design concepts, Characterization and durability of fuel cells. Hydrogen as fuel from water – hazard analysis. Energy storage systems - Thermal energy storage systems. Energy savings. Smart grids. Pump storage schemes.	**07**

Text books

1. Mathur, A. N., and Rathore, N. S., (1990), "Renewable Energy and Environment", Proceedings of the National Solar Energy, Himansu Publications, Udaipur.
2. Rao and Parulekar B. B., (1977), "Energy Technology – Non-conventional, Renewable and Conventional", 2nd edition, Khanna Publishers.
3. Robert A. Ristinen, Jack P.Kraushaar, (2006). "Energy and the Environment"
4. Reza Toossi., (2008). Energy and the Environment: Sources, Technologies, and Impacts.
5. De, B. K., (2017). Energy Management audit & Conservation, 2nd Edition, Vrinda Publication.

Reference books

1. Saha, H., Saha, S.K., and Mukherjee, M.K., (1990), "Integrated Renewable Energy for Rural Development", Proceedings of the National Solar Energy Convention, Calcutta, India.
2. The Energy Research Institute (TERI), New Delhi, Publications. Ministry of Environment and Forests, Government of India, Annual Reports.
3. Turner, W. C., Doty, S. and Truner, W. C., (2012). Energy Management Hand book, 7th edition, Fairmont Press.
4. Murphy, W. R., (2016). Energy Management, Elsevier.
5. Smith, C. B., (2016). Energy Management Principles, Pergamum.

Course Outcomes	Program Outcomes												PSO's		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	3	3	2	2	2	1	1	3	2	3
CO2	1	3	3	3	3	2	1	2	1	1	1	1	3	3	2
CO3	3	1	3	3	1	3	3	2	1	1	1	1	2	1	3
CO4	3	3	3	1	3	3	3	2	1	1	1	1	3	3	3
CO5	1	3	3	3	3	2	1	3	1	1	3	3	3	3	2

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Computer Applications in Environmental Engineering	***Course Code: 20EV552***
Credits: 3	***Total Contact Hours (L:T:P): 39:0:0***
Type of Course: Theory	***Category: Professional Elective Course- 1***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Introduction to Programming

Course Objectives

This unique course lays a strong foundation for the students to appreciate, understand and develop theoretical knowledge related to computer programme writing skills for a variety of environmental engineering applications and stresses the need for CAD and analysis.

Course Outcomes: After completing this course, students should be able to:

CO1:	Outlines and writes programmers related to population forecasting and water supply and treatment system design
CO2:	Ability to develop skill of writing programmers for wastewater collection and treatment units design and understands Streeter-Phelps and other water quality prediction models
CO3:	Gains knowledge to perform exercises related to predicting ground level air pollutant concentrations, effective stack height calculation and design of particulate matter control units through C programming language
CO4:	Acquires theoretical base on CAD, computer graphics and DBMS and their applications in the field of environmental engineering
CO5:	Have an exposure to various software's related to water and air quality prediction, design of water supply system, sewerage system and air pollution control systems.

Unit No.	Course Content	No. of Hours
1	**Introduction to programming and coding basic programs** Flow Sheets and 'C' program for Population Forecasting: Arithmetic Increase Method, Geometric Increase Method and Incremental Increase Method. Flow Sheets and 'C' program for Water Supply and Treatment: Rising main design, Pumping unit, Water treatment units design — Cascade aerator, plain sedimentation tank, clariflocculator tank, filters (rapid and slow sand)	**08**
2	**Flow Sheets and 'C' program for Wastewater Treatment Units:** Screen and Grit chamber, Primary settling tank, Aeration tank and Secondary settling tank of ASP, Trickling filter unit, Sludge drying beds and Septic tank.	**08**

3	Flow Sheets and 'C' program for surface water quality models: discharge of conservative and non-conservative pollutants in rivers, DO models for rivers (Streeter- Phelps equation). Flow Sheets and 'C' program for Air Quality models: Effective stack height, Gaussian Plume Model for gaseous and particulate dispersion from point sources, Settling chamber for particulate removal.	**08**
4	**CAD:** Introduction to CAD and its application to Environmental Engineering; Introduction to Database Management System (DBMS) **Computer Graphics** – Applications. Introduction to the concepts of Fuzzy logic. Artificial Neural Networks, Data mining, statistical analysis, MATLAB for environmental data	**07**
5	**Introduction to Application Software's** - RMAIN, WATPLANT, DOWATTS, LOOP,QUALOOP, EPANET, SEWER, STREAM, ISCST/LT, CALINE, MIXING ZONE MODELS, SWMM (storm water management model).	**08**

Text books

1. Krishna Murthy, C. S., and Rajeev, S., (1998), "Computer Aided Design software and
2. Analytical Tools, (2012) – Norosa Publishing House.
3. Sincero, A. P., and Sincero, G. A., (2014), "Environmental Engineering – A Design Approach" Prentice Hall of India.

Reference books

1. Water Supply and Treatment – CPHEEO Manual (Latest version), New Delhi.
2. Wastewater Collection, Treatment & Disposal – CPHEEO Manual (Latest version), New Delhi.
3. Wark K. Warner, G. F., and Davis, W.T., (1998), "Air Pollution its Origin and Control" – Addison- Wesley.
4. Thomann, R. V., and Mueller, J. A., (1987), "Principles of Surface Water Quality Modeling and Control" –, Harper Int. Edition.
5. Statistical software's for environmental applications.

Course Outcomes	**Program Outcomes**												**PSO's**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	3	2	2	3	2	2	2	1	1	1	2	3	2	3
CO2	3	3	2	2	3	2	2	3	1	1	1	2	3	2	3
CO3	3	3	2	2	3	2	2	3	1	1	1	2	3	2	3
CO4	2	2	3	2	3	2	2	3	1	1	1	2	3	2	3
CO5	3	3	3	2	3	2	2	3	1	1	1	2	3	2	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Life Cycle Analysis & Environmental Risk Assessment	***Course Code: 20EV553***
Credits: 3	***Total Contact Hours(L:T:P): 39:0:0***
Type of Course: Theory	***Category: Professional Elective Course-1***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Elements of environmental engineering

Course Objectives

The course deals with sufficient information on need and principles of environmental life cycle assessment, risk, assessment methodologies, environmental modelling for monitoring, assessing and quantifying risks through dose-response relationships.

Course Outcomes: After completing this course, students should be able to:

CO1:	Able to define terminologies, understands life cycle approach analysis and risk assessment models. Performs the process of risk assessment and develops knowledge on exposure assessment models
CO2:	Appreciate and understand various release assessment models and monitoring methodologies including statistical models
CO3:	Apply various testing methods for exposure assessment in different environmental systems and human exposure models. Gets a fair knowledge of their strengths and Limitations
CO4:	Outlines various modelling methods for assessing health consequences and understands the impact of influencing agents on environment
CO5:	Capable of analyzing and evaluating risk estimation uncertainties, completeness, accuracy and practicality of risk assessment.

Unit No.	Course Content	No. of Hours
1	**Life-cycle Analysis (LCA) - Concept & fundamentals:** LCA -Goals and principles, Conceptual framework, Pollution prevention and LCA, LCE, General applications. **Risk Assessment:** Terminology and definitions, Environmental problems, Resources and environmental issues, Risk sources and agents, Effects of risk agents on human health and environment, Soundness-Completeness-Practicality-Effectiveness of risk assessment.	**06**
2	**LCA Applications:** Strategic planning, application in public sector, Industrial applications, Case study on municipal solid-waste management practices, LCA in plastic manufacturing industry, Environmental performance and LCA in product development. LCA Software's – SimaPro, Sphera, USEtox etc.,	**07**
3	**Methods of Environmental Risk Assessment:** **Statistical models** - Component failure & initiating event models event tree, fault tree analysis, Decision tree analysis Release assessment models, Discharge models **Exposure models** - Atmospheric models, surface water models, groundwater	**10**

	models, watershed runoff model, food chain models, multimedia models **Consequence assessment models -** Dose response, dynamic models, matrix models, stochastic models, Markov models	
4	**Evaluation of Environmental Risk Assessment** Risk indices, Risk estimation - Classical methods, Monte-Carlo method, Source uncertainty, Qualitative analysis, Accuracy of assessment, Acceptability-Limitations-Credibility & Failure of risk assessment, Standardization of risk assessment, Accounting of uncertainty and Conservationism.	**08**
5	**Risk Assessment of Anthropogenic Activities** Resource depletion, Heavy metal contamination of soil and groundwater, Radio-active contamination, mining, major transport corridors on forest and wild life, Nuclear reactors.	**08**

Text books

1. Mary Ann Curran (1996). "Environmental Life-Cycle Assessment" McGraw Hill.
2. Ian Lerche & Walter Glaesser, (2006). "Environmental Risk Assessment - Quantitative Measures, Anthropogenic Influences, Human Impact" Springer Heidelberg.

Reference books

1. John E. Till & Helen A. Grogan (2000). "Radiological Risk Assessment and Environmental Analysis", Oxford.
2. Vincent T. Covello & Miley W. Merkhofer, (1993). "Risk assessment methods – Approaches for assessing health and environmental risks" Springer.

Course Outcomes	**Program Outcomes**												**PSO's**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	2	2	2	2	3	2	2	2	2	1	1	2	3	2	3
CO2	2	2	2	2	1	2	2	3	1	2	1	1	1	2	3
CO3	2	1	2	2	3	2	2	3	1	1	2	2	3	3	3
CO4	2	2	3	2	1	2	2	3	1	2	1	2	3	2	3
CO5	3	3	3	2	3	2	2	3	1	1	1	2	3	1	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Waste to Energy Technologies	*Course Code: 20EV561*
Credits: 3	*Total Contact Hours (L:T:P): 39:0:0*
Type of Course: Theory	*Category: Open Elective course I*
CIE Marks: 50	*SEE Marks: 100*

Pre-requisite: Environmental studies, Elements of Environmental Engineering

Course Objectives

The objective of the course is to provide insights into waste management options by reducing the waste destined for disposal and encouraging the use of waste as a resource for alternate energy production.

Course Outcomes: After completing this course, students should be able to:

CO1:	Understands the 4R concept, sources and characterization of different wastes. Able to identify improper practices of solid waste disposal and their environmental implications. Understands the basic engineering principles of solid waste management.
CO2:	Identify different waste to energy biochemical and thermos-chemical technologies.
CO3:	Appreciates the recovery of byproducts during energy production from waste for effective management of environment.
CO4:	Develops a concise idea on global as well as Indian practices on energy recovery from waste with success and failures of the applications.
CO5:	Discuss in house industrial waste to energy plants, Centralized and Decentralized Energy production, distribution and use.

Unit No.	Course Content	No. of Hours
1	**Introduction** Need of energy production from wastes, Principles of Waste Management and Waste Utilization. Current Energy scenario and energy from waste, Waste Management Hierarchy and 5R concept. Waste as an Alternate Energy source. Wastes suitable for energy production. Waste Sources & Characterization Waste production from different sectors. Classification of waste, domestic waste, industrial waste (hazardous and non-hazardous). Characterization of waste for energy utilization - Physical, Chemical, Proximate and ultimate analysis, Leaching properties.	**12**
2	**Technologies for Waste to Energy** Biochemical Conversion – Biomass energy, Energy production from organic waste through anaerobic digestion and fermentation, energy production from algae. Energy from fecal sludge. Thermo-chemical Conversion – Incineration and heat recovery, Pyrolysis, Gasification; syngas utilization, Plasma Arc Technology and other newer technologies.	**06**

3	**Waste to Energy Options** Landfill gas, collection and recovery. Refuse Derived Fuel (RDF). Alternate Fuel Resource (AFR) – production and use in Cement plants, Thermal power plants and Industrial boilers. Co-generation and Tri-generation concepts. Conversion of wastes to fuel resources for other useful energy applications. Energy from Plastic Wastes – Non-recyclable plastic wastes for energy recovery.	**08**
4	**Centralized and Decentralized Waste to Energy Plants** Location and Siting of 'Waste to Energy' plants. Industry Specific Applications – current-In-house use – agro-waste, pharmaceuticals, Pulp and paper, refinery and petrochemical industry and any other industry. Centralized and Decentralized Energy production, distribution and use. Waste to Energy & Environmental Implications, Environmental standards for Waste to Energy Plant operations and gas clean-up.	**08**
5	**Recent Trends** Ethical issues on converting waste to energy, Global Best Practices in Waste to energy production. Indian Scenario on Waste to Energy production. Role of the Government and NGOs in promoting Waste to Energy. National energy management with specific implications in developing countries.	**05**

Text Books:

1. Marc Rogoff, Francois Screve., (2011). "Waste-to-Energy Technologies and Project Implementation". ISBN: 9781437778724. 2nd Edition.
2. Rajeev Pratap Singh, Vishal Prasad, Barkha Vaish. Advances in Waste-to-Energy Technologies. 2013. 1st Edition.
3. Naomi B Klinghoffer, Marco J Castaldi., (2013). "Waste to Energy Conversion Technology". Woodhead Publishing ISBN: 9780857096364

Reference Books:

1. Industrial and Urban Waste Management in India, TERI Press.
2. Wealth from Waste: Trends and Technologies by Banwari Lal and Patwardhan, TERI Press.
3. Fundamentals of waste and Environmental Engineering, S.N Mukhopadhyay, TERI Press.
4. Gazette Notification on Waste Management Rules 2016.
5. CPCB Guidelines for Co-processing in Cement/Power/Steel Industry
6. Waste-to-Energy in Austria – White Book – Figures, Data Facts, 2nd edition, May 2010
7. Report of the task Force on Waste to Energy, Niti Ayog (Formerly Planning Commission) 2014.
8. Municipal Solid Waste Management Manual, CPHEEO, 2016

Course Outcomes	Program Outcomes												PSO's		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	2	2	1	2	3	2	1	2	2	2	1	3	3	1	3
CO2	2	3	2	1	1	2	2	3	1	1	2	2	2	2	1
CO3	3	2	1	2	3	1	2	3	2	2	1	3	3	1	3
CO4	2	2	3	1	1	2	1	3	1	1	1	2	2	2	2
CO5	1	3	3	2	3	2	2	3	1	1	2	3	3	2	3

0 -- No association, 1---Low association, 2--- Moderate association, 3---High association

Course Title: Disaster Management and Mitigation	*Course Code: 20EV562*
Credits: 3	*Total Contact Hours (L:T:P): 39:0:0*
Type of Course: Theory	*Category: Open Elective course I*
CIE Marks: 50	*SEE Marks: 100*

Pre-requisite: Environmental Studies, Elements of Environmental Engineering, Ecology

Course Objective: The course imparts thorough understanding of Natural and Manmade disasters, impact and vulnerability assessment, preparedness and their mitigative measures.
Course Outcomes: After completing this course, students should be able to:

CO1:	State and classify disasters and identifies the cause– effect relationships.
CO2:	Apply the knowledge of vulnerability assessment for pre-planning, early warning systems and response plan. Prepare on-site and off-site ERPs.
CO3:	To comprehend the lessons learnt from different natural and man-made disasters leading to newer initiatives for forecasting, planning and mitigation and prepare Disaster and Environmental Management Plan.
CO4:	Recognize the role of IT in creating vulnerability scenarios through simulation exercises using GIS and other related software and consolidates the information on National policy on disaster management along with required legal framework for effective mitigation.
CO5:	To deal with case studies regarding different natural and man-made disasters and mention its effect- cause relationship.

Unit No.	Course Content	No. of Hours
1	**Introduction** Disasters, causes and impacts, scope of disaster management, disaster Managers-professionals and specialists active in various phases of disasters, Risk management, preparedness, operational functions of disaster management, Resource management, impact reduction, Climate change and disaster. Disasters: Natural disasters - Drought, Floods, Earth Quake, Volcanoes, Land Slides, Cyclones, Tsunami; Water safety plan. **Manmade** - Air accidents, Rail and Road accidents, Industrial, Chemical, Biological (Bio- Terrorism) nuclear Disasters, accidental oil spills and other.	**09**
2	**Disaster Assessment & Preparedness** Disaster management steps, Vulnerability assessment (VA). Importance and advantages, Process of VA, Steps in VA, Report, Prioritization, Emergency Response Plan (ERP). **Pre disaster Planning:** Earthquakes, cyclones, epidemics outbreak, drought and famine. Disaster resistant constructions, rehabilitation and reconstruction. Early warning and management, Global Disaster alerting and coordination system (GDACS), Flood forecasting, flood control systems.	**08**

3	**Disaster Prevention and Mitigation** Earthquake mitigation, Cyclone mitigation, Landslide hazard mitigation, Flood preparedness and response, building bye-laws and adaptation. Environmental Management Plans (on site and off site) and Disaster Management Plans (DMP).	**07**
4	**Legal Framework** Disaster Management Act and Code, National Policy on Disaster Management. Information Technology in Disaster Management: Application of GIS and Remote sensing for Disaster Management, Simulation studies. Use of Unmanned aerial vehicles (UAVs) in disaster management and monitoring.	**08**
5	**Case studies** Bhopal gas tragedy, Meuse valley, Chernobyl, Fukushima, Tsunami, Forest fires, Gujarat earthquake, Gulf of Mexico Oil Spill, COVID-19 pandemic, Amazon Forest Fire and recent episodes.	**07**

Text books

1. Peter R.J. Trim, (2004), "An Integrative Approach to Disaster Management and Planning", Emerald Group Publishing Ltd.
2. Ramesh R. Rao, Jon Eisenberg, and Ted Schmitt, Editors, Committee on Using Information Technology to Enhance Disaster Management, National Research Council "Improving Disaster Management: The Role of IT in Mitigation, Preparedness, Response, and Recovery", The National Academies Press, Washington, D. C.
3. Committee on Planning for Catastrophe, (2007), "A Blueprint for Improving Geospatial Data, Tools, and Infrastructure, National Research Council, "Successful Response Starts with a Map: Improving Geospatial Support for Disaster Management", The National Academies Press, Washington, D. C.

References

1. Committee on Disaster Research in the Social Sciences: Future Challenges and Opportunities, "Facing Hazards and Disasters- Understanding Human Dimensions" Division on Earth and Life Studies, (2006), The National Academies Press, Washington, D. C.
2. UNEP Report, (2005), "Environmental Management and Disaster Preparedness" Lessons Learnt from the Tokyo Typhoon (Typhoon 23 of 2004) in Japan.
3. UNEP Report, "Environmental Management and Disaster Preparedness" Building a multi-stakeholder partnership.

Course Outcomes	**Program Outcomes**												**PSO's**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	1	2	2	1	2	2	1	2	2	1	1	2	1	1
CO2	2	2	1	2	2	2	2	1	2	3	1	1	3	2	3
CO3	3	2	2	2	2	1	2	1	3	3	1	1	3	2	3
CO4	3	2	2	2	3	2	1	2	3	3	2	1	2	3	2
CO5	2	2	1	3	2	2	2	1	1	2	1	1	2	1	1

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Built Environment	***Course Code: 20EV563***
Credits: 3	***Total Contact Hours (L:T:P): 39:0:0***
Type of Course: Theory	***Category: Open Elective course I***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Environmental Studies, Ecology and Elements of Mechanical Engineering

Course Objective

This course provides innovative ideas in sustainable construction and helps to understand the basic principles of Social Engineering and Environmental Performance.

Course Outcomes: After completing this course, students should be able to:

CO1:	Understand the basic principles of Social Engineering and Environmental Performance.
CO2:	Design suitable approaches for buildings and study sustainable concepts.
CO3:	Analyze Environmental Impact- Principles and Methodologies and deal with Environmental Planning.
CO4:	Understand the concepts of Built Environment with a practical approach.
CO5:	Apply management skills for Built Environment with suitable case studies.

Unit No.	Course Content	No. of Hours
1	**Introduction** Need and Importance, Principles of Social Engineering, Renewable Energy, Climate Change & Sustainable Development, Building Energy & Environmental Performance, Life Cycle Assessment & Sustainability, Town & Regional Planning.	**08**
2	Approaches to Interior Design of Building, Design of Intelligent Buildings, Efficient Building Services, Passive Design, Zero Carbon and Low Energy Housing Development, Building products: Materials and components, Architecture and building: Sustainable construction and operation.	**08**
3	Environmental Impact Principles and Methodologies, Infrastructure Planning and Management, Liveable Landscapes & Urban Ecology, Material Strategies for Physical World, Landscape Architecture and Site Planning, Housing and Neighborhood Planning. Regional planning.	**08**
4	Cities and neighborhoods: Buildings, infrastructure and resource flows, Regions: From supply chains to value webs, transition to a Circular Built Environment, a practical approach, EDGE green building certification.	**08**
5	Specifications Estimation and Costing Urban Design, Case study on Project and Construction Management, Construction Management & Entrepreneurship Development, Indian Green Building Council (IGBC) concepts.	**07**

Text books

1. Simon Foxell, "A Carbon Primer for the Built Environment", Taylor & Francis Ltd.
2. King, A. (ed.) (1997) Culture, Globalization and the World-System: Contemporary Conditions for the Representation of Identity. Minneapolis: University of Minnesota.
3. Oliver (2006) Built to meet needs: Cultural issues in vernacular Architecture, Oxford: Architectural press.

