Course Scheme and Syllabi

(with effect from **July 2023**)

M.Tech.

Environmental Science and Technology

Department of Energy & Environment

Thapar Institute of Engineering & Technology, Patiala

M.Tech Environmental Science and Technology

Total No. of Seats: 18

Admission Criteria:

Admission to ME/M.Tech. programme will be open to the candidates who obtained at least 60% marks in aggregate in the qualifying examination from a recognised University.

Admission shall be made on the basis of valid GATE Score in relevant discipline. First preference will be given to the GATE qualified candidates. After offering seats to the GATE qualified candidates, admission for the remaining vacant seats (if any) will be made on the basis of merit in the qualifying degree.

Eligibility Criteria:

- BE/B.Tech. degree in any branch of Engineering or Technology (or)
- M.Sc. in any disciplines.
- **For Sponsored candidates:** with two years of work experience after qualifying degree.

M.Tech. Environmental Science and Technology

Program Objectives:

- To prepare the graduates in Environmental Science and Technology fundamentals, and capable in addressing the diverse present and potential environmental problems
- To prepare the students for successful career in the industry; regulatory agencies, departments and boards; consulting firms; and academic and R&D institutions of international standard
- To prepare the environmentalists who are sensitive to and well aware of the environmental concerns, issues and problems, and who can apply their specialized and modern environmental knowledge for the environmentally sound development.
- To lay firm foundation for environmental managers who can work in multidisciplinary and interdisciplinary teams and who understand the language of both masses and the specialists from different disciplines.

First Semester

Course No.	Course Title	L	T	P	Cr
PES116	Elements of Environmental Sciences	3	1	2	4.5
PES111	Air Quality Modelling and Climate Change	3	1	2	4.5
PES117	Wastewater Treatment Technologies	3	1	2	4.5
PES208	Solid and Hazardous Waste Management	3	1	2	4.5
PMA102	Research Methodology*	2	0	2	3.0
PES118	Remote Sensing and GIS: Principles and Applications	2	0	4	4.0
	Total	**16**	**4**	**14**	**25**

***Proposed by BoS to be modified by respective department/school**

Second Semester

Course No.	Course Title	L	T	P	Cr
PES206	Water Quality Modelling and Treatment	3	1	2	4.5
PES205	Air Pollution Control Engineering	3	1	2	4.5
PES225	Environmental Legislation and Impact Assessment	3	1	0	3.5
PES213	Environmental Safety and Management	3	1	0	3.5
	Elective-1	3	0	0	3.0
	Elective-II	3	0	0	3.0
	Total	**18**	**4**	**4**	**22**
Note: Any one of the above courses may be offered through MOOC if available					
List of Electives					
Elective -1		**3**	**0**	**0**	**3.0**
PES215	Industrial Pollution Abatement				

PES216	Sustainability and Cleaner Technologies				
PES234	Watershed Management				
PES226	Energy and Environment				
Elective – II		**3**	**0**	**0**	**3.0**
PES217	Sanitation and Public Health				
PES219	Sustainable Materials and Green Buildings				
PES227	Environmental Biotechnology				
PES228	Contaminant Transport				

Note: Electives are offered on the basis of preferences from each of the two groups. An elective is offered only if the number of students registered is five or more.

Third Semester

Course No.	Course Title	L	T	P	Cr
PES391	Seminar	-	-	-	4.0
PES395	Minor Project	-	-	-	6.0
PES492	Dissertation/ Industrial Project (Starts)	-	-	-	-

Fourth Semester

Course No.	Course Title	L	T	P	Cr
PES492	Dissertation/ Industrial Project	-	-	-	16.0

Total Credits: 73

Program Outcomes:

- Acquiring fundamental knowledge and understanding of environmental sciences
- Acquiring basic environmental monitoring skills, including design and conduct of experiments and data analysis
- Having fundamental knowledge of environmental technologies, and acquiring capabilities for the design, diagnosis and analysis of pollution control systems and devices, and of water supply and wastewater engineering
- Acquiring abilities and capabilities in the areas of development and implementation of environmental management systems, and environmental analysis, environmental aspects identification and environmental impacts assessment
- Obtain basic understanding on the aspects closely related with the environment, such as, energy, climate change, ISO 14001 based management systems and auditing, and project management

PES116 ELEMENTS OF ENVIRONMENTAL SCIENCES

L	T	P	Cr
3	1	2	4.5

Course Objectives:

To provide understanding of basic mechanisms underlying chemical and biological aspects of environmental issues; inculcate concern for one's own surrounding and sustainable living; and develop capacity to act at own individual level to protect and management the environment

Introduction to Environmental Systems: Definitions, principles and scope; Physico-chemical and biological factors of Environment; Geographical classification and zones; Mass and energy transfers across the various interfaces; Material balance in ecosystem; Laws of thermodynamics and their relevance to ecological systems

Environmental Chemistry: Stoichiometry in nature; Gibb's energy; Chemical potential, equilibria and reactions in nature; Water chemistry, solubility, carbonate system; Chemical speciation in air; Chemical processes for the formation of inorganic and organic particulate matter; Thermo and photochemical reactions of atmosphere; Oxygen and ozone chemistry; Photochemical smog, hydrocarbons, free-radicals and radionuclides; Soil chemistry.

Environmental Biology: Structure and functional components of ecosystem; Species, population and community dynamics; Variety and variability in ecosystems; Biodiversity; Microflora of air.