Reference books

1. Lawrence Roderick J., "Creating Built Environments", Taylor & Francis Inc.
2. SY Patki, MG Shah, Kale CM (2019), "Building Drawing with an integrated approach to Built Environment", (6th Edition), McGraw-Hill.
3. Routledge (2018), "Regreening the Built Environment: Nature, Green Space, and Sustainability", Taylor & Francis Ltd.

Course Outcomes	**Program Outcomes**												**PSO's**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	2	2	1	1	2	1	2	3	2	2
CO2	2	3	2	2	3	2	2	1	2	1	1	2	3	3	2
CO3	3	3	2	2	2	1	1	1	2	1	1	2	3	3	3
CO4	2	2	2	1	2	2	2	1	1	1	1	2	2	2	2
CO5	1	3	2	2	1	2	2	2	2	3	1	2	2	3	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Water Treatment Process Laboratory	***Course Code: 20EV57L***
Credits: 1.5	***Total Contact Hours (L:T:P): 0:0:39***
Type of Course: Laboratory	***Category: Professional Core Course***
CIE Marks: 50	***SEE Marks: 50***

Pre-requisite: Elements of Environmental Engineering, Sources and Characterization, Environmental Chemistry and applications.

Course Objective

The lab course provides an opportunity to collect and preserve water samples, conduct various tests on water quality parameters, perform experiments on selected lab scale treatment processes.

Course Outcomes: After completing this course, students should be able to:

CO1:	To acquaint with precision and accuracy of analytical data and to appreciate rounding off to a significant value in the Context of water quality parameters, to adopt various sample preservation techniques
CO2:	To determine treatment efficiency of various water treatment processes–aeration, adsorption experiments with isotherms and break through curve, jar test for optimum dose of coagulant and settling experiments
CO3:	To develop the ability to plan and perform filtration experiments, understand the significance of breakpoint chlorination and to plot particle size distribution curve, able to analyze, interpret and infer the laboratory data.

Unit No.	Course Content	No. of Hours
1	Water treatment process Laboratory – Introduction to the laboratory / equipment / instruments and applications. Precision and Accuracy, Significant numbers. Sample collection preservation techniques.	**3**
2	Dissolved oxygen (DO)	**3**
3	Aeration Process for Fe removal. Aeration for improving DO (continuous monitoring) – linkage with two film theory	**3**
4	Determination of colour and metals in water	**3**
5	Water Softening – Determination of initial and final concentration for parameters – Total hardness, TDS, Alkalinity etc.	**3**
6	Jar Test apparatus for Optimum coagulant (Natural and chemical) dose determination	**3**
7	Types of Settling - Column study with different salts (aluminum and copper)	**3**
8	Filtration Process - Single Media and Dual Media Filters. Particle size distribution analysis, Determination of Effective Size and Uniformity Coefficient	**3**
9	Batch Adsorption – GAC, Natural Adsorbents, Isotherms and Break through curves & interpretations.	**3**
10	Chlorine demand, Available chlorine and Break Point Chlorination curve	**3**

	Residual chlorine in water distribution system (Near OHT and in different user taps)	
11	Household Water Treatment Units – Ground water, RO treated water and Bottled water quality analysis	**3**
12	Field visit to water treatment plant	**3**
13	Continuous Internal Examination	**3**

Reference books

1. Sawyer, C. N., Mc Carty, P. L., and Perkin, G. F., (2015), "Chemistry for Environmental Engineering and Science", V Edn., Tata McGraw Hill Publishing Company Ltd., New Delhi.
2. NEERI Laboratory Manual, Nagpur, Maharashtra
3. AWWA (2012), "Standard Methods for Examination of Water and Wastewater", 21st Edition

Course Outcomes	**Program Outcomes**												**PSO's**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	2	2	3	1	2	3	3	2	2	2	3	1	2	3	3
CO2	1	3	3	3	3	2	1	2	3	1	1	1	3	3	2
CO3	3	1	3	3	1	3	3	2	1	3	3	1	2	1	2

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Atmospheric and Computer Applications Laboratory	*Course Code: 20EV58L*
Credits: 1.5	*Total Contact Hours: 0:0:39*
Type of Course: Laboratory	*Category: Professional Core Course*
CIE Marks: 50	*SEE Marks: 50*

Pre-requisite: Basics of C- programming and Water treatment units' design

Course Objective

The laboratory course focuses on atmospheric processes, sampling, monitoring and data interpretation of air pollutants and noise measurements. The lab course also discusses about executing environmental Engineering related software's.

Course Outcomes: After completing this course, students should be able to:

CO1:	Able to carry out different monitoring tests on ambient air quality parameters – gaseous pollutants and vehicle exhaust emissions
CO2:	Capable of developing wind rose diagrams, noise measurements and interpretation and measurement of light intensity for different applications. Gets a fair knowledge of stack monitoring and various air pollution control equipment through demonstration.
CO3:	Capable of writing and executing programmers related to statistical analysis, population forecasting and water and wastewater systems and prediction of air pollutant dispersion using air quality dispersion models
CO4:	Able to use the software to design water treatment units and predict future population using available software's.

Unit No.	Course Content	No. of Hours
1	Atmospheric and Computer Applications Laboratory – Introduction to the laboratory / equipment / instruments environmental software's and applications.	**3**
2	Air Pollution Monitoring, Introduction to Atmospheric Monitoring: Particulate Sampling – Dust Fall, Particulate Matter - PM10, PM2.5 using High Volume Air Sampler (H.V.A.S.).	**3**
3	Estimating Sulphur oxides and nitrogen oxides in ambient air using H.V.A.S. Monitoring and identification of air borne microbes	**3**
4	Exercises on auto exhaust analyzer for Petrol Vehicles. Exercises on noise measuring instruments. Exercises on Lux-meter (Light Intensity measuring Instrument)	**3**
5	Windrose Diagrams - Wind Monitoring and Analysis of Data Stack Sampling Techniques and Demonstration of Stack Monitoring.	**3**
6	Exercises on Ambient Gas Monitoring using GASTEC Device. VOC meter.	**3**
7	To write C programs related to aeration, sedimentation.	**3**
8	To write C programs related to tricking filter rapid sand filters, stack emission etc., and execute the same using C++ software.	**3**
9	To write C programs related to air quality models, stack emission etc., and execute the same using C++ software.	**3**

10	Environmental System Software To execute the softwares of: Population forecast, rising main design.	**3**
11	Environmental System Software To execute the softwares of: LOOP water distribution design, Sewer design, WATPLANT.	**3**
12	Environmental System Software To execute the softwares of: ISCST3 Air pollutant dispersion model and CALINE model.	**3**
13	Continuous Internal Examination	**3**

Reference books

1. Noel D Nevers, (2000), "Air Pollution Control Engineering", McGraw Hill International Editions, Civil Engineering Series, McGraw Hill
2. Wark K., Warner C.F., and Davis W.T., (1997), "Air Pollution – Its Origin and Control", Third Edition, Prentice Hall of India Publishers
3. Crawford M, (1976), "Air Pollution Control Theory", TMH Edition, Tata McGraw Hill Publishing Company Ltd., New Delhi

Course Outcomes	**Program Outcomes**												**PSO's**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	2	1	2	1	3	2	2	2	1	1	1	2	2	2	2
CO2	3	3	2	1	3	2	2	1	1	1	1	2	3	2	3
CO3	2	1	2	2	3	2	3	3	1	1	1	2	2	2	2
CO4	2	2	3	2	3	2	2	3	1	1	1	2	3	2	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Constitution of India & Professional Ethics	***Course Code: 20HU510***
Credits: 0	***Total Contact Hours (L:T:P): 26:0:0***
Type of Course: Theory	***Category: HSMC***
CIE Marks: 50	***SEE Marks: -***

Course Objective.

1. To provide basic information about Indian Constitution.
2. To identify individual role and ethical responsibility towards society.

Course Outcomes: Have general knowledge and legal literacy and thereby to tale up competitive examinations.

Unit No.	Course Content	No. of Hours
1	Introduction to the constitution of India, The Making of the Constitution and Salient features of the Constitution. Preamble to the Indian Constitutional Fundamental Rights & its limitations.	**05**
2	Directive principles of State Policy & Relevance of Directive principles of State Policy Fundamental Duties. Union Executives – President, Prime Minister, Parliament, Supreme Court of India.	**05**
3	State Executives – Governor, Chief Minister, State Legislature, High Court of State. Electoral Process of India, Amendment Procedures, 42nd, 44th, 74th, 76th, 86th, and 91st Amendments	**05**
4	Social Provision for SC & ST Special Provision for Women, Children and Backward Classes, Emergency Provisions. Powers and Functions of Municipalities, Panchayats and Co-operative Societies.	**05**
5	Scope and Aims of Engineering Ethics, Responsibility of Engineers Impediments to Responsibility. Risk, Safety and liability of Engineers, Honesty, Integrity and Reliability in Engineers	**06**

6th Semester

Syllabus

Course Title: Wastewater Treatment Engineering	*Course Code: 20EV610*
Credits: 4	*Total Contact Hours(L:T:P): 52:0:0*
Type of Course: Theory	*Category: Professional Core Course*
CIE Marks: 50	*SEE Marks: 100*

Pre-requisite: Environmental Chemistry, Environmental Microbiology and Ecology

Course Objective

The course offers comprehensive knowledge on principles and design aspects of wastewater collection, treatment and disposal systems, updated with the latest technological advancements.

Course Outcomes: After completing this course, students should be able to:

CO1:	Explain the basics of sampling, characterization, seasonality of wastewater and apply the knowledge of hydraulic elements curve for design of sewer system
CO2:	Describe the functioning and design of various domestic wastewater treatment units
CO3:	Describe the fundamentals of nutrient removal and explain the principles of physico-chemical, biological advanced wastewater treatment systems.
CO4:	Analyze the characteristics of sludge and suggest disposal options.
CO5:	Design fecal sludge management and explain recent technologies for wastewater treatment.

Unit No.	Course Content	No. of Hours
1	**Introduction:** Sources of domestic wastewater, Characteristics of wastewater - parameter interlinks. Estimation of dry and wet weather flow, Mass loading, Simple problems. Types of sewerage systems. Hydraulic design of sewers: Self-cleansing and non-scouring velocities, partial flow and force main, hydraulic elements curve. Sewer Appurtenances: Manholes, inverted siphons. Materials of sewers, laying, joining and testing. Pre-fabricated sewer systems.	**10**
2	**Unit Operations and Unit Processes** Objectives, process flow sheets based on characterization. Chemical and Biological reaction kinetics, Types of reactors. Pumps, screens, equalization, comminution, grit chamber, oil and grease removal, primary sedimentation tank. Secondary sedimentation tank - design criteria and examples. Aerobic, Anoxic and Anaerobic systems, Suspended and attached growth systems, activated sludge process and modifications, rotating biological contactors, design criteria and examples. Natural Wastewater Treatment Systems – Wetlands, Septic tanks and soak pits, dispersion trenches.	**12**
3	**Advanced Wastewater Treatment Systems** Need for Advanced Wastewater Treatment Systems, nutrient removal, Electrochemical coagulation, Gas Stripping, DAF, Advanced Oxidation, Electro-dialysis, Ion Exchange, Adsorption, Membrane filtration, Membrane bio reactors, Microbial fuel cells, Sequential Batch Reactor, Decentralized Wastewater Treatment System.	**10**

4	**Sludge Management** Chemical, biological and electro-chemical sludge – sources and generation, Quantification and characterization, sludge volume index (SVI), centrifugal settleability index (CSI), alternate uses of sludge and disposal options. Calorific value estimation from proximate and ultimate analysis data. Sludge Digestion- aerobic and anaerobic, Sludge Drying Bed, Sludge Thickeners, sludge filter press, design criteria and examples.	**10**
5	**Fecal Sludge Management (FSM)** Fecal Sludge- Characteristics, Quantification, FS Value Chain, Containment, Transportation, Collection and Conveyance. Design of a Fecal Sludge Treatment plant; Case studies. **Recent Trends** Genetically modified microorganisms for wastewater treatment – externalities; bio sensors, Hybrid Wastewater Treatment Systems, water reclamation facilities.	**10**

Text books

1. Metcalf and Eddy, (2014), "Wastewater Engineering, Treatment and Reuse", 4th Edition, Tata McGraw Hill Edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi
2. Karia, G. L., and Christian, R. A., (2018) "Wastewater Treatment: Concepts And Design Approach ", Prentice – Hall of India.

References

1. Quasim, S. R., (1985), "Wastewater Treatment Plants – Planning, Design and Operation", Holt Rinehart and Winston, CBS College Publishing.
2. Qasim Syed R., (2009), "Wastewater treatment plants: planning, design, and operation" - 2nd edition, CRC Press LLC
3. Peavy, H. S., Rowe, D. R., and Tchobanoglous, G., (2015), "Environmental Engineering", McGraw Hill Book Co.
4. Benefield R. D., and Randal C. W., (1980), "Biological Process Design for Wastewater Treatment", Prentice Hall, Englewood Chiffs, New Jersey.
5. Ronand L., and Droste, (1997)," Theory and Practice of Water and Wastewater Treatment", John Wiley and Sons Inc.
6. Moo-Young M., Anderson W.A., Chakrabarty A.M., (2007), "Environmental Biotechnology – Principles and Applications," Kluwer Academic Publishers.
7. CPHEEO Manual on Wastewater Treatment (Recent Edition)
8. CDD manual on Faecal Sludge Management

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	2	2	2	1	3	3	3	2	2	2	3	3	2	3
CO2	3	3	3	3	2	3	3	3	2	2	1	3	3	3	2
CO3	3	2	3	3	3	2	3	3	3	2	2	3	3	3	2
CO4	3	2	2	2	3	2	3	3	2	3	3	3	2	3	3
CO5	3	2	2	3	2	2	3	3	3	2	3	3	3	2	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Estimation and Costing	***Course Code:20EV620***
Credits :4	***Total Contact Hours(L:T:P):39:13:0***
Type of Course: Theory	***Category: Professional Core Course***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Construction Engineering Materials, Survey Engineering, Geology and Geotechnical Engineering

Course Objective

The course prepares the student to understand and apply the essentials of cost estimation and specifications, practice value-based engineering profession, and to know basics of financial aspects.

Course Outcomes: After completing this course, students should be able to:

CO1:	Describe the fundamentals of estimation and specifications for construction materials
CO2:	Estimate quantities of building materials and prepare a budget estimate for a given specification and schedule of rates
CO3:	Evaluate detailed specification of different components of construction and pipe materials of water supply and sewer system
CO4:	Describe the need for value engineering and its significance in Engineering Practices
CO5:	Assess financial implications including tax and rebates in water and energy sector and describe tender document

Unit No.	Course Content	No. of Hours
1	**Introduction and applications in Environmental Engineering** **Earthwork** - volume by cross-section, spot levels and contour - calculation of haul, over haul and economic haul, lead and lift. **Specifications for materials:** aggregates, cement, Steel, water supply pipe materials and fittings, sewer materials **Specifications for construction work:** Earthwork, foundation, cement mortar, plain and reinforced concrete, brick masonry, stone masonry, roofing, flooring, plastering, wood work, water supply distribution system. Open drains, sewer line.	**8:3**
2	**Estimation**: Types of estimates, Methods of working out quantities. **Rate Analysis:** Cement mortar, cement concrete, brick and stone masonry, flooring, plastering, RCC works, doors, windows and ventilators. Use of current Schedule of Rates.	**8:3**
3	Preparation of detailed and abstract estimates for - store room, pump house, cascade aerators, venturi-flume, sedimentation tank/clariflocculator, water supply system, septic tank, manhole, sewer network systems, storm water drains, electromechanical equipment Quantification of Steel for various basic components - slab, chejja, lintel and valve chambers.	**9:3**

4	**Principles of value engineering** Financial Aspects: Purpose. Cost, price, value–different forms of value Balance sheet, Gross income, net income, outgoings – types of out goings – obsolescence, annuity, year's purchase. Capital cost – fixed and variable, time value of money, Net Present Value (NPV), Internal Rate of Return (IRR), Depreciation– methods, sinking fund, cost fixation on the produced commodity. Debt equity (DE), debt service coverage ratio (DSCR).	**8:2**
5	**Fiscal Incentives and penalty for environmental protection**: Taxes and tax rebate, Investment and Depreciation allowance, exemption from Tax to capital gains, rebate in cess levied on water consumption and energy. Financial assistance for environmental facilities, Tendering for construction of environmental facilities, subsidies for environmental facilities.	**6:2**

Text books

1. Dutta, B. N., (2015), "Estimating and Costing in Civil Engineering" - CBS Publishers and Distributors,
2. Mahajan, S.P., (2006), "Civil Estimating & Costing Valuation & Specifications" – Satya Prakashana.

Reference books

1. Manual on water supply and Treatment", CPHEEO, Ministry of Urban Development, GoI, New Delhi, 2012.
2. Manual on Sewerage and Sewage Treatment", CPHEEO, Ministry of Urban Development, GoI, New Delhi.
3. Current Schedule of Rates (SR) of CPWD, KPWD, Board SR.
4. Panneer Selvam, (2005), "Engineering Economics", Eastern Economy Edition.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	2	3	3	2	2	3	1	3	3	2
CO2	3	2	3	3	3	2	3	2	3	1	2	1	3	3	2
CO3	3	2	3	3	3	2	3	2	3	1	2	1	3	3	2
CO4	2	2	2	1	2	2	3	2	2	2	3	1	2	2	2
CO5	2	2	2	1	2	2	3	2	2	2	3	1	2	1	2

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Environmental Impact Assessment	***Course Code: 20EV630***
Credits: 3	***Total Contact Hours (L:T:P): 39:0:0***
Type of Course: Theory	***Category: Professional Core Course***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Elements of Environmental Engineering, atmospheric environmental Engineering, sources and characterization, water and wastewater treatment, municipal and biomedical waste management.

Course Objectives

The course provides knowledge on environmental impact assessment, tools and methods, importance of public participation with applications for developmental activities.

Course Outcomes: After completing this course, students should be able to:

CO1	Explain the need for impact analysis of developmental activities on environmental systems and basic requirements of EIA process
CO2	Refer and assimilate recent guidelines/notifications pertaining to EIA and describe the significance of NABET and the role of NGT in EIA activities
CO3	Assess the impact of given project (both qualitative and quantitative) on environmental attributes using EIA tools/techniques and propose EMP/DMP
CO4	Predict the impact of developmental activity using simulation models and describe the process and significance of public participation
CO5	Describe types of audit and carry out environmental audit for a given scenario

Unit No.	Course Content	No. of Hours
1	**Introduction -** Definition, Purpose and Scope of EIA, Types of EIA. Evolution of EIA in India and other countries. The EIA process, Chapter contents in EIA, Procedural and methodological Limitations. EMP in NDS reports.	**06**
2	**Guidelines and Regulations** – EPA, EIA Notification of 2006 and subsequent amendments, EC practices in India, terms of reference – Standard and additional for EIA/EMP report for projects/activities, MoEF&CC guidelines on siting of industries, ecologically sensitive areas, NABET accreditation for EIA consultants, Role of National Green Tribunal in EIA. EIS.	**10**
3	**Methodologies & Techniques in EIA -** Adhoc, checklist, matrix, overlays, networks, Battle Environmental Evaluation Systems (BEES), Cost-Benefit-Analysis (CBA), brain storming, fuzzy, Delphi technique, **Contents of EIA** -Structure of EIA, Onsite and Offsite Emergency Plan, Environmental Management plan (EMP) and Disaster Management Plan (DMP).	**09**
4	**Environmental Attributes -** Value function plots and standards for Environmental attributes - Air, water, land; Simulation models. Impacts on Socio economic aspects, biodiversity. **Public participation in EIA -** Need, objectives, elements and framework for public participation – step by step procedure.	**08**

5	**Post EIA activities -** EIA audit –Types and auditing procedure **EIA case studies –** Category A, B1 and B2	**06**

Text books

1. Y Anjaneyulu and Valli Manickam (2020), "Environmental Impact Assessment Methodologies", 3rd Edition, B S Publications.
2. N S Raman, A R Gajbhiye, S R Khandeshwar (2014), "Environmental Impact Assessment".1st Edition, IK International Publications Pvt. Ltd.
3. Rau and Wooten, (1981), "Environmental Impact Assessment" Handbook.
4. Jain R.K., Urban L.V., Stacey G.S., (1977), "Environmental Impact Analysis – A New Dimension in Decision Making", Van Nostrand Reinhold Co.

References

1. Anji Reddy Mareddy. (2019), 1st Edition, B S Publications, "Environmental Impact Assessment theory and practice".
2. Clark B.C. Bisett and Tomlinsan P, (1985), "Perspective on Environmental Impact Assessment", Allied Publishers.
3. Canter L., (1995), "Environmental Impact Assessment", McGraw Hill.
4. Journals - Science Direct, acs.org.
5. EIA notifications and Publications, MoEF & CC, GoI

Course Outcomes	**Program Outcomes**												**PSOs**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO2	3	2	2	2	2	2	2	2	3	2	2	3	2	3	2
CO3	3	3	2	3	2	1	2	2	3	3	3	2	2	2	3
CO4	1	2	3	1	2	2	2	3	3	3	2	2	2	3	2
CO5	3	2	2	3	2	3	2	3	2	3	3	3	2	2	2

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Hazardous Waste Technology and Management	***Course Code: 20EV641***
Credits: 3	***Total Contact Hours (L:T:P): 39:0:0***
Type of Course: Theory	***Category: Professional Elective Course - II***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Environmental Chemistry, Solid Waste Management, Atmospheric Environmental Engineering, Wastewater Engineering.

Course Objectives

The course provides fundamentals on sampling, characterization of hazardous waste, design of treatment scheme and relevant rules, guidelines for management and economic analysis.

Course Outcomes: After successfully completing this course, the students will be able to:

CO1	Explain the basics of hazardous materials/wastes and remember the related Acts and regulations
CO2	Carryout analysis to declare the given waste is hazardous or not and assess its toxicological impacts and risk involved
CO3	Evaluate waste minimization, resource recovery and transportation options for hazardous wastes
CO4	Describe and design ideal treatment scheme for remediating contaminated sites and suggest disposal options.
CO5	Explain recent trends in hazardous waste management based on application of life cycle engineering concepts.

Unit No.	Course Content	No. of Hours
1	**Introduction:** Definition, history – episodes, sources and generation of hazardous wastes. Biomedical wastes, household hazardous wastes. **Regulations:** Management and Handling transboundary movement Rules, Super fund amendments and reauthorization Acts (SARA), hazard ranking system (HRS), Resource conservation recovery Act (RCRA), Assessment of Hazardous waste sites. Hazardous waste Acts in all countries, E-waste rules.	**08**
2	**Characterization of Hazardous wastes:** Ignitability, corrosivity, reactivity, toxicity. Designated hazardous wastes. **Toxicology and Risk assessment:** Toxic effects – persistent organic pollutants. LD/LC50, Dose-response, Risk exposure assessment, risk characterization and hazard quotient/index (HQ/HI), chronic daily intake (CDI), potency/slope factor and reference dose (RfD); Numerical examples.	**07**
3	**Waste minimization and resource recovery:** Elements of waste minimization strategy, waste reduction techniques and benefits, development of waste tracking system, waste compatibility for treatment and disposal, hazardous waste conversion to useful end products. **Transportation of hazardous wastes:** Regulation for hazardous materials, registration codes for hazmat vehicles for bulk transport of hazardous wastes, hazardous substances emergency response.	**08**

4	**Treatment of hazardous wastes:** Air stripping, soil vapor extraction, carbon adsorption – numerical problems. Biological methods, in-situ and ex-situ remediation processes using several techniques, slurry phase treatment and solid phase treatment; thermal processing – incineration, plasma, pyrolysis, etc. **Land disposal:** Secured landfills – design approaches, liner and cover systems, stability of landfills, closure and post closure operations and environmental monitoring; other disposal options.	**10**
5	**Recent trends:** Cradle-grave concepts, Life cycle engineering concepts, soil remediation, site remediation options, hazardous waste source reduction, hazardous liquid waste treatment – new options, electronics hazardous waste processing, air and water quality at secured landfills, hazardous wastes from electrical/fuel cell vehicles, hazardous waste stabilization, municipal hazardous wastes, hazardous wastes management and economic losses.	**06**

Text Books

1. Hazardous waste management – Wentz C A (recent edition) McGraw Hill International.
2. Michael D. L., Philip L. B. and Jeffrey C. E., (2001). "Hazardous waste management", Second edition, McGraw- Hill Higher Education.

Reference Books

1. CPCB, India - guidelines on hazardous wastes.

Journal articles

1. Journal articles on Sciencedirect.com, acs.org, springer link and Taylor & Francis.

2. Predatory Journals are not referred for information.

Course Outcomes	**Program Outcomes**												**PSOs**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	3	3	3	2	2	1	2	3	2	3
CO2	3	2	3	3	2	3	3	3	2	2	1	2	3	2	3
CO3	3	2	3	3	3	2	3	3	2	2	1	2	3	2	2
CO4	2	2	3	2	3	2	3	3	2	3	1	2	2	3	3
CO5	2	2	3	3	2	2	3	3	2	2	1	2	3	2	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Environmental Systems Optimization	*Course Code: 20EV642*
Credits: 3	*Total Contact Hours (L:T:P): 39:0:0*
Type of Course: Theory	*Category: Professional Elective Course -II*
CIE Marks: 50	*SEE Marks: 100*

Pre-requisite: Engineering Mathematics, Water Treatment and Supply Engineering, Municipal and Bio-Medical Waste Management

Course Objectives

The student appreciates the knowledge gained in this course as it emphasizes the importance of optimization techniques, linear programming, numerical search methods and simulation as applied to environmental engineering problems

Course Outcomes: After completing this course, students should be able to:

CO1:	Describe the need for optimization studies and state, construct and classify optimization problems with and without constraints
CO2:	Explain single and multivariable optimization techniques and state its applications to environmental engineering problems
CO3:	Apply various techniques to solve linear programming problem
CO4:	Apply transportation methods for solving linear programming problem with related applications to Wastewater Reuse and Solid Waste Management.
CO5:	Describe numerical search methods and apply simulation techniques for developmental activities

Unit No.	Course Content	No. of Hours
1	Introduction: Definition and engineering applications of optimization. Optimization Problems – Statement, formulation, classification and special cases	**08**
2	Classical Optimization Techniques: Single variable optimization, Multivariable optimization with no constraints (Hessian matrix), with equality constraints (Lagrange multiplier) and with inequality constraints (Kuhn-tucker) - Statement of theorem without proof.	**07**
3	Linear programming: Graphical method, Pivot operation for the solution of simultaneous equation, Simplex and Two phase method, Big-M technique, Duality in Linear programming. Application of Linear Programming: Problems on Air Pollutant Transport, Water and Wastewater Treatment Problems.	**08**
4	Transportation Problem: Definition, Transportation array, Applications, Solution by North West Corner rule and Vogels Approximation methods, Applications to Wastewater Reuse and Solid Waste Management.	**08**
5	Numerical Search Methods: Elimination Methods, Dichotomous Search and Fibonacci methods. Simulation: Basic concepts, Development, Simulation process, Pre-simulation and Developmental activities, Operational activities, Sensitivity analysis and Parametric analysis. Introduction to statistics and artificial intelligence based optimization	**08**

Text books

1. Rao. S. S., (1984), Optimization Techniques, Wiley.
2. Rich L. G., (1973), Environmental Systems Engineering, McGraw Hill.

Reference books

1. CPHEEO. Manual on Water Supply and Treatment.
2. Jewell T. K., (1986), "A Systems Approach to Civil Engineering Planning and Design", Harper & Row, NewYork.
3. Ravindran A., 2008, Operations Research Methodologies, CRC Press
4. Taha, H. A. (1976), "Operations Research: An Introduction, 8th ed., Prentice Hall
5. Novotny & Chesters, (1981), "Handbook of Non-point Pollution Sources and Management", Van Nostrand & Reinhold Publication

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	2	1	2	1	1	1	2	3	2	3
CO2	3	2	3	2	2	2	1	2	1	1	1	2	3	2	3
CO3	3	3	3	3	3	2	2	2	1	1	1	2	3	2	3
CO4	3	3	3	2	3	2	2	2	1	1	1	2	3	2	3
CO5	3	3	3	2	3	2	2	2	1	1	1	2	3	2	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Non-Point Sources of Pollution and Management	***Course Code: 20EV643***
Credits: 3	***Total Contact Hours (L:T:P): 39:0:0***
Type of Course: Theory	***Category: Professional Elective Course- II***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Elements of Environmental Engineering, Sources and Characterization, Water Resources Engineering and Management, Remote Sensing and GIS in Environmental Engineering

Course Objectives

This course demonstrates basic knowledge on differentiate assessment methods for various non-point sources of pollutants. Apply general engineering principles to new problems and situations.

Course Outcomes: After completing this course, students should be able to:

CO1	Explain the basic concepts of nonpoint source pollution, stream standards and stream's waste assimilative capacity
CO2	Identify and assess the non-point source pollution load from hydrologic components, also including wet deposition
CO3	Quantity non-point source pollution load from urban areas and explain various urban low impact development strategies
CO4	Perform qualitative and quantitative analysis of pollutant loads from agricultural, mining, and areas of fugitive source emissions
CO5	Apply simulation models to study non-point sources of pollution and assess the effectiveness of best management practices.

Unit No.	Course Content	No. of Hours
1	**Introduction** Problem and magnitude, Surface and ground water problems, in-stream and effluent discharge standards, designated use of water, Waste assimilative capacity, Total Maximum Daily Load (TMDL). Population equivalent estimation for NPS.	**07**
2	**Hydrologic considerations** Rainfall–runoff relationship, Overland routing of precipitation excess, Interflow, Groundwater flow. Pollution from the atmosphere – atmospheric input (wet deposition).	**08**
3	**Pollution from impervious urban areas** Urban storm water quantification, Deposition and accumulation of pollutants on impervious surfaces, Removal of solids from street surfaces, Urban runoff, Urban low impact development (LID)	**08**
4	**Fugitive air emissions -** Area, line sources **Pollution from agricultural and mining areas -** Quantification and qualitative analysis. **Pollution from semi urban areas –** septic tanks, pet waste, livestock, Pollution from forestry activities etc,	**07**
5	**Non-point source pollution simulation models** Basic concepts, salient features of non-point source pollution simulation models. Best Management Practices (BMPs) for non-point source pollution control.	**09**

Text books

1. Holly V. Campbell, (2018) Nonpoint Source Pollution - A Multidisciplinary Perspective, Taylor & Francis Group.
2. Abrar Yousuf, Manmohanjit Singh (2019), Watershed Hydrology, Management and Modeling**,** CRC Press

References

1. Novotny, V., and Chesters, G., (1981), "Hand Book of Non-Point Pollution", "Sources and Management" - Van Nostrand Reinhold Company.

Course Outcomes	**Program Outcomes**												**PSOs**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	1	1	2	1	3	3	3	2	2	1	3	3	2	2
CO2	3	2	2	2	2	3	3	3	2	2	2	3	2	3	2
CO3	3	3	3	2	2	3	3	3	2	2	2	3	3	3	2
CO4	3	3	3	2	2	3	3	3	2	2	2	3	3	3	2
CO5	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: **Environmental Law**	*Course Code: 20EV651*
Credits: 3	*Total Contact Hours (L:T:P): 39:0:0*
Type of Course: Theory	*Category: Open Elective Course - II*
CIE Marks: 50	*SEE Marks: 100*

Pre-requisite: Environmental Studies

Course Objective

The course offers knowledge on existing laws, acts and subsequent amendments and notifications relevant to all the environmental attributes for overall protection of the environmental

Course Outcomes: After completing this course, students should be able to:

CO1:	Explain the concepts of law, acts and Indian Constitution relevant to Environmental protection
CO2:	Summarize the acts, rules and penalizations amendments with respect to environmental attributes including air, water, noise, soil/solid waste.
CO3:	Relate international principles, laws and legal developments for Conservation and Protection of Environment and common concerns at the global scale
CO4:	Assess Environmental impacts of development activities and identify the importance of laws for protection of forest and wildlife.
CO5:	Associate the importance of biodiversity and the related laws. Identify IPR related to laws for conservation and management of the environment.

Unit No.	Course Content	No. of Hours
1	Introduction to Law & Legal Systems Indian law and the Indian legal system. History of Environmental protection in India - Provisions in Indian Penal Code for Environmental protection-The Union list- State list – Concurrent list.	**07**
2	Philosophy, Principles, Environmental Justice and Pollution Control Right To Environment – Basic Human Right: Constitutional Law Perspective, Environmental Principles of Governance, Traditional, Common and Criminal Law Remedies for Environmental Protection, Environmental Justice: Role & Policy, Water Pollution and Control Laws, Air (Prevention and Control of Pollution) Act, 1981, Law Relating To Waste Management.	**08**
3	International Environmental Law Customary International Law and Environmental Summits, Common Heritage: Oceans and Seas, Biodiversity and Species Conservation, Eco System and Conservation, Common Concerns: Ozone and Climate Change, Trade and Waste Management Regime, International Principles for Conservation and Protection of Environment, International Legal Developments on Sharing Natural Resources, Environmental Ability Regime and Environmental Conflict Resolution.	0**8**
4	Natural Resource Management Law Common Property Resources and the Law (Including Watersheds), Environmental Safeguards Relating to Development, Forest Management & Conservation: Law & Policy, Law Relating to Wildlife: Strategy & Protection,	**08**
5	Biodiversity and Intellectual Property Rights (IPR) Law relating to Biodiversity and its interface with IPR, Land Conservation and Management, Environmental Decision Making Process in India.	**08**

Text books

1. J.N. Pandey, Constitutional Law of India, 58th Edition
2. Nishtha Jaswal and P S Jaswal, Environmental Law, Publisher: Allahabad Law Agency (1 January 2017)
3. Arnold W Reitze, Air Pollution Control Law: Compliance and Enforcement, September 2001
4. Ann Powers, Jeffrey Miller, and Nancy Long Elder , Introduction to Environmental Law: Cases and Materials on Water Pollution Control. Publisher: Environmental Law Institute; 1st edition (1 August 2008)

Reference books

1. S.N. Mishra, Indian Penal Code - With The Criminal Law (Amendment) Act, 2018.

Course Outcomes	**Program Outcomes**												**PSOs**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	1	3	1	2	1	3	2	3	2	2	1	1	3	1	2
CO2	1	3	1	2	1	3	2	3	2	2	1	1	3	1	2
CO3	1	3	1	2	1	3	2	3	2	2	1	1	3	1	2
CO4	1	3	1	2	1	3	2	3	2	2	1	1	3	1	2
CO5	2	3	2	3	1	3	2	3	2	2	2	1	3	1	2

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Climate Change & Impact on Global Economy	*Course Code: 20EV652*
Credits: 3	*Total Contact Hours (L:T:P): 39:0:0*
Type of Course: Theory	*Category: Open Elective Course- II*
CIE Marks: 50	*SEE Marks: 100*

Pre-requisite: Environmental studies

Course Objectives

The course provides conceptual understanding of the drivers of climate change and its impacts on global climate, food-energy-environment nexus and the need for sustainable development along with mitigate measures integrated with cost benefit analysis.

Course Outcomes: After completing this course, students should be able to:

CO1:	Explain key concepts of climate change and its anthropogenic drivers and occurrence of extreme events
CO2:	Analyse the inter links of weather, emissions, global warming and food security, inflation, poverty and need for sustainable development and carry out cost benefit analysis for given climate variability scenario
CO3:	Discuss the technical possibilities for climate change reversal
CO4:	Review the global level policy options and implications
CO5:	Interpret the trends in global emissions and understand the possible economic options to regulate climate change through carbon pricing

Unit No.	Course Content	No. of Hours
1	**Global climate** – Global carbon emissions- past, present, future scenario, burden of climate change, vulnerability to climate change. **Climatic variability and extreme weather events** - radiative forcing, cloud burst, heat wave, drought, floods, hurricanes, hydro-geological hazards, relevant episodes	**09**
2	**Economic analysis of Global Climate Change-** Cost benefit analysis of global climate change, global warming and climate damage function, Impact on growth and inflation, global production function, supply and demand effects Market economy vulnerable to global warming for sectors- water, agriculture, coastal resources, energy, forestry, tourism and others Stern report and Nordhaus model, economic liability	**08**
3	**Low-carbon pathway for sustainable future** - energy security and energy transition index, zero emission coalitions, methods/technologies for reversing global heating, clean development mechanism (CDM) and applications, ecological foot print index	**07**
4	**Policy Responses to climate change**- Paris agreement 2015, COP26, sustainable development goals (6,7,13) Proactive policy approaches – pollution prevention acts of different countries	**07**

5	**Climate change mitigation** **Economic policy options** - Carbon pricing emission trading, carbon taxes **Climate change adaptation strategies** (by sector) - water, agriculture, infrastructure, human health	**08**

Text books

1. P K Rao (2015), The Economics of Global Climate Change, Routledge, Taylor and Francis Group.

Reference books

1. Intergovernmental Panel on Climate Change Reports -2013, 2014, 2018
2. UNCC e-learning course on climate change
3. http://mudancasclimaticas.cptec.inpe.br/~rmclima/pdfs/destaques/sternreview_report_complete.pdf

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	3	3	3	1	2	1	3	3	2	1
CO2	3	2	1	3	1	3	3	3	2	2	3	3	3	2	3
CO3	3	3	2	2	1	2	3	3	2	2	1	3	3	2	3
CO4	3	1	1	2	1	3	3	3	1	3	2	3	3	3	1
CO5	3	3	2	3	2	3	3	3	1	2	3	3	1	2	2

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Urban Environment & Sustainability	***Course Code: 20EV653***
Credits: 3	***Total Contact Hours (L:T:P): 39:0:0***
Type of Course: Theory	***Category:*** **Open Elective Course - II**
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Environmental studies

Course Objectives

The course provides knowledge on the interrelationship between urbanization and environment and application of technologies/techniques of life cycle analysis and zero waste governed by acts and regulations for sustainable cities

Course Outcomes: After completing this course, students should be able to:

CO1:	Explain urbanization and associated environmental issues.
CO2:	Associate the significance of town planning and its implications on the environmental and related laws.
CO3:	Apply appropriate ecological approaches integrated with public awareness and accountability for sustainable and livable cities.
CO4:	Explain the need for sustainability and inherent challenges.
CO5:	Apply the concepts of life cycle analysis, zero waste, carbon credits and relevant technologies governed by environment acts and protocols for sustainable urbanization.

Unit No.	Course Content	No. of Hours
1	**Environment in an urban setting** Introduction to urbanization; urban speculation and associated environmental issues; commoditization of nature; metros, cities and towns as sources and sinks; resource consumption - social, cultural, economic and ecological perspectives; urban transformation; Urban heat island and environmental implication.	8
2	**Urban dwelling** Housing scenario across a range of large-medium-small cities; poverty and slums in an urban context; Town planning Acts and their environmental aspects; waste disposal, accumulation and impacts on environmental attributes; environmental costs of urban infrastructure; challenges associated with sustainability and urban future. Horizontal and vertical growth concept. Concept of 'controlled nature'; organization and planning of green spaces such as parks, gardens and public spaces; concept of green belts; urban natural forest ecosystem as green lungs.	9
3	**Planning and environmental management** Environmental planning – types of planning – planning processes and tools – indicators of sustainability in planning and development of settlements, natural resource utilization, smart cities, management of urban environment; alternative resources; policy and management decisions. Environmental ethics, laws and management –principles of ecological approach to urban and regional planning – public awareness and accountability. Blending environmental concepts, Environmental Management systems for urban development.	8

4	**Sustainability** Need and concept, challenges, Environmental issues: climate change, resource depletion, food-energy-water nexus, eutrophication, acidification, human/ecosystem toxicity, smog, ozone depletion, sustainable urban environment.	7
5	**Models and Frameworks for Sustainability** Environment acts and protocols, Global, regional and local environmental issues, carbon credits, zero waste concept, LCA, sustainable habitat, Green buildings and materials, Energy – conventional and renewable, technology and sustainable development, sustainable urbanization, Industrial ecology. landscape engineering.	7

Text books

1. Sioshansi Fereidoon, (2011), Energy sustainability and the environment technology,
2. BUEREN, E.V., (2012), Sustainable urban environments: an ecosystem approach.
3. Adams, W.M. (2001): Green Development: Environment and Sustainability in the Third World, Routledge, London.

Reference books

1. Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case studies, Pretice Hall.
2. Gaston, K.J. 2010. Urban Ecology. Cambridge University Press, New York.
3. McIntyre, N.E. 2000. Urban ecology as an interdisciplinary field: differences in the use of 'urban' between the social and natural sciences. Urban Ecosystems 4: 5-24.
4. Montgomery, M.R. 2009. Urban Transformation of the developing world. Science 319: 761-764.
5. The Urban Environment, Royal Commission on Environmental Pollution, Twenty-sixth Report, chairman: Sir John Lawton CBE, FRS.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	1	1	1	2	3	3	3	1	1	1	3	3	1	1
CO2	3	3	2	1	1	3	3	3	1	1	2	3	3	3	3
CO3	3	2	2	1	1	2	3	3	3	3	2	3	2	2	3
CO4	3	2	2	2	2	3	3	2	1	2	1	3	2	1	3
CO5	3	3	2	2	2	3	3	2	1	2	1	3	2	2	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Environmental Hygiene and Sanitation	*Course Code: 20EV661*
Credits : 3	*Total Contact Hours: (L:T:P): 39:0:0*
Type of Course: Theory	*Category: Open Elective Course -III*
CIE Marks: 50	*SEE Marks: 100*

Pre-requisite: Environmental Studies

Course Objectives

The course offers knowledge on the interlinks between environment, water, sanitation and hygiene (WASH), as applicable to both individual and community/public health and also provides insights on various initiatives related to WASH in the country.