Environmental Geosciences: El Nino; Droughts, cyclones and western disturbances; Earth processes; Residence, time and rates of natural cycles; Geological formations and hazards; Prediction and prevention of hazards; Minerals, mining and environmental impacts; Groundwater, exploitation and pollution; Soil and land use patterns and impact; Principles of remote sensing.

Environmental Toxicology: Toxicology - Definition and Branches; Classification of toxic agents; Acute and chronic exposure; Spectrum of toxic effects; Dose-Response Relationship; Toxicokinetics; Mechanism of action; Toxicology of emerging pollutants

Laboratory Work: Estimation of pH in water samples; determination of conductivity, hardness, acidity, alkalinity, chloride, fluoride, iron, total solids, suspended solids, total dissolved solids, and MPN in different water samples; determine residual chlorine in water sample by break point chlorination; estimation of optimum dose of coagulant by jar test; isolation, microscopic examination and characterization of microbes in soil and water samples

Course Learning Outcomes (CLOs):

On the completion of course, students will be able to:

- Apply core concepts and methods of ecological and physical sciences in environmental problem solving.
- Analyse the role of anthropogenic influences on biogeochemical processes.
- Conceive and evaluate the effects of environmental toxicants on human and animal systems.

Recommended Books

1. *Sawyer CN, McCarty PL and Parkin GF, Chemistry for Environmental Engineering and Science, McGraw Hill (2003).*
2. *Shaw IC and Chadwick J, Principles of Environmental Toxicology, Taylor& Francis ltd. (1998).*

3. ***Kolwzan B,*** *Adamiak W, Grabas K and Pawelezyk K,* ***Introduction to Environmental Microbiology:*** *Oficyna Wydawnicza Politechniki Wroclaweskiej, Wroclaw (2003).*
4. *Gray NF, Biology of Wastewater Treatment, Imperial College Press (2004).*
5. *Cunningham W, Environmental Science – A Global Concern, 12th Edition, McGraw Hill (2010).*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	40
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	30

PES111 AIR QUALITY MODELLING AND CLIMATE CHANGE

L	T	P	Cr
3	1	2	4.5

Course Objectives:
To inculcate fundamental knowledge and understanding of air pollution; to facilitate acquiring basic skills of air quality monitoring and modelling techniques to understand effect of meteorological parameters on the dispersion of air pollutants; and to develop awareness of the global climate Change related issues.

Introduction: Overview of current air quality monitoring, trends and challenges; Basic concepts; sources and effects of air pollutants; origin & classification of air pollutants; Air Quality Index and Standards.
Air Quality Monitoring: Preliminary information required for planning an air quality survey; Guidelines for planning a survey; Site Selection; Design of an air quality surveillance network; Ambient air quality and source monitoring – Particulates and gaseous pollutants; Iso-kinetic sampling; Tail pipe emissions monitoring; Indoor air quality monitoring; On-line monitoring; Storage and transportation of environmental samples; Preparation of samples for analysis.
Meteorology: Micro and Macro-meteorology; Wind roses; atmospheric stability; inversions; mixing height and topographic effects; Application of meteorological principles to transport and diffusion of pollutants, Scavenging processes; Plume behaviour; Plume rise.
Air Quality Modelling: Basic Components of an Air Quality Simulation Model; Steady state; Non-Steady-state and Grid Meteorological Modelling; Dispersion and Receptor modelling techniques; Gaussian plume model; Pasquilli's stability classification; Modeling softwares; Validation of Models; Applications of Modeling; Air Pollution Forecast Models.
Climate Change: Climatic classifications; Climatic controls; Spatial and temporal patterns of climate parameters in India; Possible causes of climate change- External and Internal; Causes and consequences of global warming; international conventions on climate change; The concept of carbon sequestration. Carbon cycle; Introduction to Global Circulation Model, Scenarios and representative concentration pathways (RCP's), Downscaling, IPCC and data sources.

Laboratory Work: Ambient air monitoring for particulates and gaseous pollutants; Stack monitoring; Tail pipe emissions monitoring; Measurement of indoor air quality; Air modelling softwares - ISCST3; Aermod, Calroads, Calpuff, etc.

Course Learning Outcomes (CLOs):
On the completion of course, students will be able to:

- learn techniques employed in the monitoring of particulates and gaseous pollutants in ambient air and flue gases
- demonstrate a detailed knowledge of study the effect of meteorological parameters in the dispersion of air pollutants
- predict ground level concentration of pollutants from a given source through air quality modelling
- comprehend the concepts of climate change and related protocols

Recommended Books

1. *Borrego C and Ana IM,Air Pollution Modeling and its Application; Springer (2008).*
2. *Tiwary A and Colls J, Air Pollution: Measurement; Modelling and Mitigation; Spon Press 3rd Ed. (2002).*
3. *Khare M, Air Pollution – Monitoring; Modelling; Health and Control; InTech Publishers (2012).*
4. *Brebbia CA,Power H and Tirabassi T, Air Pollution V: Modelling; Monitoring and Management; InTech (1997).*
5. *Boubel RW, Fox DL, Turner DB and Stern AC, Fundamental of Air Pollution, Academic Press (1994).*
6. *RaoMN and Rao HVN, Air Pollution, Tata McGraw-Hill (2006).*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

PES117 WASTEWATER TREATMENT TECHNOLOGIES

L	T	P	Cr
3	1	2	4.5

Course Objectives:

To understand the science and technologies of wastewater treatment processes and operations. To know the design, analysis, operation and control of the routinely used wastewater treatment units. To understand the sampling and analytical techniques required for the wastewater characterization and for the monitoring of the wastewater treatment plants. To acquire knowledge on the facilities and provisions required for the handling and management of the wastewater treatment sludge.