Course Outcomes: After completing this course, students should be able to:

CO1:	Develop a conceptual understanding on key issues related to environment, Ecology and Water Management
CO2:	Describe the significance of hygiene for physical well being
CO3:	Paraphrase the urban, rural sanitation and use of social media (print and digital) for sanitation awareness
CO4:	Associate environmental attributes, lifestyle practices and policy matters to individual/community/public health
CO5:	Explain the existing policies and programmes in the country related to WASH

Unit No.	Course Content	No. of Hours
1	**Introduction** Environment and Ecology: Concepts, Principles and Components. Environmental Pollution and Health Hazards. Sustainable Development Goals (SDG) pertaining to Environmental Issues. WASH (Water, Sanitation and Hygiene): Concept, Principles and Practices and programme. **Water Management:** Water: Use, Sources, Systems in Rural and Urban Settings. **Techniques for Effective Water Management**- Rainwater Harvesting, Liquid Waste Management. Institutional Frame work for Monitoring Quality and Strategizing	**08**
2	**Hygiene** Definition, Concept, Principles, Importance and Applications. Types of Hygiene: Personal, Food safety- sources of contamination and its effects, Community Medical and Culinary hygiene **Standard Hygiene Practices:** Adoption of Hygiene Guide lines for Protection and Promotion of Health and Welfare.	**08**
3	**Sanitation** Sanitation: Definition, Concept, Principles, Importance and Applications Types of Sanitation: Rural (Rural Community Health: Village health sanitation) and Urban, Institutional. Sanitation in Public places, scenarios of open defecation and their impacts. Waste Management: Types and its Management	**08**

	Public Awareness through Digital Media - Mobile Apps of Government of India: National Health Policy, Swasth Bharat, Pradhan Mantri Surakshit Mantritva Abhiyan (PM SumanYojana), My Hospital (Mera aspataal), India fights Dengue, Jansankhya Sthirata Kosh (JSK) Helpline, Ayushman Bhava, Arogya Setu, Covid 19.	
4	**Public Health** Health: Determinants of Health and Well-being, Right to Health Community Health, Health Status and Health Problems in India Communicable and Non-Communicable, water and air borne Diseases Lifestyle Illnesses Emerging Concerns related to Public Health	**08**
5	**Health Administration and Policies and Programmes related to WASH** Organization and Administration of Health Care from Centre to the Village Level. Health Education: Components, and Importance. Communication Strategies for Health Promotion. Health Policies and Programmes in India. Policies and Programmes related to WASH- Governmental Policies and Programmes - Total Sanitation Campaign (TSC) Programme 1999, Nirmal Bharat Abhiyan 2012; Swachh Bharat Mission 2014, and Role of Local Bodies. Accelerated Rural Water Supply Programme (ARWSP), the Sector Reforms Project, Swajal Dhara, and the National Rural Drinking Water Programme (NRDWP), Swacch Jal, Jal Jeevan Mission (JJM). Best practices in India.	**07**

Text books

1. Adelaide M. L. (2008). Environmental Sanitation and Gender among the Urban Poor. Germany: VDM Verlag Dr. MuellerE.K.
2. Bansil,P.C. (2004).Water Management in India. NewDelhi: Concept Publishing Company.
3. Murali, K.V.S.G.K. (2012). Environmental Sanitation. New Delhi : Reem Publications

Reference books

1. Cronin, A. A. (2019). Gender Issues in Water and Sanitation Programmes: Lessons from India. New Delhi:Sage Publication
2. NathK. J. & SharmaV. P. (2017). Water and Sanitation in the New Millennium. New Delhi: Springer.
3. Sharma, P. D. (2012). Ecology and Environment. Meerut : Rastogi Publications.

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	3	2	3	2	3	3	3	1	1	2	2	2	3	3
CO2	3	3	2	3	2	3	3	3	1	1	2	2	3	2	3
CO3	3	3	2	3	2	3	3	3	1	1	2	2	3	2	2
CO4	3	3	2	3	2	3	3	3	1	1	2	2	2	3	2
CO5	3	3	2	3	2	3	3	3	1	1	2	2	2	2	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High associatio

Course Title: Environmental Impact of Infrastructure Projects	*Course Code:20EV662*
Credits: 3	*Total Contact Hours: (L:T:P):39:0:0*
Type of Course: Theory	*Category: Open Elective Course -III*
CIE Marks: 50	*SEE Marks: 100*

Pre-requisite: Environmental studies

Course Objectives

The course offers knowledge on the need and importance of impact assessment for sustainable development, tools and methods for assessing the adverse and positive impacts of infrastructure activities on environmental attributes and public participation with demonstrated case studies.

Course Outcomes: After completing this course, students should be able to:

CO1	explain the need for impact analysis of infrastructure projects and its activities on environmental systems, purpose, scope, hierarchical aspects and the different stages of EIA process.
CO2	Analyze various Techniques of conducting EIA process and describe the role and necessity of EMP.
CO3	Evaluate the impacts of developmental projects on the concerned environmental attributes.
CO4	Explicate the need and importance of public participation, its framework and describes EIA audit procedure.
CO5	Analyze the case studies and apply the knowledge of EIA to various infrastructure development activities.

Unit No.	Course Content	No. of Hours
1	**Introduction -** Definition, Purpose and Scope of EIA, Types of EIA. Evolution of EIA in India and other countries. The EIA process, Chapter contents in EIA, Procedural and methodological Limitations. Environmental Management Plan (EMP).	**07**
2	**Methodologies & Techniques in EIA -** Adhoc, checklist, matrix, overlays, networks, BEES, Cost-Benefit-Analysis (CBA), brain storming, fuzzy, Delphi technique.	**08**
3	**Guidelines and Regulations** – Environmental Protection Act, EIA Notification of 2006 and subsequent amendments, Environmental Clearance practices in India, terms of reference – Standard and additional for EIA/EMP report for projects/activities, MoEF&CC guidelines on infrastructure projects, ecologically sensitive areas, NABET accreditation for EIA consultants, Role of National Green Tribunal in EIA.	**08**
4	**Environmental Attributes -** Air, water, land, sound, socio economic aspects, biodiversity. Prediction models used in EIA. **Public participation in EIA -** Need, objectives, elements and framework for public participation – step by step procedure.	**08**

5	**Post EIA activities** - EIA audit –Types and auditing procedure, EIA case studies – Category A, B1 and B2	**08**

Text books

1. Anjaneyulu Y and Valli Manickam (2020), 3rd Edition, B S Publications, "Environmental Impact Assessment Methodologies".
2. Raman N S, A R Gajbhiye, S R Khandeshwar (2014), 1st Edition, IK International Publications Pvt. Ltd., "Environmental Impact Assessment".
3. Rau and Wooten, (1981), "Environmental Impact Assessment" Handbook.
4. Jain R.K., Urban L.V., Stacey G.S., (1977), "Environmental Impact Analysis – A New Dimension in Decision Making", Van Nostrand Reinhold Co.

References

1. Anji Reddy Mareddy and Anil Shah (2017), 1st Edition, B S Publications, "Environmental Impact Assessment - Theory and Practice". Elsevier Science
2. Clark B.C. Bisett and Tomlinsan P, (1985), "Perspective on Environmental Impact Assessment", Allied Publishers.
3. Canter L., (1995), "Environmental Impact Assessment", McGraw Hill.
4. Journals - Science Direct, acs.org.
5. EIA notifications and Publications, MoEF & CC, GoI

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	1	1	1	1	3	3	3	3	2	1	3	2	1	1
CO2	3	2	3	3	2	2	3	3	2	2	2	3	3	2	2
CO3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3
CO4	1	3	2	2	1	3	3	3	3	3	2	2	2	2	2
CO5	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Waste Management	*Course Code: 20EV663*
Credits (L:T:P): 3	*Total Contact Hours: (L:T:P):39:0:0*
Type of Course: Theory	*Category: Open Elective Course III*
CIE Marks: 50	*SEE Marks: 100*

Pre-requisite: Environmental Studies

Course Objectives

The course provides knowledge of engineering principles and practices of municipal, biomedical and e-waste management including treatment and disposal options.

Course Outcomes: After completing this course, students should be able to:

CO1:	Identify and have the knowledge of basic engineering principles and practices of waste management of solid waste and their environmental implications.
CO2:	Explain the proper basic engineering principles of Hazardous waste and of biomedical waste management and their environmental implications.
CO3:	Explain the basic engineering principles of E- waste management and disposal and their environmental implications,
CO4:	expound the necessity and implications of Waste Minimization, Resource Recovery and Lifecycle assessment and the management concepts.
CO5:	Identify and relate the relevant regulation of waste management policy adopted in national and international level

Unit No.	Course Content	No. of Hours
1	**Solid Waste Management:** Introduction, Characteristics and Quantities, generation rates, waste Collection, transportation, segregation, processing, treatment and disposal: Case Studies.	**09**
2	**Hazardous Waste Management:** Hazardous wastes and the environment, Waste management hierarchy, Transportation, Hazardous wastes treatment, storage, and disposal facilities, Source reduction, recycling, disposal, and treatment, major safety operations in the management of hazardous waste. **Biomedical Waste Management:** Introduction, types and categories, Segregation, collection and transportation, disinfection, processing, treatment and Disposal of biomedical waste : Case Studies.	**09**
3	**Electronic Waste (E-Waste) Management:** Issues and Status in India and Globally E-Waste Management Rules 2016 and Management Challenges Exposure pathway of pollutants emitted from Recycling of E-Waste E-waste Management: Case Studies.	**06**
4	**Construction and Demolition (C&D) waste management:** Environmental degradation due to indiscriminate disposal of C & D wastes, Quantification & composition of C & D waste generation, Type of C & D wastes products proposed under Rules, Roadmap for C & D waste management, C & D waste processing, Hierarchy in waste management, Importance of recycling C & D Wastes, Sustainable Model' on C & D waste management Environmental Management – noise and dust, impact on soil and water.	**09**

5	Municipal Solid Waste (Management and Handling) Rules, 2000; Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2015 Bio-medical Waste Management Rules, 2016, C & D Waste Management Rules, 2016 **Current Issues**: Life cycle assessment, Flyash rules; recycled plastics usage rules; commuter vehicle batteries (management and handling) rules Swachh Bharat Mission and Status in Smart Cities in the Country Construction and Demolition (C&D)	**06**

Text books

1. George Techobanoglous et al, (2014) "Integrated Solid Waste Management", McGraw - Hill, 2014.
2. Techobanoglous Thiesen Ellasen (2014), "Solid Waste Engineering Principles and Management", McGraw – Hill.
3. Tchobanoglous G., Theisen H., Viquel S.A., "Integrated Solid Waste Management: Engineering, Principles and Management issues", Tata McGraw Hill Publishing Company Ltd., New Delhi.
4. Wentz C. A., (1995),"Hazardous Waste Management", McGraw Hill International Edition.
5. Davis M. L., and Cornwell D.A. (1998),"Introduction to Environmental Engineering", McGraw Hill International Edition.
6. Johri R., "E-waste: implications, regulations, and management in India and current global best practices", TERI Press, New Delhi.

Reference books

1. Manual on Municipal Solid Waste Management, CPHEEO, Ministry of Urban Development, Govt. Of. India, New Delhi, 2000.
2. Guidelines for Hazardous Waste Management, CPHEEO, Ministry of Urban Development, Govt. Of. India, New Delhi.
3. Guidelines for Biomedical Waste Management, CPHEEO, Ministry of Urban Development, Govt. Of. India, New Delhi
4. Guidelines for E-waste Management and Handling, CPHEEO, Ministry of Urban Development, Govt. Of. India, New Delhi.

Web links

1. https://cpcb.nic.in/openpdffile.php?id=TGF0ZXN0RmlsZS8xNTlfMTQ5NTQ0NjM5N19tZWRpYXBob3RvMTkyLnBkZghttps://cpcb.nic.in/uploads/MSW/SWM_2016.pdf
2. https://cpcb.nic.in/displaypdf.php?id=aHdtZC9IV01fUnVsZXNfMjAxNi5wZGY

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	3	3	2	1	1	2	2	3	3	3
CO2	3	3	3	2	3	3	3	2	1	1	2	2	3	3	3
CO3	3	3	3	2	3	3	3	2	1	1	2	2	3	3	2
CO4	3	3	3	2	3	3	3	2	1	1	2	2	3	3	2
CO5	3	3	3	2	3	3	3	2	1	1	2	2	3	2	2

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Wastewater Treatment Process Laboratory	***Course Code: 20EV67L***
Credits: 1.5	***Total Contact Hours (L:T:P): 0:0:39***
Type of Course: Laboratory	***Category: Professional Core Course***
CIE Marks: 50	***SEE Marks: 50***

Pre-requisite: Wastewater Treatment Engineering

Course Objective:

The lab course provides an opportunity to collect, preserve, characterize wastewater and industrial wastewater samples using conventional and advanced instruments, and perform bench scale treatability studies.

Course Outcomes: After completing this course, students should be able to:

CO1:	Describe the standard procedure for collection, preservation and characterization of domestic and industrial wastewater samples.
CO2:	Carryout bench scale treatability studies for treating wastewater and evaluate its compliance for relevant management options.
CO3:	Infer the laboratory results obtained and perform sludge characterization studies. Describe the application of advanced equipment's.

Unit No.	Course Content	No. of Hours
1	Introduction to the laboratory Wastewater Treatment Process Laboratory	**3**
2	Domestic and industrial Wastewater Characterization.	**3**
3	Determination of BOD and other parameters	**3**
4	Determination of COD and other parameters	**3**
5	Coagulation and Flocculation Experiments followed by sedimentation process.	**3**
6	Bench Scale Experiments – Aerobic/anaerobic treatment units	**3**
7	Wastewater Polishing Units - Water Hyacinth, Duckweeds, etc.	**3**
8	Adsorption (batch/column studies) experiments for the removal of color from effluent.	**3**
9	Sludge Analysis – Proximate analysis, ultimate analysis, VSS, VFA, Nitrates & Phosphates.	**3**
10	Sludge Analysis – VSS, VFA, Nitrates & Phosphates.	**3**
11	Sludge Analysis – Settleability, filterability using Buchner funnel Tests, Capillary Suction Time Test.	**3**
12	Demonstration of Advanced Instruments - GC, HPLC, ICP, TKN, SEM and XRD.	**3**
13	Continuous Internal Evaluation	**3**

Text books

1. Metcalf and Eddy, (2014), "Wastewater Engineering, Treatment and Reuse", 4th Edition, Tata McGraw Hill Edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi.

Reference books

1. American Public Health Association, American Water Works Association, (2012), Standard Methods for Examination of Water and Wastewater, 21st Edition, APHA.
2. Adams and Eckenfelder Jr. W.W. (1974), "Environmental, Process Design Techniques for Industrial Waste Treatment", Nashville (USA), 1974.

Course Outcomes	**Program Outcomes**												**PSOs**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	3	2	2	3	3	1	3	3	3	3
CO2	3	3	3	3	3	3	3	2	3	3	2	3	3	3	3
CO3	3	3	2	3	3	2	3	2	3	1	1	3	3	2	3

0 --- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Design & Drawing of Environmental Systems	***Course Code: 20EV68L***
Credits: 1.5	***Total Contact Hours(L:T:P): 0:0:39***
Type of Course: Laboratory	***Category: Professional Core Course***
CIE Marks: 50	***SEE Marks: 50***

Pre-requisite: Water Treatment and Supply Engineering, Atmospheric Environmental Engineering

Course Objectives

The course reinforces design aspects, drawing skills and capabilities to prepare Engineering drawings of water supply, wastewater collection and treatment facility along with air pollution control equipment.

Course Outcomes: After completing this course, students should be able to:

CO1:	Explain the basics of drawing and design of water treatment and supply components.
CO2:	Carryout design and drawing of conventional and decentralized wastewater treatment systems.
CO3:	Draw typical drawings for storm and air pollution control equipment.

Unit No.	Course Content	No. of Hours
1	Drawing basics, use of scales, One BHK and Two BHK Plan, Elevation and Section	**3**
2	**Design and drawing of water supply scheme:** Bell mouth canal and river / reservoir intakes	**3**
3	**Design and drawing of water supply scheme:** Cascade aeration unit. Clari-flocculator	**3**
4	**Design and drawing of water supply scheme:** Rapid sand filters	**3**
5	**Design and drawing of water supply scheme:** Layout of water supply system – and house service connection	**3**
6	**Wastewater treatment facilities:** Screens and Grit Chamber	**3**
7	**Wastewater treatment facilities:** Settling Tank. Trickling Filter	**3**
8	**Wastewater treatment facilities:** Anaerobic Digester and Sludge Drying Beds, Stabilization Pond	**3**
9	**Wastewater treatment facilities:** Septic Tank, Dispersion Trench and Soak Pit.	**3**
10	**Storm water design:** Typical drawings on street inlet (V, L and Box/ trapezoidal) drains.	**3**
11	**Air Pollution Control Systems:** Typical drawings on Settling Chambers, Bag Filter and Cyclone Separator.	**3**
12	Hydraulic Profile of Conventional water treatment plant, Conventional wastewater Treatment System.	**3**
13	Continuous Internal Evaluation	**3**

Text books

1. Metcalf and Eddy, (2014), "Wastewater Engineering, Treatment and Reuse", 4th Edition, Tata McGraw Hill Edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi
2. Karia, G. L., and Christian, R.A., (2018) "Wastewater Treatment: Concepts And Design Approach "– Prentice – Hall of India

Reference books

1. CPHEEO Manual on "Water Supply and Treatment" Ministry of Urban Development, Government of India, New Delhi.
2. Raju, B. S. N., (1995), "Water Supply and Wastewater Engineering", Tata McGraw Hill Pvt. Co. Ltd., New Delhi.
3. Quasim, S. R., (1985), "Wastewater Treatment Plants – Planning, Design and Operation", Holt Rinehart and Winston, CBS College Publishing.
4. Hammer, M. J., (2013), "Water and Wastewater Technology", SI Version, Second Edition, John Wiley and Sons.
5. Quasim Syed R., (1985), **"**Wastewater Treatment Plants – Planning, Design and Operation" – Holt Rinehart and Winston, CBS College Publishing.
6. CPHEEO Manual, **"**Sewerage & Sewage Treatment",, Government of India.
7. Sincero, A. P., and Sincero, G.A., (2014), **"**Environmental Engineering: A Design Approach" –Prentice Hall of India.
8. Wark. K., Warner, and Davis, W.T., (1998), **"**Air Pollution its Origin and Control**",**

Course Outcomes	**Program Outcomes**												**PSOs**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	3	3	1	2	2	1	2	1	2	2	3	2	3	2
CO2	3	3	3	1	2	2	1	2	1	2	2	3	2	3	2
CO3	3	2	2	1	1	2	1	2	1	2	2	3	2	3	2

0 -- No association 1---Low association, 2--- Moderate association, 3---High associatio

Course Title: Mini Project	*Course Code: 20EV69P*
Credits : 02	*Total Contact Hours: (L:T:P):0:0:0*
Type of Course: Mini Project Work	*Category: Mini Project Work*
CIE Marks: 50	*SEE Marks: -*

Pre-requisite: Nil

Course Objectives:

The project work trains the students to carry out literature review, critically think and identify the gaps/problems, devise workable objectives and methodology, conduct the investigation following engineering ethics, and analyze, interpret and present the findings. Active involvement develops creative thinking, planning, time management, leadership qualities and managerial skills.

Course Outcomes: After completing this course, students should be able to:

CO1:	Define workable objectives and scope of work based on thorough literature review
CO2:	Develop skills in terms of design, conduct investigations and data analytics
CO3:	Develop oral and written communication skills for report preparation, paper publication and technical presentation

Guidelines:

1. The mini-project is a team activity having 3-4 students in a team.
2. Each student shall be associated with a faculty member serving as his/her guide to supervise the mini project.
3. The student will work with the project guide/supervisor towards the identification of the problem through a systematic literature review and will finalize the objectives and scope of work.
4. Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and submit the proposal within first week of the semester to the Department Under-Graduate Committee (DUGC) after due approval from the guide.
5. The student is expected to exert on design, development and testing of the proposed work as per the schedule.
6. There shall be an interim progress review and a final presentation.
7. Completed mini project and documentation in the form of mini project report is to be submitted at the end of semester.

Evaluation procedure:

- CIE of 50 marks
- Interim review
- Final presentation
- Report

Course Outcomes	Program Outcomes												PSOs		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	2	3	2	3	2	3	2	3	2	3
CO2	3	3	3	2	3	2	3	2	3	2	3	3	3	2	3
CO3	3	3	3	2	2	2	3	3	3	3	2	3	3	3	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Essence of Indian Traditional Knowledge	***Course Code: 20HU611***
Credits: 0	***Total Contact Hours(L:T:P): 26:0:0***
Type of Course: Theory	***Category: HSMC***
CIE Marks: 50	***SEE Marks: -***

Course Objective:

- The course aims at imparting basic principles of thought process, reasoning and inferencing.
- To focus on introduction to Indian Knowledge Systems, Indian perspective of modern scientific world-view, and basic principles of Yoga and holistic health care system.

Course Outcomes:

CO1: Ability to understand, connect up and explain basics of Indian traditional knowledge in modern scientific perspective.

Sl. No.	Course Content
1	Basic structure of Indian Knowledge System: Ashtadhashavidya–4 Veda, 4 Upaveda (Ayurveda, Dhanurveda, Gandarvaveda, Sthapathya Adi) 6 Vedanga (Shiksha, Kalp, Nirukth, Vyakaran, Jyothishya, Chand) 4 Upadg (Dharmashashtra, Mimamsa, Purana, Tharkashashtra).
2	Modern Science and Indian Knowledge System
3	Yoga and Holistic Health care
4	Case studies

References:

1. V. Sivaramakrishnan (Ed.), Cultural Heritage of India-course material, Bharatiya Vidya Bhavan, Mumbai. 5th Edition, 2014.
2. Swami Jitatmanand, Modern Physics and Vedant, Bharatiya Vidya Bhavan.
3. Swami Jitatmanand, Holistic Science and Vedant, Bharatiya Vidya Bhavan.
4. Fritzof Capra, Tao of Physics.
5. Fritzof Capra, The Wave of life.
6. VN Jha (Eng. Trans.), Tarkasangraha of Annam Bhatta, International Chinmay Foundation, Velliarnad, Arnakulam.
7. Yoga Sutra of Patanjali, Ramakrishna Mission, Kolkata.
8. GN Jha (Eng. Trans.), Ed. RN Jha, Yoga-darshanam with Vyasa Bhashya, Vidyanidhi Prakashan, Delhi 2016.
9. RN Jha, Science of Consciousness Psychotherapyand Yoga Practices, Vidyanidhi Prakashan, Delhi 2016.
10. P B Sharma (English translation), Shodashang Hridayan. Pedagogy: Problem based learning, group discussions, collaborative mini projects.

7th Semester Syllabus

Course Title: Management Practices In Environmental Engineering	***Course Code*: *20EV710***
Credits: 4	***Total Contact Hours: (L:T:P): 52:0:0***
Type of Course: Theory	***Category: HSMC***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Nil

Course Objectives

To provide the engineering graduates with technical expertise in Environmental Management which enables them to have a career and professional accomplishment in the public or private sector which helps to develop, implement, monitor and maintain environmental strategies, policies, programmes and systems that promote sustainable development.

Course Outcomes: After completing this course, students will be able to:

CO1	The student clearly distinguishes between reactive and proactive management, able to correlate between environment and economy and understands the need for organizational structure for effective environmental management.
CO2	Develop ability to define functions and identifies types and levels of management, develops SWOT /SWOC for improved management style.
CO3	Builds the base for efficient personnel management by acquiring skills like time management, interactive leadership style, human relationship.
CO4	Able to appreciate the project formulation, applies CPM & PERT for good decision making. Capable of planning appropriately using carrying capacity concept.
CO5	Imbibes excellent communicating skill, understands the role of non-profit organizations and media in environmental management.

Unit No.	Course content	No. of Hours
1	**Introduction**: Proactive and Reactive environmental management. Environment and economy – excludability and rivalry. Continuous and continual improvement. Organizational structure for Environmental Management at central and state levels. Environmental audits.	**10**
2	**Management Basics & Strategies:** Definitions of management, Functions of management - classification, coordination, Types and levels of management, TOWS matrix, TQM and environmental protection, ISO 14000 and 18000 series of Standards.	**10**
3	**Personnel management:** Motivation–importance, need theory-Moslow, pre-requisites. Time and man management, factors of production and entrepreneurship. Employee- employer relationship, leadership styles and situational model, leadership qualities. Communication – elements and objectives, characteristics, barriers, (verbal & nonverbal), downward & upward, factors and soft skills.	**10**

4	**Project formulation:** Bar chart & milestone charts, programme evaluation & review technique (PERT) & time estimates, Critical path method (CPM) and scheduling, decision matrix – problems. Innovative Formulation of SWM Project **Cleaner technologies:** cleaner production and prevention of pollution in small businesses, CT and their role in environmental management: limitations. Incorporating cleaner production in to EIA. Life cycle assessment in to process, zero emissions-the ultimate goal of cleaner production. CP in select red category industries – mining, breweries, pulp and paper mills. Sugar, Automobile Manufacturing, Milk and dairy products.	**12**
5	**Environmental communication:** Role of institutions, (NGOs, GOs, educational institutions), Politics, Popular Culture, role of public, media. **Environmental Research:** Need, areas of research, applied and advanced research, premier research organizations.	**10**

Text books

1. Lohani, B. N., (1984), "Environmental Quality Management" - South Asian Publishers, New Delhi.,
2. Schermerhorn J.R., (2010), "Introduction to Management", Tenth Edition, International Student Version, John Wiley and Sons Inc., UK
3. Richard Welford, (1999), "Corporate Environmental Management", Universities Press.

References

1. Suresh, K. and Dhameja, (2000), "Environmental Engineering and Management", S. K. Kataria and Sons
2. Peurifoy, R. L., (2016), "Construction Planning Equipment and Methods", McGraw Hill.
3. Banga, and Sharma, (2007), "Industrial Organization and Engineering Economics", Khanna Publishers.

Course Outcomes	**Program Outcomes**												**PSO's**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
CO2	3	2	2	2	2	1	2	1	3	2	2	3	2	3	2
CO3	3	3	2	3	2	1	2	2	3	2	3	2	2	2	3
CO4	1	2	1	1	2	2	1	3	3	3	2	2	2	3	2
CO5	3	2	2	3	2	3	2	3	2	3	3	3	2	2	2

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Operation and Maintenance of Environmental Facilities	***Course Code: 20EV721***
Credits : 3	***Total Contact Hours:(L:T:P):39:0:0***
Type of Course: Theory	***Category: Professional Elective Course - III***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Water Treatment Supply Engineering, Wastewater Treatment Engineering.

Course Objectives

The course encompasses intricate aspects regarding operation and maintenance of environmental facilities.

Course Outcomes: After completing this course, students will be able to:

CO1:	Understands the need for O & M, basic principles, learns organization structure, work plan scheduling and the necessity of automation in environmental facilities
CO2:	Identity operational problems and develops a plan for corrective measures of water supply and treatment facilities
CO3:	Explain the operational problems and providing corrective measures for wastewater collection and treatment facilities
CO4:	Develops sufficient knowledge on operational problems and remedial measures of air pollution control equipment
CO5:	Gains knowledge on O&M of sanitary and hazardous waste disposal facilities.

Unit No.	Course Content	No. of Hours
1	**Operation, Maintenance & Management:** Aims, Basic Principles, Data Base Facilities, Drawings, Detailed Plans, Record Keeping, Organizational Structure, Work Planning and Scheduling, Operation Manuals. Training needs and planning. Automation in O & M of Water and Wastewater systems. O & M costing for environmental facilities.	**07**
2	**Water Supply Facilities:** Operational Problems and Corrective Measures for Intakes, pumps, rising mains, Distribution System - Loss of carrying capacity in pipes, Projection of Pipe Break Rates, Leak Detection and control. Appurtenances – Valves, Hydrants and Fittings. **Water Treatment Facilities:** Operational Problems and Corrective Measures for Screens, Aeration Unit, Sedimentation Tank, Clariflocculator, tube settlers, Pulsators, Filtration, Disinfection units and advance treatment units.	**09**
3	**Wastewater Collection Facilities:** Operational Problems and Corrective measures in Sewer Network, Inspection Methods, Safety Methods, Appurtenances and pumps. **Wastewater Treatment Facilities:** Operational Problems and Corrective Measures for Screening, Grit chamber, aeration tanks, trickling filters and bio-towers, SBR and Membrane techniques, settling tanks, Sludge Thickener, sludge digesters, sludge drying beds, Disinfection units. Operation & Maintenance of Fecal Sludge Treatment plant.	**09**

4	**Air Pollution Control Facilities:** Operational Problems and Corrective Measures for Gravity Settlers, Cyclone Separators, Bag Filters, Scrubbers, Electrostatic Precipitators, and Gaseous Emission Control Devices – Absorption Beds and Adsorption Columns, Thermal Oxidizers, Incinerators.	**06**
5	**O & M of disposal facilities:** Operational Problems and Corrective Measures for engineering landfill, hazardous and biomedical waste disposal facilities. Recent trends : preventive and predictive O &M strategies, online monitoring of environmental quality parameters, Financial models	**07**

Text books

1. Metcalf & Eddy Inc, (2014) , "Wastewater Engineering, Treatment and reuse"-4th Edition, Tata McGraw Hill Publishers Co. Ltd, New Delhi
2. Hammer, M.J., (2013), "Water and Wastewater Technology–SI Version" -2nd Edition, John Wiley and Sons.
3. William L Neumann, (1997) "Industrial Air Pollution Control Systems" – McGraw- Hill Professional.
4. Walski, T.M. (1987), "Analysis of Water Distribution Systems" – CBS Publications, New Delhi.
5. Raju, B. S. N., (1991), "Water Supply and wastewater Engineering" – Tata McGraw-Hill Publishing Co. Ltd.

Reference books

1. Training Manual on O&M for Municipal Staff", Asian Development Bank, Government of Karnataka.
2. CPHEEO, (1999), "Manual on water supply and Treatment", Ministry of Urban Development, GoI, New Delhi.
3. CPHEEO, (2013), "Manual on Sewerage and Sewage Treatment", Ministry of Urban Development, GoI, New Delhi.
4. Manual on Solid Waste Management" – CPHEEO (2016)

Course Outcomes	Program Outcomes												PSO's		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	3	2	3	3	2	2	2	1	1	3	2	3	2	3
CO2	3	3	2	3	3	2	2	2	1	1	3	2	3	2	3
CO3	3	3	2	3	3	2	2	2	1	1	3	2	3	2	3
CO4	3	3	2	3	3	2	2	2	1	1	3	2	3	2	3
CO5	3	3	2	3	3	2	2	2	1	1	3	2	3	2	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Occupational Safety and Health	***Course Code: 20EV722***
Credits : 3	***Total Contact Hours:(L:T:P):39:0:0***
Type of Course: Theory	***Category: Professional Elective Course - III***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Elements of Environmental Engineering – Sources and characterization

Course Objectives

This course enables student to learn the basic principles of safety, OSH act and the national policy. It in stills knowledge on cause- effect relationships of accidents at workplaces, need for economics & ergonomics, hazard identification and control aspects, fire prevention and control. Work place health related issues are also covered.

Course Outcomes: After completing this course, students will be able to:

CO1	Gain knowledge on safety principles, right-to-know laws and manages situation applying theories of accident at workplace
CO2	Develop skill of understanding the ergonomics and address specific problems with appropriate strategies
CO3	Identify, analyse the hazards using various techniques and prepare preventive plans. Also, understands the hazards in selected industries and suggests remedial measures for their control
CO4	Describe the need for product safety and its importance and acquires knowledge on various aspects of fire-types, prevention and protection
CO5	Have an exposure to Health and Safety Considerations at different work places with a thorough understanding of ISO series of standards and Corporate Social Responsibility.

Unit No.	Course Content	No. of Hours
1	**Introduction:** History and development, occupational safety and health act, occupational safety and health administration, right to know laws, principles of safety and safety triangle, introduction to factories act 1948. Key elements and review of health and safety policies.	**05**
2	**Accident:** causation, investigation, investigation plan, Methods of acquiring accident facts, Supervisory role in accident investigation, Facts and fact finding – safety psychology and education. Theories of Accidents: Domino, human factor, Petersen's accident incident, epidemiological, human error model and combination theory. Ergonomics: Definition, factors associated with physical stress, worksite analysis programme, hazard prevention and control. Specific ergonomic problems and problem solving strategies, economics of ergonomics, visual ergonomics.	**10**

3	**Occupational Hazard and Control:** Hazard identification, hazard analysis, human error analysis in causation with hazard analysis, fault tree analysis and problems. Emergency response, decision for action, purpose and considerations. Engineering versus management control, hazard control measures, hazards and their control in various industries.	**10**
4	**Fire Prevention and Protection:** Fire development and its severity, effect of enclosure, need for early detection of fire, extinguishing fire, Fire risk assessment and fire emergency plan. Electrical Safety, Product safety – Technical Requirements of Product safety. Handling of chemicals- Routes of entry, sources of information used to convey a chemical's hazard, Safe handling of chemicals, safe handling of Equipment's and training.	**06**
5	**Occupational Health:** Health and safety considerations, personal protective equipment, effects of exposure and treatment for metal working trades, municipal solid waste, epoxy resins, and foundries. Occupational health and safety considerations in water and wastewater treatment plants, epidemiological survey. Recent Trends: ISO 14000 series, ISO 18000 series, ISO 45000. Corporate social responsibility and its rating, Introduction to BBS. Human – robot interaction, total safety management. International guidelines for OSHA	**08**

Text books

1. Colling, D. A., (1990), "Industrial Safety Management and Technology"–Prentice Hall, New Delhi.
2. Goetsch, D. L., (2019), "Occupational Safety and Health for Technologist, Engineers and Managers", 3rd Edition, Prentice Hall, New Delhi

Reference books

1. Della, D.E., and Giustina, (1996), "Safety and Environmental Management"– Van Nostrand Reinhold International Thomson Publishing Inc
2. Anand Gopal Mukherjee, (1986), "Environmental Pollution and Health Hazards – Causes and Control", Galgotia Publications Pvt. Ltd., New Delhi.
3. Trescothic, R.A., (1973), "Environmental and Industrial Health Hazards", William Heinemann Medical Books Ltd., London

Course Outcomes	**Program Outcomes**												**PSO**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	2	1	3	2	3	2	1	3	2	3	3	3	2	3
CO2	3	3	2	3	2	3	2	1	2	3	2	3	2	3	2
CO3	3	3	2	3	2	1	3	2	3	2	3	2	3	2	3
CO4	3	1	2	3	2	3	2	3	2	3	2	3	2	3	3
CO5	3	3	1	2	3	2	3	2	3	2	3	3	3	2	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Reactor Design Technology	***Course Code: 20EV723***
Credits: 03	***Total Contact Hours (L:T:P): 39:0:0***
Type of Course: Theory	***Category: Professional Elective Course III***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Environmental Chemistry, Engineering Mathematics, Advanced wastewater Treatment.

Course Objectives

The course emphasizes on the fundamental concepts of reaction kinetics, design approaches and design criteria for pressure and reaction vessels at lab-pilot-commercial scale.

Course Outcomes: After completing this course, students will be able to:

CO1	Explain the fundamentals of chemical kinetics
CO2	Identify and apply appropriate design fundamentals for material and process design of reactors
CO3	Design pressure vessels considering the system conditions and necessary accessories
CO4	Design reaction vessels considering the system conditions and necessary accessories
CO5	Apply the lab/pilot scale design considerations to scale-up and design commercial scale reactors

Unit No.	Course Content	No. of Hours
1	Chemical Kinetics: types of reactions, reaction order, rate of reaction, types of reactors.	**08**
2	Design Fundamentals – Material and energy balance approach, Mechanical design of reactors, Influencing parameters. Material selection, factors affecting design, stresses due to static and dynamic loads (Internal and External), temperature effects, and economic considerations.	**08**
3	Design of Pressure Vessels: Design parameters, conditions and stresses. Design of shell and other vessel components. Vessel at low and high operating temperatures. Design of components, supports and selection of vessels accessories and mountings. Numerical problems.	**08**
4	Design of Reaction Vessels: Design of reaction tanks-agitators, baffles, jackets, tank dimensions. Power calculations. Drive calculations and accessories. Support calculations for the system. Numerical problems.	**08**
5	Single and multiple reactor systems, batch, semi and continuous systems, scale up and design.	**07**

Text books

1. Smith J.M., (2014), "Chemical Engineering Kinetics", 3rd Edition, McGraw Hill International
2. Himmelblau D.M., (2015), "Basic Principles and Calculations in Chemical Engineering", PHI, New Delhi
3. S. D. Dawande, "Process Design of Equipment", Vol 1, Central Techno Publications. 3/e, 2003.

References

1. Bailey J. E., and Ollis D.F., (2011), "Biochemical Engineering Fundamentals", McGraw Hill International
2. Kutepor A. M., Bondareva T.I., and Berengarten M.G., (1988), "Basic Chemical Engineering with Practical Applications", Mir Publishers, Moscow
3. Geonkoplis C.J., (1999), "Transport Processes and Unit Operations", PHI, New Delhi

Course Outcomes	Program Outcomes												PSO		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	1	1	1	2	1	1	1	1	1	1	3	3	3	3
CO2	3	3	2	2	1	2	2	2	2	2	1	3	3	3	3
CO3	3	2	2	2	2	2	2	2	2	1	1	3	3	3	3
CO4	3	2	2	2	2	2	2	2	2	1	1	3	3	3	3
CO5	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Application of Statistics In Environmental Engineering	***Course Code:20EV731***
Credits: 3	***Total Contact Hours:(L:T:P):39:0:0***
Type of Course: Theory	***Category: Professional Elective Course IV***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Engineering Mathematics

Course Objectives

The student will have an overall understanding of statistics, types, and applications for effective management of environmental data. It covers a wide range of statistical aspects including data characteristics and grouping, correlation & regression, probability, testing hypotheses and time series analysis.

Course Outcomes: After completing this course, students will be able to:

CO1	The student outlines different forms of data, characteristics of data and its grouping, frequency analysis.
CO2	Able to learn skewness of the data, moving average and weighted mean concepts
CO3	Ability to analyze data distribution using random and non-random sampling, variance, probability and probability distribution
CO4	Able to calculate different types of correlation coefficients for a given set of data using linear, non-linear and multiple regression techniques
CO5	Understands clearly the time series analysis of data to establish trend and seasonal variations and uses methods of testing hypotheses

Unit No.	Course Content	No. of Hours
1	Introduction; Sample and Population; Discrete and Continuous; Collection, Arranging and Presentation of data; Sturge's rule; Frequency grouping; Frequency and relative frequency distribution; Cumulative frequency; Frequency polygon; Ogives; Problems.	**07**
2	Characteristics of Distributions: Central Tendency – Averages: Arithmetic mean (Ungrouped data & Grouped data); Median (Ungrouped data & Grouped data); Mode (Ungrouped data & Grouped data); Skewness; Geometric mean; Weighted mean; Moving averages – equations to river hydraulics; Problems. Characteristics of Distributions: Dispersion – Range; Interquartile Range; Variance; Standard Deviation (Population & Sample); Bessel's correction; Mean Deviation; Coefficient of Variation; Problems.	**07**
3	Probability distributions: Binomial distribution – derivation; Poisson distribution – derivation; Normal distribution – errors, Gauss function, Area under normal curve, Use of standard normal probability distribution table; Problems. Sampling and Sampling Distributions: Types – nonrandom and random; analysis of sampling types.	**08**

4	Correlation and Regression Analysis: Scatter Diagrams; Correlation coefficient; Multiple correlation coefficient; Simple linear regression; Multiple regression equation; Estimation using regression line; Method of Least Squares; Standard error of estimate; Time Series; Problems, SPSS, Minitab, Design of experiments	**10**
5	Testing Hypotheses: Concepts; Null hypothesis; Level of Significance; Degrees of Freedom; Hypothesis testing of Means; Chi-Squared test; F distribution; Students t- test; Analysis of Variance – within samples and between samples; Problems.	**07**

Text books

1. Adam M. Neville and John B. Kennedy, (1966), "Basic Statistical Methods for Engineers and Scientists", 2nd Edition, IEP
2. Richard I. Levin and David S. Rubin, "Statistics for Management" (2020), Prentice Hall of India Pvt. Ltd., New Delhi.

References

1. George E. P. Box, William G. Hunter, and J. Stuart Hunter, "Statistics for Experiments - An Introduction to Design, Data Analysis, and Model Building", John Wiley & Sons.

Course Outcomes	**Program Outcomes**												**PSO's**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	2	3	2	2	2	2	1	1	2	2	1	2	2	2	2
CO2	2	3	2	2	2	2	1	1	2	2	1	2	2	2	2
CO3	2	3	2	2	2	2	1	1	2	2	1	2	2	2	2
CO4	2	3	3	2	2	2	1	1	2	2	1	2	2	2	2
CO5	2	3	2	2	2	2	1	1	2	2	1	2	2	2	2

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Industrial Wastewater Treatment Technologies	*Course Code: 20EV732*
Credits:3	*Total Contact Hours: (L:T:P):39:0:0*
Type of Course: Theory	*Category: Professional Elective Course IV*
CIE Marks: 50	*SEE Marks: 100*

Pre-requisite: Environmental Chemistry, Elements of Environmental Engineering, Sources and Characterization, Wastewater Treatment Engineering, Environmental Process laboratory exposure.