Wastewater Classification, Characteristics, and Effluent Standards: Physical, chemical and biological parameters of wastewater; DO; BOD and BOD kinetics; Nutrients; Continuous monitoring; Effluent standards,

Wastewater Treatment Schemes: Overview of treatment technologies for wastewater generated from different sources- domestic and industrial wastewaters.

Preliminary Treatment: Screens; Grit removal facilities; Effluent sumps and pumps; and Equalization tanks; Skimming tanks.

Primary Treatment: Neutralization and precipitation; Primary sedimentation tanks; Membrane filtration processes.

Biological Treatment: Activated sludge process and its modifications including SBR; Trickling filters and RBC units; MBR and MBBR technologies; UASB reactors and Waste stabilization pond systems.

Other Treatment Technologies: Biological nutrient removal; Filtration and chlorination; Membrane processes for TDS reduction and Advanced oxidation processes; MEE; MVR; Wastewater sludge management; O&M of wastewater treatment plants.

Wastewater Recycling and Reuse: Introduction to water footprint and Zero Liquid Discharge.

Laboratory Work: DO, BOD and COD measurements**;** BOD kinetic parameters; MLSS, MLVSS and SVI; Biogas generation potential; Settling column tests for primary and secondary clarifiers, TKN estimation. Phosphorus estimation, Oil and grease estimation, Sulphate estimation

Course Learning Outcomes (CLOs):

On the completion of course, students will be able to:

- decide on the scheme of treatment for wastewaters
- design, analysis, operate and control the routinely used wastewater treatment units
- monitor the wastewater treatment plants and characterize the wastewater samples
- decide on the facilities and provisions for the handling and management of the wastewater treatment sludge.

Recommended Books

1. *Metcalf, Eddy ,Tchobanoglous, G., Burton, F.L., Stensel, H.D., Wastewater. Engineering – Treatment, Disposal and Reuse, Tata McGraw Hill, 4th ed. (2002).*
2. *Eckenfelder WW Jr., Industrial Water Pollution Control, McGrawHill 3rd ed. (2003).*
3. *Biological Wastewater Treatment, Edited Volume Series, IWA (2008).*
4. *Garg S. K, Sewage Disposal and Air Pollution Engineering, Environmental Engineering (Vol II), Khanna Publications, 34th edition (2016).*

Evaluation Scheme:

S.N.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes)	25

PMA102 RESEARCH METHODOLOGY

L	T	P	Cr
2	0	2	3.0

Course Objectives:

Ability to elaborate the concept of distribution functionability to distinguish between a discrete and continuous random variable and discuss transformation of one-dimensional, two-dimensional variables; develop potential towards problem solving using analysis of variance techniques;able to compute and interpret Karl Pearson's correlation coefficient and Spearman's rank correlation coefficient. Able to constitute random block design, Latin square design, and derive their probability distributions

Introduction: Nature and objectives of research, Study and formulation of research problem, Scope and formulation of hypothesis, Preparation and presentation of research and project proposals, Selection of thrust research.

Introduction to Statistical Analysis: Measures of Central Tendency and Dispersion, Mean, Median, Mode, Range, Mean deviation, Standard Deviation.

Random Variables and Probability Distribution: Definition, Distributions, Functions, Mathematical Expectation, Binomial, Poisson, Geometric, Negative bionomial, Exponential, Normal and log-normal distributions.

Hypothesis Testing: Tests of Significance based on normal, t and chi-square distributions, Analysis of variance technique.

Linear Regression and Correlation: Linear regression, Least square principle and fitted models, Karl Pearson's correlation coefficient, Rank Correlation, Lines of regression.

Design of Experiments: Completely randomized design, Random block design, Latin square design, Statistical analysis and variances of estimates, Analysis of covariance.

Laboratory Work: Implementation of statistical techniques using statistical packages *viz*., SPSS, ORIGIN PRO & MATLAB, R Programming, Mathematica including evaluation of statistical parameters and data interpretation, Regression Analysis, Covariance, Hypothesis testing and analysis of variance.

Course Learning Outcomes (CLOs):

On the completion of course, students will be able to:

- acquire skills for formulating research problems and hypotheses to be tested, and for the preparation and presentation of research/project proposals
- interpret probability and data distribution functions and becoming capable of estimating mathematical expectations
- analyse regression and correlation analysis, development of statistical models, and calibration, validation and use of the models
- design of experiments for investigations and hypotheses testing relating to research problems and projects
- acquaint with the commercially available software packages for the statistical data analysis

Recommended Books

1. *Dowdy S, Wearden S and Chilko D. Statistics for Research, Wiley Series 2nd ed (2004).*
2. *Walpole RE, Myers RH, Myers SL. and Ye K. Probability and Statistics for Engineers and Scientists, Pearson Education 7Th ed (2002).*

Evaluation Scheme:

S.N.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizzes/Lab Evaluations)	40

PES118: REMOTE SENSING AND GIS: PRINCIPLES AND APPLICATIONS

L	T	P	Cr.
2	0	4	4.0

Course Objectives: To analyze the remote-sensed data for solving geospatial problems.