Course Objectives

The course provides a strong base of different industrial waste processes, effluent flow and characteristics, approaches to waste minimization, strength and volume reduction. Also, exposes the student to the areas of toxicity and treatability studies. Makes the student to understand the need for process flowsheets with waste streams of different industries.

Course Outcomes: After completing this course, students will be able to:

CO1:	Know the characteristics and effect of industrial wastewater on water and land. Knowledge on monitoring and its protocol.
CO2:	Understand the need for combined wastewater treatment system and technical approaches to waste minimization.
CO3:	Understand the process and treatment flow schemes for selected industries and builds up qualitative data on the characteristics of each process effluent.
CO4:	Understand the process and treatment flow schemes for selected industries including zero discharge concept.
CO5:	Explain the perform bench-scale as well as pilot scale treatability studies, for designing real time treatment facilities and 5-R concepts

Unit No.	Course Content	No. of Hours
1	**Introduction:** Basic information's. Origin, characteristics and effects of industrial wastewaters on surface water, land and sewer. Industrial waste survey. Discharge guidelines and Standards. **Classification of industry:** Red, Orange, White and Green categories of industries**.** **Variations in Flow and Concentration:** Monitoring and mass load calculations of Effluent**.**	**08**
2	**Combined Treatment:** Raw Industrial Wastes and Domestic Wastewater after mixing partially or fully. Selection of Treatment Methods- based on characteristics. **Technical Approaches to Waste Minimization -** Equalization, Neutralization, Volume Reduction, Strength Reduction and Proportioning.	**08**
3	**Process Flow Schemes and Characteristics**: Flow Diagrams, sources, stream identification and Treatment of Industrial Wastes from - Pulp & Paper, Textile, Tanneries, Sugar & Distilleries, Dairy, slaughter house, Food processing.	**08**
4	Steel manufacturing, electro plating, petrochemical, fertilizer and pharmaceuticals Zero Liquid Discharge concept, cleaner technology, green processes. Sludge handling and disposal, reclamation facilities, Case studies.	**08**

5	**5R APPROACH** – Reduce, Reuse, Recycle, Recover, Reclaim – for waste minimization. **Toxicity:** Toxicity tests. **Treatability Studies**: Bench and pilot scale studies.	**07**

Text books

1. Nemerow, N. L., (1982), "Liquid Waste of Industry- Theories, Practice and Treatment", Addison Wesley
2. Rao, M. N., and Datta, A. K., (2003), "Wastewater Treatment", Oxford and IBM Publishers

Reference books

1. Mahajan, S. P., (1987), "Pollution Control in Process industry", TMH Co.
2. Metcalf and Eddy inc, (2019): "Wastewater Engineering, Treatment and Reuse", 4TH Edition, Tata McGraw Hill Publishing Co., Ltd.,
3. Manivasakam N., (1987). Industrial Effluents- Origin, characteristics, effects analysis and treatment. Sakthi publications.

Course Outcomes	Program Outcomes												PSO's		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	2	2	2	1	1	1	2	3	2	3
CO2	3	3	3	3	3	2	2	2	1	1	1	3	3	3	3
CO3	3	3	3	3	3	2	2	2	1	1	1	3	3	3	3
CO4	3	3	3	3	3	3	2	2	1	1	1	2	3	2	3
CO5	3	3	2	2	2	3	3	2	1	1	1	2	2	3	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Environmental Economics, Legislation and Forensics	***Course Code: 20EV733***
Credits : 3	***Total Contact Hours: (L:T:P):39:0:0***
Type of Course: Theory	***Category: Professional Elective Course IV***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Elements of Environmental Engineering, Estimation and costing, Environmental Impact Assessment.

Course objectives:

The course focus on the basics of environmental economics in environmental pollution prevention, legislation policies in different economical conditions and importance of forensics in toxicology.

Course Outcomes: After successfully completing this course, the students will be able to:

CO1	Understand the importance and applications of economics in environmental pollution prevention.
CO2	Associate the relation between LCA and economics and forecasting economic burden.
CO3	Recognize and valuate the source and sinks of ecosystem.
CO4	Understand the environmental legislation policies in different economical conditions.
CO5	Recognize the significance of environmental forensics in toxicology

Unit No.	Course Content	No. of Hours
1	**Environmental economics:** Prevention of pollution or cure; Healing costs of individuals, Environmental fund generation, Environmental (land and water) remediation costs estimates – strategic and long-term planning. Environmental economics in developing and developed countries. Environmental economics. Transboundary waste disposal economics and liability.	**08**
2	Vicious circle of environmental poverty. Kuznets curve, Green behavioural solutions. Environmental finance. Economics of alternative vehicle fuels and environmental impacts. LCE and economics, Proactive economies, forecasting economic burden. Economics of treatment facilities. Mass transport and environmental economics. Environmental cost-benefit analysis, Poverty and environmental care.	**08**
3	Sources and sink functions of ecosystems, externalities as fundamental determinants. Infrastructure social responsibility and associated environmental costs and welfare. Environmental valuation of goods and services. Green national income. Ecological economics.	**07**
4	**Environmental legislation:** Past present and future, Proactive, reactive and passive legislation, Differences between rules, regulations and Acts. Environmental legislation in under developed, developing and developed economies. Identifying gaps towards proactive legislation. Environmental legislation for welfare of all living forms. Clean environmental legislation.	**08**
5	**Environmental forensics:** Importance and need, Forensic linked legislations, Multidisciplinary domain approaches, Forensic toxicology. Fingerprinting	**08**

	analytics of forensic information and feedback and interpretation of forensic data. Forensic solutions. Sue penalty and legal courts, Forensic funding.	

Text Books

1. Nick Hanley, Jason F Shorgen and Ben White, (2006), Environmental Economics Theory and Practice, First/Second Edition, MacMillan.
2. Charles D Kolstad, 2012, Intermediate Environmental Economics, Indian Edition, Oxford University Press, New Delhi
3. David W Pearce and R Kerry Turner, 1990, Economics of Natural Resources.
4. Patil S M. Law on Environment – some reflection 2005, First edition.

Reference Books

1. Ecott J. Callan and Janet M. Thomas, 2013, Environmental Economics and Management: Theory, Policy and Applications, Cengage Learning, Delhi.
2. Ramprasad Sengupta, 2013, Ecological Limits and Economic Development, Oxford University Press, New Delhi.
3. Mallick M R. Environmental pollution and Laws. 2010. Professional book publishers. New Delhi.

Journal articles

1. Journal articles on Science direct.com, acs.org, springer link and Taylor & Francis.
2. Predatory Journals are not referred for information.

Course	**Program Outcomes**												**PSO's**		
Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	2	3	1	1	1	1	2	2	1	1	1	1	2	2	3
CO2	1	1	1	2	3	1	2	3	3	2	3	2	3	2	2
CO3	1	1	1	2	3	2	3	2	1	1	3	3	2	3	2
CO4	2	2	2	1	3	1	3	1	3	2	1	3	3	2	3
CO5	2	2	2	1	2	1	2	2	2	2	1	3	3	2	2

Scale: 0 -- No association; 1--Low association; 2-- Moderate association; 3--High association

Course Title: Industrial Pollution and its Prevention	*Course Code: 20EV741*
Credits : 03	*Total Contact Hours: (L:T:P): 39:0:0*
Type of Course: Theory	*Category: Open Elective course - IV*
CIE Marks: 50	*SEE Marks: 100*

Pre-requisite: Environmental Studies

Course Objectives:

Conceptualize the importance of implementing pollution prevention methods in industries and encourage sustainable development.

Course Outcomes: After completing this course, students will be able to:

CO1:	Know the definition of environment, pollutants/pollution and idea about strategies and benefits of pollution prevention.
CO2:	Recognize general industrial process flow and waste generation points across the process and summarize on fundamental technologies for industrial pollution prevention.
CO3:	Select and evaluate feasibility of industrial pollution prevention plans.
CO4:	Outline on monitoring programs for pollution prevention; and governmental and corporate responsibilities in industrial pollution prevention.
CO5:	Predict suitable industrial pollution prevention methods through typical examples and cases studies

Unit No.	Course Content	No. of Hours
1	**Fundamentals of environmental pollution and prevention** Necessity of pollution prevention. Industrial pollution and management strategies. Types and categories of industries, rules for consent for establishment and operation, discharge standards, industrial hubs and pollution control norms. Mass load calculations at source and discharge points- simple numerical problems	**08**
2	**Industrial processes and waste streams** Typical industrial process flow diagrams, type and volume of waste generation, characterization and Toxic chemicals – effects on environment, dual, triple and hybrid treatment technologies **Pollution prevention technologies or Waste Minimization /waste prevention Techniques** Change in Plant operations, retrofit modification, 5R's concepts, process, material substitution /separation, cleaner technologies.	**08**
3	**Pollution prevention feasibility and plan.** Environmental, technical, economic & institutional feasibility analysis. Identifying pollution prevention opportunities and its implementation. Facility environmental auditing, Environmental management audit.	**06**
4	**Monitoring industrial pollution prevention programs** Product- Life Cycle Analysis and Assessment (LCA), Life cycle Engineering (LCE), Prevention of Significant Deterioration (PSD) for industrial areas. **Governmental & Corporate responsibilities** Policies & strategies, Regulations & standards, Community actions, Environmental programs, sustainable development initiatives, partnerships and international programs.	**08**

5	**Industry specific pollution prevention strategies** Study on sources/processes of waste generation and its prevention in Printing, Textile, Pulp & Paper, Electronics and pharmaceutical industry and other industries of concern. **Case studies on industrial pollution prevention** The DOW chemical company, ARAMCO pollution prevention program, five leaf rating industries, Responsible Care Program, The World Environmental Centre Program, ISO certified industries.	**09**

Text books

1. S.C. Bhatia, Pramod Kumar and Sarvesh Devaraj (2017). Industrial Pollution and Its Control (Volume I & II). Wood head Publishing India Pvt. Ltd.
2. Harry Freeman (1994). Industrial Pollution Prevention Handbook (1st Edition). MacGraw Hill Inc.
3. Ryan Dupont, Kumar Ganesan and Louis Theodore (2016). Pollution Prevention: Sustainability, Industrial Ecology and Green Engineering (2nd Edition). CRC Press.
4. S.C Bhatia (2003). Managing Industrial Pollution (1st Edition). Macmillan.
5. H. Panda (2011) The Complete Guide on Industrial Pollution Control (1st Edition). Asia Pacific Business Press Inc.
6. Ireneusz Zbicinski (2006) Product Design and Life Cycle Assessment (1st Edition) Baltic University Press.

Reference books

1. S. P. Mahajan (2008) Pollution Control in Process Industries (22nd reprint). Tata McGraw Hill Education.
2. Nancy J. Sell (1992). Industrial Pollution control – Issues and Techniques (2nd Edition). John Wiley & Sons.
3. Nelson Leonard Nemerow (1978) Industrial Water Pollution: origins, characteristics, treatment (1st Edition) Addison-Wesley Educational Publishers Inc.
4. Nelson L. Nemerow (1995) Zero Pollution for Industry (1st Edition). Wiley-Interscience.

Web Resources

1. https://css.umich.edu/sites/default/files/publication/CSS95-01.pdf
2. https://www.taylorfrancis.com/books/mono/10.1201/9781315368436/pollution-prevention-ryan-dupont-kumar-ganesan-louis-theodore
3. https://www.niir.org/books/book/complete-guide-on-industrial-pollution-control/isbn-9788178331409/zb,,183,a,0,0,a/index.html
4. https://www.diva-portal.org/smash/get/diva2:604277/FULLTEXT01.pdf
5. https://corporate.dow.com/en-us/about/legal/issues/dioxin/reducing-emissions.html
6. https://www.aramco.com/-/media/publications/enviro-news/2018-28.pdf
7. https://www.aramco.com/-/media/publications/enviro-news/2020-31.pdf

Course Outcomes	Program Outcomes												PSO's		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	2	2	2	1	1	2	2	3	1	3
CO2	3	3	2	2	3	3	3	2	2	3	2	3	3	2	3
CO3	3	3	2	3	3	1	3	3	3	3	2	3	3	2	3
CO4	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	2	3	2	2	3	3	3	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Environmental Systems Management	***Course Code: 20EV742***
Credits : 3	***Total Contact Hours: (L:T:P): 39:0:0***
Type of Course: Theory	***Category: Open Elective Course IV***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: None

Course Objectives

The course acquires deeper knowledge about Environmental Management Systems (EMS) and to get practice in introducing Environmental Management Systems, be stimulated to discuss and reflect on the possibilities and limitations of Environmental Management Systems, and train their critical thinking and writing abilities and also to develop Engineered systems for resources, energy recovery & material recovery and also to carry out Environmental Audit.

Course Outcomes: After completing this course, students will be able to:

CO1	Identify the complex environmental issues and their impact on business and industry.
CO2	Specify strategies and polices used to promote cleaner production in industry.
CO3	Identify mitigation methods for minimizing the environmental risk due to anthropogenic activities.
CO4	Describe criteria and process for implementing Environmental Management systems.
CO5	Analyze the case studies and apply the knowledge of Waste Audits and Pollution Prevention opportunities for various industries.

Unit No.	Course Content	No. of Hours
1	Environmental Management Standards Development, trade and environment linkages – Environmental guidelines – Business and Citizen Charters for Sustainable Production and Consumption - National policies on environment, abatement of pollution and conservation of resources - Environmental quality objectives – Environmental standards - Concentration and Mass standards Effluent and stream standards – Emission and ambient standards -Minimum national standards - Measuring performance evaluation: Indicators, Benchmarking - Systems approach to environmental management	**08**
2	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	**08**
3	Environmental Management System EMAS, ISO 14000 - EMS as per ISO 14001– benefits and barriers of EMS – Concept of continual improvement and pollution prevention - environmental policy – initial environmental review – aspect and impact analysis – legal and other requirements objectives and targets – environmental management programs – structure and responsibility – training awareness and competence- communication – documentation and document	**08**

	control – operational control – monitoring and measurement – management review.	
4	Environmental Audit and Applications Environmental management system audits as per ISO 19011- – 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.	**08**
5	Case studies: Waste Audits and Pollution Prevention opportunities in Textile, Sugar, Pulp & Paper, Electroplating, Mining, petroleum refining, Tanning industry, Dairy, Cement, Chemical industries, etc.	**07**

Text books

1. Hillary, R., Environmental Management Systems and Cleaner Production, Wiley Publishers, 1997
2. Christopher Sheldon and Mark Yoxon, Installing Environmental Management Systems – a step by step guide, Earthscan Publications Ltd, London, 1999
3. ISO 14001/14004: Environmental management systems – Requirements and Guidelines – International Organization for Standardization, 2004
4. Environmental Management Systems: An Implementation Guide for Small and Medium-Sized Organizations, Second Edition, NSF International, Ann Arbor, Michigan, January 2001

Reference books

1. Planning and Implementation of ISO14001, Environmental Management System- G Gyani and A Lunia, Raj Publishiong House, Jaipur, 2000.
2. ISO 14001 Auditing Manual - G Woodside, and P Aurrichio, McGraw- Hill, 1999.
3. An Introduction to Environmental Audit - RD Tripathi, Alpha Publications, 2009.
4. "The ISO: 14000 Handbook" – J Caseio (Ed), Published - CEEM Information Services. 2000
5. A Guide to the Implementation of the ISO: 14000 Series on Environmental Management - I Ritchie, and W Hayes, Prentice Hall, New Jersey, 1998. 6. OHSAS & SA Guidelines.

Course Outcomes	**Program Outcomes**												**PSO's**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	2
CO2	3	2	1	2	2	1	1	1	3	2	2	3	2	3	2
CO3	3	3	2	3	2	1	1	1	3	2	3	2	2	2	3
CO4	1	1	1	1	2	2	1	3	3	3	2	1	2	3	2
CO5	3	2	2	3	2	3	2	3	2	3	3	3	2	2	2

0 -- No association 1---Low association, 2--- Moderate association, 3---High associati

Course Title: Environmental Health and Safety in Industries	***Course Code: 20EV743***
Credits: 3	***Total Contact Hours (L:T:P): 39:0:0***
Type of Course: Theory	***Category: Open Elective Course IV***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Elements of Environmental Engineering – Sources and characterization

Course Objectives

The course educates about the health hazards and the safety measures to be followed in the industrial environment and describe the industrial legislations (Factories Acts, Workmen's Compensation and other laws) enacted for the protection of employee's health at work place, to compare prevention and control of Occupational Health diseases, accidents/emergencies and other hazards

Course Outcomes: After completing this course, students will be able to:

CO1	Understand the health hazard, exposure pathways and to toxic substances, and their effects .
CO2	Demonstrate the workplace safety and safety systems and an in depth knowledge of the safety technologies
CO3	Gain knowledge on need of training and education of EHS.
CO4	Explain Safety, Health & Environment related to ISO standards, accidents/emergencies and other hazards
CO5	Describe about the Management Information System and related case studies.

Unit No.	Course Content	No. of Hours
1	**Industrial Hygiene and Health** Occupational health hazard, classification of health hazards. Properties of dangerous chemicals, dust, gases, fume, mists, vapors, smoke and aerosols - health effects. Exposure pathways and human responses to hazardous and toxic substances, bio chemical action of toxic substance and toxicity, type and degrees of toxic effects, Physiology of work and occupational diseases. Hierarchy of control measures for occupational health risks. Role of personal protective equipment and the selection criteria. Effects of noise, radiation and excessive stress on humans, control methods and attenuation.	**08**
2	**Workplace Safety and Safety Systems** Features of the satisfactory design of work premises Heating, ventilation, and air conditioning (HVAC). Safe installation and use of electrical supplies. Fire safety and first aid provisions. Safe systems of work for manual handling operations. Control methods to eliminate or reduce the risks arising from the use of work equipment. Procedures and precautionary measures for handling hazardous substances. Contingency	**08**

	arrangements for events of serious and imminent danger.	
3	**Education and Training** Importance of the provision of information, instructions, training and supervision. Mock drills, safety operations and protocols Factors to be considered in the development of effective training programmes. Awareness on occupational diseases in various industries and control measures. Principles and methods of effective training. Feedback and evaluation mechanism.	**07**
4	**Monitoring for Safety, Health & Environment** Occupational Safety, Health and Environment Management System, Bureau of Indian Standards on Safety and Health: 14489 – 1998 and 15001 – 2000, ILO, ISO and EPA Standards. Principles of Accident Prevention: Definition: Incident, accident, injury, dangerous, occurrences, unsafe acts, unsafe conditions, hazards, error, oversight, mistakes etc.	**08**
5	**Management Information System** Sources of information on Safety, Health and Environment Protection. Compilation and collation of information, Analysis & use of modern methods of programming, storing and retrieval of MIS for Safety, Health and Environment. **Case studies:** Safety in Chemical Industries; Safety in Petroleum Refinery, Mining and Petrochemical Industry; Safety in Construction and Cement Industry; Safety in Thermal power plants.	**08**

Text books

1. Environmental and Health and Safety Management by By Nicholas P. Cheremisinoff and Madelyn L. Graffia, William Andrew Inc. NY, 1995
2. Effective Environmental, Health, and Safety Management Using the Team Approach by Bill Taylor, Culinary and Hospitality Industry Publications Services. 2005.
3. The Facility Managers Guide to Environmental Health and Safety by Brian Gallant, Government Inst Publ., 2007.

References:

1. Slote. L, Handbook of Occupational Safety and Health, John Willeyand Sons, NewYork.2019.
2. Heinrich H.W, Industrial Accident Prevention, Mc GrawHill Company, NewYork,1980.

Course Outcomes	**Program Outcomes**												**PSO's**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	2
CO2	3	2	1	2	2	1	1	1	3	2	2	3	2	3	2
CO3	3	3	2	3	2	1	1	1	3	2	3	2	2	2	3
CO4	1	1	1	1	2	2	1	3	3	3	2	1	2	3	2
CO5	3	2	2	3	2	3	2	3	2	3	3	3	2	2	2

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

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Course Title: Environmental Social Governance	*Course Code: 20EV751*
Credits:3	*Total Contact Hours: (L:T:P):39:0:0*
Type of Course: Theory	*Category: Open Elective Course V*
CIE Marks: 50	*SEE Marks: 100*

Pre-requisite: NIL

Course Objectives

The course imparts a thorough understanding of Environmental Social Governance, its importance, risks and opportunities. It helps to study on Management practices on energy and water and also it deals with various environmental issues locally and globally.

Course Outcomes: After completing this course, students will be able to:

CO1:	Able to state ESG importance, risks and opportunities, Environmental sustainability and development.
CO2:	Apply the knowledge of Management practices on energy and water; describe various environmental issues locally and globally.
CO3:	Comprehend the lessons learnt from Environmental Sociology, its response to Environmental Issues and social responsibility.
CO4:	Recognize the role of governance in Environmental sustainability and its development practices.
CO5:	Deal with Environmental Sociology, social movements in and around the world and its environmental concerns.

Unit No.	Course Content	No. of Hours
1	**Introduction** ESG and its importance, key environmental, social, and governance issues; stakeholders influence on ESG performance, ESG risks and opportunities, The Concept of Sustainability, Environment and Sustainable Development, Environmental Democracy and Climate Change.	**07**
2	**Environment** Climate & Green House Gas Emissions (GHGs), Energy Management, Water Management, Waste Management, Circular Economy, Hazardous Materials Management, Pesticides & its Management, Packaging Reduction, Logistics Efficiency, Supply Chain Transparency Biodiversity.	**08**
3	**Social** Introductory to Environmental Sociology, Emergence of Environmental Sociology , Sociology's Response to Environmental Issues and Recent Trends in Environmental Sociology, People Management, Diversity & Inclusion, Health, Safety & Wellbeing, Social Responsibility Culture, Ethics & Fair Operating Practices, Human Rights & Modern Slavery, Community Involvement	**08**
4	**Governance** Sustainability Purpose, Sustainable Sourcing, Operations, Reporting, SDG Alignment, Resource, Property and Resource Governance Regimes, Governing Common Pool Resources, Collective Action for Governing the Commons: Theoretical Approaches, Governing Forests as Common	**08**

	Property; Governing Water as Common Property.	
5	**Environmental Sociology** Environmentalism Around the World: Past and Present, New Social Movements and the Environmental Concerns, Political Ecology and Environmental Movements.	**08**

Text books

1. Gieseke T (2020), "Collaborative Environmental Governance Frameworks", Taylor & Francis Ltd.
2. John Hill, "Environmental, Social and Governance (ESG) Investing", Academic Press, Elsevier.
3. Matthew W. Sherwood and Julia Pollard (2019), "Responsible Investing An Introduction to Environmental, Social, and Governance Investments", Reviewer's Book watch, Oregon.

Reference books

1. Magdalena Ziolo (2021), "Adapting and Mitigating Environmental, Social, and Governance Risk in Business", IGI global.
2. Prakash Chand Kandpal (2018), "Environmental Governance In India" SAGE Texts.

Course Outcomes	**Program Outcomes**												**PSO's**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	2	2	2	2	3	2	3	1	2	2	2	2	3	2	2
CO2	2	3	2	2	2	2	3	1	1	2	2	2	2	2	2
CO3	1	2	1	2	1	2	2	1	2	3	2	2	2	2	2
CO4	1	1	2	2	2	3	3	1	2	2	2	2	2	2	2
CO5	1	2	2	2	3	2	2	1	2	2	2	2	2	2	2

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

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Course Title: Instrumentation and Automation for Environmental Applications	***Course Code: 20EV752***
Credits:3	***Total Contact Hours: (L:T:P):39:0:0***
Type of Course: Theory	***Category: Open Elective Course V***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: None

Course Objectives:

The course provides exposure to the students on the applications of sensors, data loggers, IoT in data dissemination and real time monitoring of air, water and land systems.

Course Outcomes: After completing this course, students will be able to:

CO1	Identify the need for instrumentation, discuss the working principle of sensors and data loggers, and database design
CO2	Explain the concepts of electromagnetic radiation, its interaction with the atmospheric, relationship between the meteorological parameters and atmospheric air quality
CO3	Explain the specific aspects in hydrology and hydrodynamics that require application of instrumentation and automation for improved monitoring
CO4	Identify and apply the concepts of instrumentation and automation in water, wastewater, soil and air attribute systems
CO5	Discuss the applications of information management systems for environmental monitoring and the implication on policy matters and societal outreach.

Unit No.	Course Content	No. of Hours
1	Need for instrumentation and automation **Sensors** - Principles of circuits and electronics, Sensor technology, operation principles, calibration, and maintenance. Data acquisition systems, data loggers, sensor networks, Telemetry, Radio waves, transmission, reception, antennas, Wireless communications and networks. **Databases** - Database design and implementation, Long-term monitoring, Metadata – standards and data interoperability, Data sharing and preservation, Web interface **Power sources and storage** - Solar cells, optimizing power, Power quality, Batteries, super capacitors, charging, Energy harvesting.	**06**
2	Atmosphere – Solar radiation, Electromagnetic Spectrum, energy interactions with the atmosphere Fiber Optics, spectrometers. Measurement from airborne and space borne platforms Atmospheric air quality - Aerosols and particulate matter, Gases, Ozone, NO2, CO2, Meteorological parameters - temperature, Rain, Relative Humidity, Wind velocity and direction	**10**
3	Hydrology and hydrodynamics Soil moisture, Water velocity, discharge, Water level and depth Water quality and aquatic ecosystems - pH, chlorophyll, conductivity, turbidity, DO, BOD, productivity and respiration	**10**

4	Water treatment and supply - pH, flow measurement, leakage detection, head loss/level monitors Wastewater/sludge treatment facilities - sensors to detect pH, dissolved oxygen, dissolved hydrogen, nutrients, ammonia, alkalinity, biogas flow and composition, VFAs, biodegradable organic matter, and toxicity. Air monitoring - Sensors to determine air pollutant concentrations, atmospheric water vapour/humidity, Soil monitoring - sensors to detect soil moisture, nutrient deficits,	**06**
5	Introduction to Management Information System, Supervisory control and data acquisition (SCADA), IoT applications Environmental observatories, Policy and decision making, Education and public outreach, Analysis and modeling Case studies of water treatment plant, sewage and industrial effluent treatment plants, ambient air quality monitoring,	**07**

Text books

1. Hand book of analytical Instruments by R. S. Khandpur, TMH publication 1st Edition 1989, New Delhi.

Reference books

1. S. J. Holler & T. A. Nilman. (2018). Principles of Instrumental analysis. Saunders College Publications 5th Ed.
2. Subhas Chandra Mukhopadhyay, Alex Mason (Editors), 2013, Smart Sensors for Real-Time Water Quality Monitoring, Springer-Verlag Berlin Heidelberg.

Course Outcomes	**Program Outcomes**												**PSO's**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	2	2	1	1	1	1	2	3	1	1
CO2	3	2	1	3	3	3	3	2	3	3	3	3	3	2	1
CO3	3	3	3	1	3	2	2	2	3	3	3	3	1	2	2
CO4	3	2	2	3	1	3	3	3	2	3	1	3	3	2	3
CO5	3	2	2	3	3	3	2	3	3	3	2	3	3	3	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

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Course Title: Environmental Forensics	*Course Code: 20EV753*
Credits :3	*Total Contact Hours: (L:T:P):39:0:0*
Type of Course: Theory	*Category: Open Elective Course V*
CIE Marks: 50	*SEE Marks: 100*

Pre-requisite: Nil

Course Objectives

Knowledge about the Principles of Environmental Forensics applied for the evaluation of fate and transport of contaminants in the environment.

Course Outcomes: After completing this course, students will be able to:

CO1:	Understand the definition, needs and history of environmental forensics.
CO2:	Apply the knowledge through field investigation, standard protocols and assessment reports. And also, to identify contaminant source(s) in air, water and soil.
CO3:	Illustrate environmental statistical data distribution and its analysis.
CO4:	Analyze and interpret the risks of data collection and evaluation in environmental forensics.
CO5:	Simulate knowledge on environmental forensics via review of case studies.

Unit No.	Course Content	No. of Hours
1	**Environmental Forensics-** Definition, Need for environmental forensics and Requirements; History of environmental forensics.	**05**
2	**Field investigations and data collection-** Requirements of field investigative team, Essential observations, Source identification, Sampling techniques and sampling plan, Site assessment report and Standard protocol. **Chemical Fingerprinting of Contaminants-** Methods for fingerprinting airborne toxins, hydrocarbons in soil and water, pathogens in water supply.	**10**
3	**Forensic evaluation of environmental data-** Statistical evaluation of data distribution, comparison of data sets, reviewing data analysis techniques, Study on variance of samples and probability plots.	**06**
4	**Risks in environmental forensics-** Data collection, Gaps/incomplete data, Exposure and pathways, Calculation of risk, court cases.	**08**
5	**Case studies on environmental forensics-** Investigative case studies on: Water borne diseases (epidemics); Soil Contamination-Industrial effluent discharges; Oil Spills-Ocean/sea/river, subsoil & groundwater; Urban air quality; Lake/river contamination from sewage disposal. Forensics and feed back	**10**

Text books

1. R.E. Hester and R.M Harrison (2008). Environmental Forensics (1st edition). Cambridge Royal Society of Chemistry Publisher.
2. Robert D. Morrison (2000). Environmental Forensics – Principles and Applications (1st Edition). CRC Press.
3. Paul Mac Berthouex and Linfield C. Brown (2018). Statistics for Environmental Engineers (2nd Edition). Lewis Publishers / CRC Press.
4. Patrick J. Sullivan, Franklin J. Agardy and Richard K. Traub (2014). Practical Environmental Forensics – Process & Case Histories (1st Edition). John Wiley & Sons Inc.
5. Zhendi Wang and Scott A. Stout (2007). Oil Spill Environmental Forensics - Finger Printing and Source Identification (1st Edition). Academic Press, Elsevier Inc.

Reference Books

1. Greg Macmaster (2020). Environmental Forensics (1st Edition). Cyclogenesis Publish.
2. Stephen M. Mudge (2008). Methods in Environmental Forensics (1st Edition). CRC Press.
3. Robert Morrison and Brian Murphy (2010). Environmental Forensics – Contaminant Specific Guide (1st Edition). Academic Press.
4. Gwen O'Sullivan and Court Sandau (2014). Environmental Forensics for Persistent Organic Pollutants (1st Edition), Elseveir.

Web Resources

1. https://www.sciencedirect.com/book/9780123695222/introduction-to-environmental-forensics
2. https://www.amazon.in/Environmental-Forensics-Contaminant-Specific-Guide-ebook/dp/B005H8CYYK
3. https://pubs.rsc.org/en/content/ebook/978-0-85404-957-8

Course Outcomes	Program Outcomes												PSO's		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	2	2	1	2	2	2	1	1	1	1	2	3	1	1
CO2	3	2	1	3	3	3	3	2	3	3	3	3	3	2	1
CO3	3	3	3	1	3	2	2	2	3	3	3	3	3	2	2
CO4	3	2	2	3	3	3	3	3	2	3	2	3	3	2	3
CO5	3	2	2	3	3	3	2	3	3	3	2	3	3	3	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Project Work Phase - 1	*Course Code: 20EV76P*
Credits : 02	*Total Contact Hours: (L:T:P):0:0:0*
Type of Course: Project Work	*Category: Project Work Course*
CIE Marks: 50	*SEE Marks: -*

Pre-requisite: Nil

Course Objectives:

The project work trains the students to carry out literature review, identify the Gaps/problems, devise workable objectives and methodology, conduct the investigation following Engineering ethics, and analyze, interpret and present the findings and thus develop creative thinking, Planning, time management, leadership qualities and managerial skills.

Course Outcomes: After completing this course, students should be able to:

CO1	Conduct systematic review of literature, identify research gaps, and define objectives and scope of work
CO2	Develop skills in terms of design, conduct investigations and data analytics
CO3	Develop oral and written communication skills for report preparation, paper publication and technical presentation

- Each student shall be associated with a faculty member serving as his/her guide to supervise the dissertation work.
- Periodic progress review presentations of the project work shall be according to the calendar of events scheduled by the University.
- The student will work with the project guide/supervisor towards the identification of the problem through a systematic literature review and will finalize the objectives and scope of work.
- The student will present synopsis and submit the same to the Department Under-Graduate Committee (DUGC) after due approval from the guide.
- The student will present the work progress as part of review during the 1st phase of the project work.
- The DUGC and guide will jointly evaluate the student performance.
-

Course Outcomes	**Program Outcomes**												**PSO's**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	2	3	2	3	2	3	2	3	2	3
CO2	3	3	3	2	3	2	3	2	3	2	3	3	3	2	3
CO3	3	3	3	2	2	2	3	3	3	3	2	3	3	3	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Industry Training/Internship	*Course Code: 20EV77P*
Credits : 01	*Total Contact Hours: (L:T:P):0:0:0*
Type of Course: Industry Training	*Category: Project Work Course*
CIE Marks: 50	*SEE Marks: --*

Course Objectives

The lab course offers opportunities for students to gain exposure into creative innovations to cater social, industry-institute and environmental quality control.

Course Outcomes

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

CO1	Understand environmental problems in industries and organizations
CO2	Establish intricate links between laboratory activities to address industrial problems.
CO3	Provides adequate input for developing practical solutions for innovative research with creative thinking.

Course delivery

- Environmental problems for attributes: air, noise, water and land in industry and related environmental policies.
- Life Cycle Assessment (LCA)
- Lab scale studies for identified problems in industries
- Use of Laboratory experimental results for industrial application.
- Water and Energy balance and operation and maintenance cost
- Manufacturing, sources of pollution and treatment process
- Solid and Hazardous waste management
- Environmental Health and Safety, emergency and disaster preparedness in Industries.
- Modification to existing pollution control systems and retrofit
- Scale up of laboratory experiments for implementation in pilot and real scale conditions.
- EIA and Audits.
- Documentation protocols in industries
- Incremental / disruptive innovations for exercising environmental control.

Note:

1. ***The student group can choose from the above content for Industry-Institute Interaction Programme & Innovative Research depending on the research needs.***
2. ***The student group should give two progress presentation and submit the final report endorsed by the guide.***

Course Outcomes	**Program Outcomes**												**PSO's**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	2	3	2	3	2	3	2	3	2	3
CO2	3	3	3	2	3	2	3	2	3	2	3	3	3	2	3
CO3	3	3	3	2	2	2	3	3	3	3	2	3	3	3	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

8th Semester Syllabus

Course Title: Natural Resources Conservation and Management	***Course Code: 20EV811***
Credits : 03	***Total Contact Hours (L:T:P): 39:0:0***
Type of Course: Theory	***Category: Professional Elective Course V***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Basic Science, Environmental Studies

Course Objectives

This course gives the student the feel and understanding of natural resources availability, impact and need for its conservation. It prepares the student with a thorough understanding of biodiversity, planning and legislation for effective resource management.

Course outcomes (Cos): At the end of the course, the students will be able to:

CO1:	Classify natural resources, identifies the threats and comprehends the flow of resources in nature capability on issues such as resource allocation, use and pollution problems of forests.
CO2:	Enhances thinking capability on issues such as resource allocation, use and pollution problems of water, and abiotic components of natural resources.
CO3:	Outlines the importance of food security, modern agricultural practices, use and impact of chemical fertilizers and pesticides. Able to estimate and identify food production and its problems related to storage, transport and allocation.
CO4:	Capable of determining energy demand. Able to understand the energy footprint, crisis in energy production, impacts of fossil fuel burning. Develops knowledge on alternate energy sources for sustainable development.
CO5:	Understands symbiotic and synergic relationships of different ecosystems. Appreciates the need for conserving biodiversity and identifies possible threats. Able to list and appreciate the ecological importance of major biodiversity hot-spots. Capable of applying the knowledge of environmental legislation for resource management.

Unit No.	Course Content	No. of Hours
1	**Natural resources** Classification, Resources Appraisal, Resource problem, Renewable resources flow, destruction versus conservation. **Forest Resources** Uses, Ecological and economic significance, types and management, forest resources of the world and India, deforestation and its impact and solution	**07**
2	**Water Resources** Hydrologic cycle, global and national water resources, demand and distribution, Classification of surface water bodies for designated best usage. Management of water resources, Environmental Impact of large dams, River water disputes, water pollution problems.	**07**
3	**Food Resources** World food production and problems, food security, agro production, live-stock production, modern agricultural practices, use of pesticides and	**08**

	fertilizers – environmental impact, environmental limits of increasing food production, sustainable agriculture. **Mineral Resources** Exploration, causes for depletion, environmental impacts and conservation measures.	
4	**Energy Resources** Energy resources, world energy demand, Indian resources, renewable, alternate / non- conventional energy resources – solar, tidal, wind, geothermal, hydel, hydrogen, biomass, nuclear, wave(ocean) **Land Resources** Land as a resource, soils – types and degradation- soil erosion and pollution, soil conservation	**07**
5	**Biodiversity Resources** Genetic and species diversity, Ecosystem diversity, types of ecosystems-structure and function, symbiotic and synergic relationship, importance of biodiversity, value of biodiversity, hot-spots of biodiversity, threats to biodiversity, conservation of biodiversity **Environmental Legislation for resource management** Legal frame work, organizations and institutions, acts promulgated by India – Wild Life Act, Biodiversity Conservation Act, Environmental (Protection) Act, Forest Act	**10**

Text books

1. Anjaneyulu Y., (2004), "Introduction to Environmental Science", B.S. Publications, Hyderabad
2. Misra S.P. and Pandey S.N., (2008), "Essential Environmental Studies", Ane Book Publishers, NewDelhi.
3. Ram krishna mandal., (2015), "Natural resources management under sustainable development"
4. Trivedi P R and sudharshan K N., "Environment and natural resources conservation"
5. Vajiram and Ravi., (2018), "NATURAL RESOURCES"

References

1. "State of India's Environment" Down to earth annual reports, Centre for science and environment (CSE).

Course Outcomes	Program Outcomes												PSO's		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO11	P012	PSO 1	PSO2	PSO3
CO1	3	2	3	3	3	3	3	3	2	2	2	3	2	3	3
CO2	3	3	3	3	3	3	3	3	2	2	2	3	3	2	3
CO3	3	3	3	3	3	3	3	3	2	2	2	3	3	3	3
CO4	3	3	3	3	3	3	3	3	2	2	2	3	3	3	3
CO5	3	3	3	3	3	3	3	3	2	2	2	3	3	3	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Instrumentation and Automation in Environmental Engineering	***Course Code: 20EV812***
Credits : 03	***Total Contact Hours (L:T:P): 39:0:0***
Type of Course: Theory	***Category: Professional Elective Course V***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Engineering Physics, Engineering Chemistry

Course Objectives

The course provides exposure to the students on various aspects of analytical instruments for analyzing organic and inorganic compounds in water, wastewater and air samples and also the application of sensors in real time data monitoring and dissemination in Environmental Engineering applications.

Course Outcomes: After completing this course, students should be able to:

CO1	Characterize a liquid sample based on its ability of absorption and emission of light.
CO2	Determine the physico-chemical properties of liquid samples using electrical methods and luminescence properties
CO3	Identify and quantify based on separation of mixtures into their constituent components, gaseous and microbial components in ambient air and vehicle exhaust.
CO4	Analyze the structure, surface morphology, composition and functional elements of solid/liquid samples
CO5	Explain the application of automatic sensors for online real time monitoring and facilities for data dissemination

Unit No.	Course Content	No. of Hours
1	**Introduction:** Need for instrumentation and automation. **Principles of optical spectroscopy:** Electromagnetic spectrum, Beer-Lambert's law, absorption instruments, colorimeters - working principle, components and applications. **Spectrophotometers:** spectroscopy, absorption spectroscopy, spectrophotometers - working principle, components and applications. **Atomic spectrometry** - working principle, components and applications - Atomic absorption spectrometry, Atomic emission spectrometry, Mass spectrometry, ICP-MS measurements	**08**
2	**Luminescence** - working principle, components and applications - Fluorescence, phosphorescence, chemiluminescence **Electroanalytical methods** - Redox process, electrode and electrode potentials, electro chemical cells. Potentiometry and Conductometry, Electrophoresis - Basic, technique, types	**06**
3	**Chromatography:** fundamental concepts and applications, Gas chromatography, Liquid chromatography, Thin layer chromatography **Gas analyser:** VOC analyser, Automatic exhaust gas analyser, Microbial air sampler.	**08**

4	**Microscopy** - working principle, components and applications - Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy. **Thermal analysis** - heat capacity, thermal conductivity, TGA **Other instrumental methods:** Flame photometers, Ion-meter, FTIR, XRD	**09**
5	**Sensors:** Basic concepts - sensors to determine physico-chemical characteristics of water and wastewater (pH, conductivity, ORP, DO, turbidity, heavy metals, water level and discharge) Online monitoring devices for liquid and air samples, data dissemination. SCADA in water and wastewater systems.	**08**

Text books

1. R. S. Khandpur, (1989), Hand book of analytical Instruments TMH publication, New Delhi.
2. Randy D. Down P.E.,, Jay H. Lehr., (2004), Environmental Instrumentation and Analysis Handbook.