Principles and Fundamentals of Remote Sensing: Sources of Energy – Active and Passive radiation – Electromagnetic Radiation – Nomenclature, Reflectance, Transmission and Absorption, Thermal Emission – Plank's formula, Stefan – Boltzman Law, Wein's Displacement Law; Emissivity – Kirchoff's Law, Characteristics of Solar Radiant Energy.

Sensors and Platforms: Types of sensors, Multispectral, hyper spectral, thermal, orbital characteristics, working principles and instrumentation. Storage and Retrieval of data - IRS satellite systems – Introduction, Stages of development, Sensory Characteristics, Orbit and Coverage's, various types of data product and its uses. Visual analysis of data in application of remote sensing to various engineering fields, NDVI and other indices.

Principles of Geographical Information Systems (GIS): Geographic information and spatial data types, Hardware and software; GIS; Steps of spatial data handling, database management systems, Spatial referencing, Image Interpretation Elements.

Analytical GIS capabilities and Applications: retrieval and classification; overlay functions, neighbourhood operations; network analysis; error propagation, Data visualization. LULC Classification.

Laboratory work:

Familiarization with GIS Software, Data Input and data formats; Image enhancement and classification techniques; Stacking of Multispectral Image; Image subsetting and Mosaicing; Creation of Thematic Maps; Normalized difference vegetation index; Supervised and unsupervised classification; Data Conversion – Vector to Raster, Raster to Vector; Adding Attribute Data – Querying On Attribute Data; Geo Referencing and Projections; Digitization of Points, Lines, and Map; Image Enhancement – Linear and Nonlinear; Developing Digital Elevation Model; Web GIS Applications.

Course Learning Outcomes (CLOs):

On the completion of course, students will be able to:

- Design the various processes involved in remote sensing
- Processes the raw data and prepare the final product after necessary corrections
- Interpret the remotely sensed data
- Learn the use geospatial data for the benefit of the end users

Recommended Books

1. *Lillisand, T.M. & Kiefer R.W, Remote Sensing and Image Interpretation (7th Edition), John Wiley and Sons, 2015.*
2. *Bhatta, Basudeb, Remote Sensing and GIS, (third edition,) Oxford, 2021.*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include assignments/quizzes/tutorial, Lab)	25

PES206 WATER QUALITY MODELLING AND TREATMENT

L	T	P	Cr
3	1	2	4.5

Course Objectives:
To facilitate understanding of water quality guidelines, criteria and standards, and water quality index; understanding and implementation of water quality programs; to acquire knowledge of the water quality modeling, sampling and analysis; and to provide exposure to the conventionally used water quality models. To understand the science and technology of water treatment; to know design, analysis, operation and control of routinely used water treatment units.

Water – Quality, Standards and Criteria: Physical; chemical and biological water quality; Heavy metals and pesticide contaminants; Water quality guidelines; criteria and standards; water Sampling and Network Design:
Water Quality Modelling: Introduction to water quality modeling; Modeling of Lakes and reservoirs; Rivers and streams and Groundwater modeling; Modeling for common water quality parameters: DO; temperature; suspended solids; algae; nutrients; coliforms and toxics; Calibration; validation and use of water quality models.
Water Treatment Schemes and Technologies: Overview; Treatment of surface waters and ground waters for - drinking; soft; RO and DM waters. Coagulation/Precipitation, Flocculation and Settling; Filtration Systems Types, Design and Applications; Disinfection Methods:
Other Water Treatment Technologies: Softening; Ion-exchange process; Adsorption process; membrane processes (Nano-filtration and reverse osmosis); Defluoridation units and household level water purification systems; Operation and Maintenance of Water Treatment Plants.

Laboratory Work: Optimum pH and dose of coagulants; Breakpoint chlorination and MPN determination; Adsorption isotherms; Ion-exchange resin capacity assessment; Membrane processes for disinfection and TDS reduction. Conventional Water Quality Models**:** EPANET/ QUAL2E – QUAL2K/ BASINS/ WASP7.

Course Learning Outcomes (CLOs):
On the completion of course, students will be able to:

- reflect basics of water quality guidelines, criteria and standards
- model water bodies for different water quality parameters, and run some of the conventional water quality models
- design, analyse, operate and control the routinely used water treatment units

Recommended Books

1. *Metcalfe and Eddy Inc., Tchobanglous G, Burton FL, Stensel HD, Wastewater Engineering – Treatment, Disposal and Reuse, Tata McGraw Hill (2007).*
2. *Eckenfelder WW Jr, Industrial Water Pollution Control, MeGraw Hill 3rd ed (2003).*
3. *Weber WJ, Physico-chemical Processes for Water Quality Control, John-Wiley (1999).*

4. *Tebbutt THY, Principles of Water Quality Control, Butter Worth Heinemann (1998).*
5. *Santosh Kumar Garg, Water Supply Engineering: Environmental Engineering - Vol. I, Khanna Publishers (2017).*
6. *Bartram J (Ed.),Water quality monitoring: A practical guide to the design and implementation of freshwater quality studies and monitoring programs, Taylor & Francis (2012).*
7. *Manivanan R, Water quality modeling: rivers, streams and estuaries, New India Publishing Agency (2008).*
8. *Chapra SC, Surface water quality modeling, Waveland press (2008).*
9. *Thomann RV and Mueller JA, Principles of surface water quality modeling and control, Harper & Row (1987).*

Evaluation Scheme:

S.N.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

PES205 AIR POLLUTION CONTROL ENGINEERING

L	T	P	Cr
3	1	2	4.5

Course Objectives:

To facilitate understanding of the principles underlying designing of industrial ventilation systems and mechanical devices used for particulate and gaseous emission control from various sources. To acquire basic knowledge in management strategies for the control of air pollution

Introduction: Role and scope of air pollution control engineering; Principles of fluid flow; Energy equations; Fluid flow measurement; Dynamics and collection efficiencies of particles in fluid; Source reduction (Fuel substitution, Fuel pretreatment, Process modifications); Emission standards.