Reference books

1. Donald J. Peitrzyk, Clyde W. Frank. 2012. Analytical Chemistry, Second Edition, Academic Press
2. H. H. Willard, L. L. Merritt & J. A. 1988. DeanInstrumental methods of analysis by , CBS Publications 7th Ed.
3. Olga Korostynska, Alex Mason (Editors) Advanced Sensors for Real-Time Monitoring Applications, MDPI Books, Switzerland.
4. S. J. Holler & T. A. Nilman. 2019. Principles of Instrumental analysis. Saunders College Publications 5th Ed.
5. Subhas Chandra Mukhopadhyay, Alex Mason (Editors), 2013, Smart Sensors for Real-Time Water Quality Monitoring, Springer-Verlag Berlin Heidelberg.

Course Outcomes	**Program Outcomes**												**PSO's**		
	PO1	**PO2**	**PO3**	**PO 4**	**PO5**	**PO6**	**PO 7**	**PO8**	**PO9**	**PO10**	**PO11**	**P012**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	2	3	2	3	3	2	2	2	3	3	3	2
CO2	3	3	3	2	3	2	3	3	2	2	2	3	3	3	2
CO3	3	3	3	2	3	2	3	3	2	2	2	3	2	3	2
CO4	3	3	3	2	3	2	3	3	2	2	2	3	2	3	2
CO5	3	3	3	2	3	2	3	3	2	2	2	3	3	2	2

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Environmental Economics	***Course Code: 20EV813***
Credits: 03	***Contact Hours (L:T:P): 39:0:0***
Type of Course: Theory	***Category: Professional Core Course V***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Nil

Course Objectives

The course enables students to maintain a balance between economic development and environmental quality in order to achieve environmental balance, environmental economists explore the various socio-economic possibilities to reduce pollution and controversial issues related to environment and their sustainable management to uplift the standard of living.

Course Outcomes: After completing this course, students should be able to:

CO1:	Understand economical impacts of environmental projects.
CO2:	Perform Cost - Benefit analysis for environmental projects.
CO3:	Analyze economics of waste management and recycling.
CO4:	Understand the influence of industrial and economic policies on pollution control.
CO5:	Analyze the need of evaluations & apply the various techniques.

Unit No.	Course Content	No. of Hours
1	The Economic Approach: Introduction -The Human–Environment Relationship Environmental Problems and Economic Efficiency- Property Rights- Externalities as a Source of Market Failure- An Efficient Role for Government. Ethics, Economics and The Environment: Introduction- Naturalist moral philosophies Libertarian moral philosophy- Utilitarianism- Criticisms of utilitarianism- Inter temporal distribution	**08**
2	Evaluating Trade-Offs: Benefit–Cost Analysis: Normative Criteria for Decision Making Evaluating Predefined Options: Benefit–Cost Analysis- Finding the Optimal Outcome Relating Optimality to Efficiency- Applying the Concepts- Valuation of environment.	**08**
3	Recyclable Resources: An Efficient Allocation of Recyclable Resources- Factors Mitigating Resource Scarcity- Market Imperfections- Disposal Cost and Efficiency. The Disposal Decision- Corrective Public Policies	**08**
4	Economics Of Pollution Control: Introduction- A Pollutant Taxonomy - Defining the Efficient Allocation of Pollution- Stock Pollutants- Fund Pollutants-Market Allocation of Pollution-Efficient Policy Responses- Cost-Effective Policies for Uniformly Mixed Fund Pollutants -Defining a Cost-Effective Allocation- Cost-Effective Pollution-Control Policies -Cost-Effective Policies for Non-uniformly Mixed Surface Pollutants- The Single-Receptor Case- The Many-Receptors Case- Other Policy Dimensions- The Revenue Effect- Responses to Changes in the Regulatory Environment- Price Volatility- Instrument Choice under Uncertainty- Product Charges: An Indirect Form of Environmental Taxation	**08**

5	Need for environmental valuation, s. Methods of economic valuation of environment (concepts) - methods based on market prices-change in productivity technique, change in income technique, replacement technique, preventive technique, relocation technique. Surrogate method- travel cost and hedonic, simulated method or survey method-contingent valuation method. Limitation of environmental valuation.	**07**

Text books

1. Dixon, J., Economic Analysis of Environmental Impacts, Earthscan Publications, 1994
2. Tietenberg Tom and Lyne Lewis, Environmental Economics and policy, Pearson Higher Education, 2009
3. Tietenberg Tom and Lyne Lewis, Environment and Natural Resources Economics, Prentice Hall, 2011
4. Turner, R.K., Pearce, D., and Batman, I, Environmental Economics, The Johns Hopkins University Press, 1993
5. Values for the Environment: A Guide to Economic Approach – JT Winpeny, Overseas Development Institute, London, HMOS, 1991.
6. Economic Analysis of Environmental Impacts - D John, LF Scura, RA Carpenter, and PB Sherman, Earthscan Publications Ltd., London 1995.

Reference books

1. Bhattacharya N, Rabindra (2001) Environmental Economics- An Indian Perspective. Oxford University Press, Delhi.
2. Kolstad C (2000) Environmental Economics. Oxford: Oxford University Press. 3.
3. MuthukrishnanSubhashini (2015) Economics of Environment, Prentice Hall India Pvt ltd.
4. Shogren, J Hanley, N and White, B. (2013) Introduction to Environmental Economics, 2nd edn, Oxford: Oxford University Press
5. Environmental Assessment Source Book (Vol. 1) World Bank, Environment Department, Washington DC, The World bank, 1991.
6. Valuing the Environment – J Barde and DW Pearce (Ed.), Earthscan Publication, London, 1991.

Course Outcomes	**Program Outcomes**												**PSO's**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	2	2	2	2	2	2	1	1	2	2	2	2	2	2	2
CO2	3	2	1	2	2	1	1	1	3	2	2	3	2	3	2
CO3	3	3	2	3	2	1	1	1	3	2	3	2	2	2	3
CO4	1	1	1	1	2	2	1	3	3	3	2	1	2	3	2
CO5	3	2	2	3	2	3	2	3	2	3	3	3	2	2	2

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Climate Change and Emission Trading	***Course Code: 20EV821***
Credits :3	***Total Contact Hours (L:T:P): 39:0:0***
Type of Course: Theory	***Category: Professional Elective Course VI***
CIE Marks: 50	***SEE Marks:100***

Pre-requisite: Elements of Environmental Engineering, Environmental Impact Assessment

Course Objectives

The course provides concepts of climate, drivers of climate change, impacts and sectorial climate models. Exposes the student to various facets of vulnerability and adaptability, possible mitigative measures. Introduces Indian climate change scenario. Also covers the importance of emission trading, trading mechanisms, regulatory framework and market potential

Course Outcomes: After completing this course, students should be able to:

CO1:	Describe the components of earth's atmosphere, its composition, drivers of climate change and predictive models for the same
CO2:	Comprehends the impacts of climate change on various sectors , assess the vulnerability component and suggest mitigation options/adaptation strategies for handling climate change
CO3:	Explain the key concepts and intricacies of emission trading mechanisms and to perform simulation studies to know the climate change over Indian region
CO4:	Describe the challenges involved in implementation of pollution prevention permits and design strategies for preventing episodic events
CO5:	Evaluate the need for enforcement framework and mechanics of financing and market variations/potential

Unit No.	Course Content	No. of Hours
1	**Introduction:** Earth's climate, climate change, drivers of climate change **Climate models:** Models for climate change, GCMs, RCMs, designing climate change experiments with climate models, climate change scenarios Sector models – water resources, Agricultural, forestry, energy.	**07**
2	**Climate change impacts:** Impacts of climate change on environment, human, agriculture and energy systems, coastal zone**.** **Vulnerability/adaptation:** Need for vulnerability assessment; generic steps, approaches and tools of assessment; adaptation to climate change by various sectors **Mitigation:** Mitigation measures for climate change	**08**
3	**Emission trading**: Introduction to emission trading, evolution of emission trading and design features Cost-effective permit markets, the role of transaction costs, the role of technical change, Consequences of emission trading **Climate change and India** Impacts, sectoral and regional vulnerability in India, Evaluation of model simulation over India; mandatory requirements for project financing	**08**

4	**The spatial dimensions:** difficulties in implementing an ambient permit system, possible alternatives, nature of evidence, borrowing, banking, and environmental target, Linking emissions and pollutant concentrations. Strategies for controlling seasonal or episodic peaks and allocation approaches	**08**
5	**Market power:** permit price manipulation, conceptual models, leveraging power between outputs and permit markets, mechanisms for controlling market power, programmatic design features that affect market power**.** **Monitoring and enforcement:** Domestic and international enforcement process, economic enforcement, current enforcement practice, program effectiveness	**08**

Text books

1. Shukla P. R, et al. (2004), "Climate Change and India: Vulnerability Assessment and Adaptation " – Universities Press.
2. Konrad Soyez and Hartmut Grabl (2008), "Basic Facts, Evaluation and Technological Options" – Springer Publications

Reference books

1. UNFCCC Reports on Climate Change.
2. Thomas H. Tietenberg (2006) "Emissions Trading: Principles and Practice", Ref Press Book
3. Noel D Nevers, (2000), "Air Pollution Control Engineering", McGraw Hill International Editions, Civil Engineering Series, Mc Graw Hill
4. Wark K., Warner C.F., and Davis W.T., (1997), "Air Pollution – Its Origin and Control", Third Edition, Prentice Hall of India Publishers
5. Intergovernmental Panel on Climate Change Reports -2013,2014,2018

Course Outcomes	**Program Outcomes**												**PSO's**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	2	3	3	3	2	2	2	3	3	3	3
CO2	3	3	2	3	2	3	3	3	2	2	2	3	3	3	3
CO3	3	3	2	3	2	3	3	3	2	2	2	3	3	3	3
CO4	3	3	2	3	2	3	3	3	2	2	2	3	3	3	3
CO5	3	3	2	3	2	3	3	3	2	2	2	3	3	3	3

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Transport and Fate of Environmental Pollutants	*Course Code:20EV822*
Credits: 3	*Total Contact Hours: (L:T:P):39:0:0*
Type of Course: Theory	*Category: Professional Elective Course VI*
CIE Marks: 50	*SEE Marks: 100*

Pre-requisite: Environmental Chemistry, Atmospheric Pollution, Wastewater Treatment Engineering, and Hydrology

Course Objectives

Student builds an understanding and application knowledge on various physical phenomena, chemical and biological processes and their influence on the fate and transport of a variety of pollutants in water, soil and air compartments.

Course Outcomes: After completing this course, students should be able to:

CO1:	The student understands the fundamentals of mass balance approach and process dynamics.
CO2:	Learns the physical phenomena–advection, convection and evaporation processes and able to derive related equations with analytical solutions.
CO3:	Able to describe the concept of mixing zone in natural aquatic bodies and its influence on pollutant dispersion. Derives 2-DStreeter-Phelps'sequation and uses it to solve simple numerical problems.
CO4:	Differentiates stratified and unstratified lake systems, develops knowledge on dispersion characteristics of pollutants in lakes, estuaries, and ocean environment.
CO5:	Acquires sufficient knowledge to derive1 and 2 D equations for pollutant dispersion in sub-surface soil. Applies effectively the Gaussian distribution model to plot ground level concentrations of air pollutants for dynamic meteorological conditions.

Unit No.	Course Content	No. of Hours
1	**Introduction** to Modelling and Transport Processes, Process Dynamics, Mass Balance Approach, Material Balance Relationship, Chemical transformations, Photochemical transformation.	**06**
2	**Mechanics of Mass Transport:** Diffusive and Convective Mass Transport. Fick's Law of Diffusion, Combined Convective-Diffusion Equations for 1 and 2 Dimensions. Analytical Solutions for 1-D & 2-D Cases, Simple Problems.	**08**
3	Principal Components of DO analysis, Sources and Sinks of DO, Effects of Oxygen Demanding Waste, Bacteria and Nutrients, Streeter –Phelp's Equation and Expression for Critical Point, 2-D models, Mixing zone concept – types of outfall and mixing regimes, Simple Problems	**09**

4	Description of Water Quality Processes in Natural Water Bodies: Lake (stratified and completely mixed), Estuary and Coastal Regions.	**08**
5	**Groundwater Quality**: Material Balance Relationship, Basic differential equations with analytical solutions for 1-D case. **Air quality modelling:** Gaussian plume model – for point source. Gaussian dispersion co-efficient, Downwind ground-level concentration computation, maximum ground level concentration.	**08**

Text books

1. Schnoor J.L., (1997), "Environmental Modelling – Fate and Transport of Pollutants in Water, Air and Soil", John Wiley and Sons.
2. Thomann R.V., & Mueller M. J., (1987), "Principles of Water Quality Modelling and Control", Harper & Row Publishers.
3. Metcalf & Eddy Inc, (2019), "Wastewater Engineering, Treatment and Reuse"- 3rd Edition, Tata McGraw Hill Publishers Co. Ltd, New Delhi.

Reference books

1. Freeze R.A. and Cherry J.A., (1979), "Groundwater", Prentice Hall, New Jersey
2. Weber W.J., (1972), "Physico - Chemical Processes for Water Quality", John Wiley & Sons,
3. Fischer H. B., List E.J., Koh R.C.Y., Imberger J., Brooks N.H., (1979), "Mixing in Inland and Coastal Waters", Academic Press Inc.

Course Outcomes	**Program Outcomes**												**PSO's**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	3	2	3	2	3	3	1	2	1	2	2	2	2	2
CO2	3	3	3	3	3	3	3	1	2	1	2	2	2	3	2
CO3	2	3	3	3	3	3	3	1	2	1	2	2	2	3	2
CO4	2	3	2	3	2	3	3	1	2	1	2	2	2	3	2
CO5	3	3	3	3	3	3	3	1	2	1	2	2	2	3	2

0 -- No association 1---Low association, 2--- Moderate association, 3---High association

Course Title: Environmental Forensics	***Course Code: 20EV823***
Credits : 3	***Total Contact Hours(L:T:P): 39:0:0***
Type of Course: Theory	***Category: Professional Elective Course VI***
CIE Marks: 50	***SEE Marks: 100***

Pre-requisite: Environmental Chemistry, Wastewater Engineering, Solid waste management, Environmental management, Life cycle analysis.

Course Objectives

This course is a combination of analytical and environmental chemistry which enhance the knowledge of students involved in field analytical studies, data interpretation and modelling connected with the attribution of pollution events to their causes.

Course Outcomes: After successfully completing this course, the students will be able to:

CO1	Understand associated terminology and analyze toxicity estimates of important priority contaminants.
CO2	Evaluate sampling protocols for forensic analysis and interpretation of data.
CO3	Understand forensics characterization of hazardous materials and real time case studies.
CO4	Understand the various EF techniques and data analysis by different analytical equipment.
CO5	Evaluate recent trends in EF and use of critical thinking skills in EF.

Unit No.	Course Content	No. of Hours
1	**Environmental forensics** – definition, terminology. Role of the Environmental forensic engineer/scientist. Forensic geochemistry, Health forensics, Forensic toxicology. Toxicity and risk estimates of priority environmental contaminants and fate. EF - past, present and future. Simple problems.	**06**
2	**Legal and forensic** - sampling, and analysis for priority parameters for court submissions. Portable separation devices for forensic analysis. Models involving pollutant transport - links with EFs covering all environmental attributes. Biosensors in forensic analysis. Environmental forensic characterization. Multivariate statistical analysis. Microbial evidences. Reverse engineering for environmental crimes. Forensic traces and nanomaterials. Interpretation of forensic data.	**11**
3	**Environmental forensics characterization** – Hazardous materials, POP's, PAHs, e-waste forensics. Case studies on forensic investigations of water pollution and solid wastes. Forensic tracking of leaking underground storage tanks (LUST). Food forensics, oil spill forensics.	**06**
4	**Environmental forensic techniques -** Finger printing tools and techniques, Touch microbiome. Analytics: Ion chromatography - mass spectrometry - proteomix, Imaging tools, two dimensional GC, atomic force microscopy, molecular spectrum fusion analysis, Laser induced breakdown spectroscopy (LIBS), Fourier transform infrared total attenuated reflectance spectroscopy (FTIR-ATR). Forensic applications of desorption electrospray ionization mass spectrometry (DESI-MS).	**10**

5	**Recent trends:** Forensic investigations feedback – strengthening legal boundaries. Electrochemical strategies for detecting forensic drugs. Blending biomedical forensics with environmental forensics. Tracing back to source approaches. Environmental crime reconstruction – 3D forensic science. Enantiomeric fractions in EF. Micro-extractions in forensic toxicology. Critical thinking skills in EF. Next generation sequencing technology. Forensic solutions. EF of micro plastics.	**06**

Text Books

1. Environmental forensics – Principles and applications. Robert D Morrison. CRC press, 1999.
2. Practical environmental forensics – Process and case histories. Sullivan, Agardy and Traub. Environmental Engineering series. 2001.

Journal articles

1. Journal articles on Sciencedirect.com, acs.org, springer link and Taylor & Francis.
2. Predatory Journals are not referred for information.

Course Outcomes	Program Outcomes												PSO's		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	P012	PSO 1	PSO 2	PSO3
CO1	2	3	1	1	1	1	2	2	1	1	1	1	3	3	3
CO2	1	1	1	2	3	1	2	3	3	2	3	2	3	3	3
CO3	1	1	1	2	3	2	3	2	1	1	3	3	3	3	3
CO4	2	2	2	1	3	1	3	1	3	2	1	3	3	3	3
CO5	2	2	2	1	2	1	2	2	2	2	1	3	3	3	3

Scale: 0--No association; 1--Low association; 2-- Moderate association; 3--High association

Course Title: Project Work Phase - II	*Course Code:20EV83P*
Credits : 10	*Total Contact Hours: (L:T:P):0:0:0*
Type of Course: Project Work	*Category: Project Work Course*
CIE Marks: 70	*SEE Marks: 30*

Pre-requisite: Environmental Engineering subjects

Course Objectives

The project work trains the students to carry out literature review, identify the Gaps/problems, devise workable objectives and methodology, conduct the investigation following Engineering ethics, and analyze, interpret and present the findings and thus develop technical creative thinking, planning, time management, leadership qualities and managerial skills.

Course Outcomes: After completing this course, students should be able to:

CO1:	Conduct systematic review of technical literature, identify research gaps, and define objectives and scope of work
CO2:	Develop skills in terms of design, conduct investigations and data analytics
CO3:	Develop oral and written communication skills for report preparation, paper publication and technical presentation

- Each student shall be associated with a faculty member serving as his/her guide to supervise the dissertation work.
- Periodic progress review presentations of the project work shall be according to the calendar of events scheduled by the University.
- The student will work with the project guide/supervisor towards the identification of the problem through a systematic literature review and will finalize the objectives and scope of work.
- The student will present synopsis and submit the same to the Department Under-Graduate Committee (DUGC) during the 1st phase and after due approval from the guide.
- During the 2nd phase, student will present the work progress as part of review of the project work.
- The DUGC and guide will jointly evaluate the student performance.

Course Outcomes	**Program Outcomes**												**PSO's**		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	P012	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	2	3	2	3	2	3	2	3	2	3
CO2	3	3	3	2	3	2	3	2	3	2	3	3	3	2	3
CO3	3	3	3	2	2	2	3	3	3	3	2	3	3	3	3

Scale: 0--No association; 1--Low association; 2-- Moderate association; 3--High association

SWAYAM / NPTEL Courses

Sl. No.	Course Name	Duration
1	GPS Surveying	4 weeks
2	Principles and Applications of Building Science	
3	Geotechnical Engineering Laboratory	
4	Organic Farming For Sustainable Agricultural Production	8 Weeks
5	Housing Policy & Planning	
6	Principles of Construction Management	
7	Project Planning & Control	
8	Plastic Waste Management	
9	Earth Sciences For Civil Engineering Part - I & II	
10	Basics of Health Promotion and Education Intervention	
11	Project Management	
12	Economics of Health And Health Care	
13	Ethics In Engineering Practice	
14	Knowledge Management	
15	Basic Environmental Engineering and Pollution Abatement	12 Weeks
16	Principles and Practices of Process Equipment and Plant Design	
17	Environmental Geomechanics	
18	Environmental Chemistry	
19	Integrated Waste Management For A Smart City	
20	Wastewater Treatment And Recycling	
21	Environmental Modeling and Simulation	
22	Availability and Management of Groundwater Resources	
23	Environmental & Resource Economics	
24	Constitution of India and Environmental Governance: Administrative and Adjudicatory Process	
25	Advanced Contracts, Tendering and Public Procurement	
26	Industrial Safety Engineering	
27	Solar Energy Engineering and Technology	
28	Water Economics And Governance	

Note:

- ***The courses listed above are subject to availability in NPTEL / SWAYAM portal.***
- ***Students can take SWAYAM courses from 3rd semester to 6th semester and qualification certificate is to be submitted to the department before the commencement of 7th semester for considering in Professional elective IV* offered in 7th semester.***
- ***Students who could not qualify/ complete the SWAYAM course from 3rd to 6th semesters should register for Professional elective – IV in 7th semester.***
- ***SWAYAM course should be minimum of 12 weeks (12 weeks or 8 + 4 weeks or 4 + 4 + 4 week or any other combination).***