Design of Industrial Ventilation Systems: Component of Ventilation systems; Air pollution control systems; Hood & Duct design and specifications; Blowers; stacks.

Particulate Emission Control: Design and operation - settling chambers (Both laminar and turbulent flow), Cyclone and multiclones, Scrubbers, Bag houses and Electrostatic precipitators.

Gaseous Emissions Control: Design and operation - scrubbers for gaseous pollutant removal, Adsorption columns and condensation devices.

Control of Mobile Sources: Control of crank case emissions, Evaporative emissions control, Air fuel ratio, Automobile emission control, Catalytic convertors, Gasoline and diesel powered vehicles, Alternative fuels.

Air Pollution Mitigation Measures: Green belt design, Management strategies for air pollution abatement.

Laboratory Work: Basic experiments of fluid flow, Boundary layer and Bernoulli's equation; Particulate collection efficiencies calculation in centrifugal separator; Efficiency calculation in gaseous removal devices like wet scrubbers; Adsorption, Stack Monitoring; Measurement of vehicular emissions; Field/Industrial visits

Course Learning Outcomes (CLOs):

On the completion of course, students will be able to:

- apply the basic concepts of fluid and particle mechanics
- Design industrial ventilation systems
- Design and evaluate removal efficiency of particulates of various air pollution control devices
- demonstrate the designing and operation of various air pollution control devices for the removal of gaseous pollutants from both stationary as well as mobile sources
- examine the management strategies for air pollution abatement

Recommended Books

1. *Flagan RC and Seinfeld JH, Fundamentals of Air Pollution Engineering, Prentice Hall (1988).*
2. *De Nevers N, Air Pollution Control and Engineering, Mc Graw Hill (1993).*

3. *Boubel RW, Fox DL, Turner B and Stern AC, Fundamental of Air Pollution, Academic Press, 3rd ed. (1994).*
4. *Perkins HC, Air Pollution, McGraw Hill (2004).*
5. *Rao CS, Environmental Pollution Control Engineering, New Age International (2006).*

Evaluation Scheme:

S.N.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (Assignments/ Projects/ Tutorials/ Quizes/Lab Evaluations)	40

PES225 ENVIRONMENTAL LEGISLATION AND IMPACT ASSESSMENT

L	T	P	Cr
3	1	0	3.5

Course Objectives:

To provide an overview on environmental legislation and acts applicable for environmental pollution; to facilitate understanding on role of pollution control boards and their procedure; and to facilitate understanding of various aspects related to EIA processes.

Definition of Terms: Conventions and protocols; Policy; law; acts and rules; Administrative and legal interpretations; Codes and specifications.

Overview of Environmental Legislation: Overview of Indian environmental law and policy; International Conventions and Protocols on Environmental Protection; Pollution control boards, MoEF &CC - Powers, functions and Procedures; Constitutional provisions Article 48 & 51A; National Green Tribunal**:**

Provisions of Various ACTs: The Water (Prevention and Control of Pollution) Act 1974 and Amendments; The Air (Prevention and Control of Pollution) Act 1981 and Amendments, Environmental Protection Act 1986 and Amendments; Public Liability Insurance Act 1991; Biodiversity Act 2002; Forest Conservation Act 1980.

Overview of other key environmental regulations- The Solid Waste Management Rules 2016; The Bio-Medical Waste Management Rules 2016; The Construction and Demolition Waste Management Rules 2016; The Hazardous and Other Wastes (Management and Transboundary Movement) Rules 2016; E-Waste (Management) Rules 2016; The Batteries (Management and Handling) Rules and the Plastic Waste Management Rules 2016; The Rules for the Manufacture, Use, Import, Export and Storage of Hazardous micro-organisms 1989; The Chemical Accidents (Emergency Planning, Preparedness, and Response) Rules 1996.

Environmental Impact Assessment: Objectives and scope of EIA; EIA notification; EIA process flow chart; Environmental feasibility analysis; Baseline studies; and environmental data collection; Methods of Impact analysis- checklists, matrices, networks, overlays, etc, Environmental clearance process - Screening; scoping; public consultation and appraisal. Provisions relating to Environmental clearance: Environmental sampling, analysis and reporting of results; Environmental standards.

EMP (Environmental Management Plan) and EIA Documentation: Principles and Elements of approach; identification and mitigation of environmental impacts.

Environmental Auditing and ISO14001: Introduction to environmental auditing and ISO14001.

Course Learning Outcomes (CLOs):

On the completion of course, students will be able to:

- comprehend the environmental legislation, environmental policies of the country and of the international environmental conventions and protocols
- examine the environmental regulations applicable to the industry and other organizations with significant environmental aspects

- estimate the environmental requirements applicable to the environmental impact assessment, and about the environmental clearance process of developmental projects
- interpret the methods and tools of identification, prediction and evaluation of environmental impacts of developmental projects

Recommended Books

1. *CPCB, Pollution Control Law Series - PCL/2/2001; Central Pollution Control Board (http://envfor.nic.in/cpcb/cpcb.html) (2001).*
2. *Jain R and Clark A, Environmental Technology Assessment and Policy; Ellis Harwood (1989).*
3. *EIA notification, Gazette Notification: SO 1533 dated 14-09-2006; MOEF. GOI (2006).*
4. *EIA compendium notification, MOEF&CC..*
5. *Canter L W., Environmental Impact Assessment, McGRAW Hill International Edition, Second Edition (1996).*

Evaluation Scheme:

S.N.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

PES213 ENVIRONMENTAL SAFETY AND MANAGEMENT

L	T	P	Cr
3	1	0	3.5

Course Objectives:

To understand the methods of identification, classification and characterization of different hazards with respect to Environment, Health & Safety materials and wastes, to know about the rules, regulations & Legal obligations with respect to Environment, Health & Safety. To understand the occupational health and safety management systems, their essential requirements and techniques elements; and to impart awareness on noise pollution and control and on personal protection equipment.

Hazardous Materials: Definition and classification, Material safety data sheets, Handling of hazardous materials, Personal Protective Equipments (PPEs), Hazardous waste disposal methods and their health impacts

Regulations: Legal requirements concerned with Environment Health & Safety, Legal register, Hazardous microorganisms; genetically engineered organisms or cells; Requirements of Factory Act 1948, E-Waste Management Rules, 2022; Battery Waste Management Rules 2022, Plastic Waste Management Rules, 2016, ISO 45001

Hazard Identification & Risk Assessment: Assessment of risk; Risk management; OSHAS 18001 and Occupational health and safety management systems; Fire Risk identification, assessment & management in an Industry

Hazard and risk control techniques: Hazards, Risks & detection techniques, ISO 14001 EMS (Environment Management System) Preliminary hazard analysis(PHA) & hazard analysis (HAZAN), 3R Principle failure mode effect analysis (FMEA), Hazard and operability (HAZOP) study, Hazard ranking (DOW & MOND index), Fault tree analysis, Event tree analysis (ETA), major accident hazard control, on-site and off-site emergency plans.

Principles of Accident Prevention: Accident definition, Accident recording, Analysis; Investigation and reporting, Internal & External communication, Rules and regulations dealing with chemical accidents, Safety in different industries as case studies

Course Learning Outcomes (CLOs):

On the completion of the course, students will be able to:

- identify, classify and characterize different hazardous materials and wastes
- implementation of the rules and regulations pertaining to the handling and management of hazardous materials and wastes
- develop the emergency preparedness and response plans and programs with the ability to identify hazard and risk assessment
- cover the basic aspect of the occupational health and safety management systems and their essential elements

Recommended Books

1. *Central Pollution Control Boards. Pollution Control Acts; Rules and Notifications Issued Thereunder. Pollution Control Law Series (PCLS/02/2006).*

2. *Gustin JF, Safety Management: A Guide to Facility Managers; Taylor & Francis (2003).*
3. *BS ISO 45001:2018 Occupational health and safety management systems: Requirements with guidance for use . First edition (2018).*
4. *International Standard ISO 14001 (Environment management System) Third Edition, (2015).*
5. *Crowl D.A. and Louvar J.F. "Chemical Process Safety: Fundamentals with Applications". 3rd Edition, Prentice Hall, (2011).*
6. *Sanders R.E. "Chemical Process Safety: Learning from Case Histories" 4th Edition, Elsevier, (2015).*
7. *Hammer W. and Price D. " Occupational Safety Management and Engineering" 5th Edition, Prentice Hall, (2001).*
8. *Mannan S., "Lee's Loss Prevention in the Process Industries: Hazard Identification, Assessment and Control" 3rd Edition, Butterworth-Heinemann, (2005).*

Evaluation Scheme:

S.N.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Case studies)	20

PES208 SOLID AND HAZARDOUS WASTE MANAGEMENT

L	T	P	Cr
3	1	2	4.5

Course Objective:

Facilitate understanding of issues and approaches associated with solid waste, hazardous waste and special category waste management. Able to access legal requirements and strategies associated with management of municipal, hazardous and special solid waste.

Introduction: Solid waste management; Nuisance potential and extent of solid waste problems; Regulatory requirements.

Characterization and Quantification: Types; composition; Methods of quantification and characterization of wastes.

Collection, Storage and Transportation of Wastes: Types of collection systems and their components; Segregation at source; solid waste transport vehicles; solid waste transit points and transport routes; design of transport routes, storage and handling of hazardous waste.

MSW Management: Recycling; Recovery of useful components of SW and its applications; composting; bio-gasification; waste to energy production, Energy calculations.

Hazardous waste Management: Definition; sources; classification; collection and segregation; Chemical and biological treatment of hazardous waste: Solidification and stabilization refuse derived fuel, gasification, pyrolysis, incineration, disposal, management of ETP sludge.

Sanitary landfills: Site selection and approval; design; development; operation and closer of landfills; management of leachate and landfill gases; environmental monitoring of landfill sites;

Special category wastes and their management: Construction and demolition wastes; biomedical wastes; Radioactive waste; E- waste; Plastic waste; Oil sludge and slurries.

Laboratory work: Proximate analysis, Moisture and Solids content, Ash content, Bulk density, Calorific value, Particle size, Permeability of compacted waste, Toxicity Characteristic Leaching Procedure (TCLP), Selected Elemental analysis, Fatty acids, Cellulose, Hemicellulose and Lignin, Landgem

Course Learning Outcomes (CLOs):

On the completion of course, students will be able to:

- Understanding and appreciating the environmental pollution and nuisance potential of municipal solid waste and of special category wastes.
- Awareness of management of MSW and hazardous waste according their characteristics (selection of management technique)
- Acquiring the knowledge of collection and transportation and solid waste route selection and types of waste collection.
- Regulatory requirement applicable to the handling and management of MSW and special category waste.

Recommended Books

1. *United Nations Environment Programme (UNEP) Solid Waste Management, (2005).*
2. *Pichtel, J, Waste management Practices-Municipal, hazardous and industrial, CRC Press (2005).*
3. *Vesilind P.A., Solid waste engineering, Thomson (2008).*
4. *Blude A.D and Sudaresan B.B, Solid waste management in developing Countries INSDOC (1972).*
5. *Tchobanoglous, C. Vigil, S.A. and Theisen, H., Integrated Solid waste management engineering Principles and management issues, McGraw Hill (1993).*
6. *LaGrega M., Buckingham, P., Evans, J. and ERM. Inc ., Hazardous Waste Management , McGraw Hill (2000).*

Evaluation Scheme:

S.N.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/ Evaluations/Lab)	40

PES215 INDUSTRIAL POLLUTION ABATEMENT

L	T	P	Cr
3	0	0	3.0

Course Objectives:

This course examines the tools applicable for determining the opportunities available for prevention of pollution in Industrial environments; and for determining the cleaner production strategies, life cycle assessment, product design and selection processes.

Assessment of pollution prevention opportunities: Approaches to pollution prevention - water treatment, air pollution control, solid waste management, hazardous waste management, pollution prevention and individual's role; Environmental sanitation; Rural sanitation

Industrialization and sustainable development: Cleaner production (CP) in achieving sustainability; Clean development mechanism (CDM); Source reduction techniques - Raw material substitution; Process modification and equipment optimization; Product design; Reuse and recycling strategies; Resources and by-product recovery from wastes; Treatment and disposal; Pollution prevention programs.

Life cycle assessment: Life cycle assessment (LCA) and its purpose; Evolution and stage of LCA; Procedures, goal, scope, analysis of inventory, environmental profiles and impact; Different applications of LCA – Private sector and government sector; Case studies with reference to compiling and documentation of inventory of relevant energy and material inputs versus the environmental releases; Evaluating the potential impacts associated with inputs and releases; Interpretation and decision making.

Pollution prevention by Industry: Potential benefits - Reference to cost savings, reducing legal liability, improved corporate image, improved worker safety; Case studies of Corporate programs; Barriers associated with approaches – Corporate culture and institutional norms; Technology specifications and expectations; Difficulty in identifying opportunities, decision making, cost-benefit analysis; case-specific studies.

Process Selection and Design: Process flow sheeting; waste tracking; process selection; Design for pollution prevention; Cost estimation; Project evaluation; Risk assessment; Scope for Improvement; Case studies.

Course Learning Outcomes (CLOs):

On the completion of course, students will be able to:

- predict and characterise the likely impacts of pollutants on the environment
- conceptualize and pilot design cleaner production strategies
- understand, select and assess pollution prevention and risk assessment strategies

Recommended Books

1. *Weiner RF and Mathews R, Environmental Engineering, Elsevier, NY (2013).*
2. *Jolliet O, Saade-Sbeih M, Shaked, S, Jolliet A, Crettaz P, Environmental Life Cycle Assessment, CRC Press (2015).*

3. *Peavy HS, Rowe DR, Tchobanoglus, TG, Environmental Engineering, Tata-Mc-Graw-Hill, India (2012).*
4. *Murali Krishna, KVSG, Environmental Sanitation Reem Publications, India (2015).*
5. *Mishra KB, Clean Production – Environmental and Economic Perspectives, Springer-Verlag, Berlin (2012).*
6. *Renolds R, Unit Operations and Processes in Environmental Engineering by Reynolds. Cengage Learning, UK (2016).*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
4.	MST	30
5.	EST	50
6.	Assignments/Quizzes/Seminars	20

PES216 SUSTAINABILITY AND CLEANER TECHNOLOGIES

L	T	P	Cr
3	0	0	3.0

Course Objectives:

To provide acquaintance with modern cleaner production processes and emerging energy technologies; and to facilitate understanding of the need and application of green and renewable technologies for sustainable development of the society

Sustainability: Concept of sustainability, Sustainable development practices; CP and sustainable industrial practices.

Introduction: Cleaner production (CP) in achieving sustainability; Clean development mechanism (CDM); Source reduction techniques - Raw material substitution; Process modification and equipment optimization; Zero effect zero defect, Carbon credits.

Cleaner Production: Overview of CP Assessment Steps and Skills; Basic analysis of material and energy flows; Green procurement; Identifying and reducing losses; New and low waste technologies; Product modification; Good housekeeping; CP audits.

Green Design: Green buildings - benefits and challenges; public policies and market-driven initiatives; Effective green specifications; Energy efficient design; Passive solar design; Green power; Green materials and Leadership in Energy and Environmental Design (LEED); GRIHA norms; Concept of smart cities

Emerging Energy Technologies: Concepts; Biomolecules and energy; Hydrogen and Fuel cells; Fourth generation energy systems.

Course Learning Outcomes (CLOs):

On the completion of course, students will be able to:

- comprehend basic concepts in source reduction and waste management
- design viable cleaner production systems utilizing steps and skills acquired
- examine and evaluate present and future advancements in emerging and renewable energy technologies

Recommended Books

1. *Kirkwood RC and Longley AJ (Eds.), Clean Technology and the Environment, Chapman & Hall, London (1995).*
2. *World Bank Group; Pollution Prevention and Abatement Handbook – Towards Cleaner Production, World Bank and UNEP; Washington DC (1998).*
3. *Modak P, Visvanathan C and Parasnis M, Cleaner Production Audit, Course Material on Cleaner Production and Waste Minimization; United Nations Industrial Development Organization (UNIDP) (1995).*
4. *Rao S and Parulekar BB, Energy Technology: Non-conventional; Renewable and Conventional; Khanna Pub.(2005) 3rd Ed.*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20

PES234 WATERSHED MANAGEMENT

L	T	P	Cr
3	0	0	3.0

Course Objectives:

To provide guidance on direction for assessment and development of water potential of regimes; to facilitate understanding of approaches for maintenance of watershed based ecosystem and to develop ability to apply theories underlying the solutions for practical problems of watershed

Introduction: Concept of watershed development; Objectives, need, integrated and multidisciplinary approach.

Characteristics of Watershed: Size; Shape; Physiography; Slope, Climate, Drainage, Land Use; Vegetation; Geology and Soils; Soils; Hydrology and Hydrogeology; Socio-Economic Characteristics; Basic Data On Watersheds.

Erosion and Measures to Control Erosion: Erosion - Types; Factors affecting and effects of Erosion; Estimation of soil loss due to erosion (universal soil loss equation); Erosion control measures: Contour techniques; Ploughing; Furrowing; Terracing; Gully control; Rockfill; Dams; Brushwood dam; Gabion.

Water Harvesting: Rainwater harvesting; catchment harvesting; Harvesting structures; Soil moisture conservation; Check dams; Artificial recharge; Farm ponds; Percolation tanks.

Land Management: Land use and land capability; Classification; Management of forest, Agricultural, grass land and wild land; Reclamation of saline and alkaline soils.

Ecosystem Management: Role of ecosystem; Crop husbandry; Soil enrichment; inter-mixed and strip cropping; Cropping pattern; Sustainable agriculture; Biomass management; Dry land agriculture; Silvipasture; Horticulture; Social forestry and afforestation.

Water Bodies and Aquatic Ecosystems: Influence of ponding on water quality; Thermal stratification and mixing; Eutrophication and water weeds; Sediment-water interactions; Effects of waste disposal and pollution; Fate of pollutants discharged into water bodies; Self cleansing capacities of water bodies.

Human Interventions for Water Quality Management: People participation; Preparation of action plans; administrative requirements; Management of catchments/watersheds and prevention of pollution; Flood control; Wetlands and constructed wetlands; Control of weeds and nutrient removal; River basin management system; Satluj river action plan; Ganga action plan.

Course Learning Outcomes (CLOs):

On the completion of course, students will be able to:

- demarcate and characterize watersheds
- analyze the watersheds and understand the issues and concerns associated with them, and to frame the watershed management objectives
- analyze the hydrological and remote sensing data
- examine best management practices for the sustainable management of watershed

Recommended Books

1. *Nathanson JA, Basic Environmental Technology. Prentice-Hall (2002).*
2. *Murthy JVS, Watershed Management, New Age International (1998).*
3. *Awurbs R andJames WP, Water Resources Engineering, Prentice Hall (2001).*
4. *Murthy VVN, Land and Water Management, Kalyani Publications (2009).*
5. *Majumdar DK, Irrigation and Water Management, Prentice Hall (2000).*

Evaluation Scheme:

S.N.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20

PES226 ENERGY AND ENVIRONMENT

L	T	P	Cr
3	0	0	3.0

Course Objectives:

To inculcate fundamental knowledge and understanding of the major energy conversion processes, their resource requirement and their impacts on environment.

Introduction – Interrelationship between energy and environment, the need of sustainability, Nature & Issues: Environment conservation and management as the key requirements of sustainability. Definitions, scope and importance, need for public awareness; Energy chain and common forms of usable energy; Classification of energy sources; Present energy scenario- World energy status, Energy scenario in India.

Conventional Energy: Environmental impacts related to harnessing to fossil fuels (coal, oil, natural gas), nuclear energy, hydropower: Overview of micro mini and small hydro power, classification of hydropower schemes; Impact of energy production on climate change.

Renewable sources of energy: Solar Energy; Active and passive systems; measurement and applications including Solar water heating, Solar cooking, Solar drying, Solar distillation and solar refrigeration, heating and cooling of buildings, Solar thermal power generation, Solar Photo-voltaic power generation; Process economics and environmental impacts; Biomass energy; generation, characterization, Biogas: aerobic and anaerobic bio-conversion processes, properties of biogas, Waste to Energy [Domestic sewage, Municipal solid wastes]; Biorefineries; Biohydrogen production. Environmental aspects of biofuel utilization - Techno-economic features of bio-fuels, Wind energy; Wind diesel hybrid systems. Control of hybrid power systems, Power generation through OTEC systems - various types - Energy through waves and tides - Energy generation through geothermal systems - types

Social issues and the environment: Environmental degradation, Environment ethics, issues and possible solutions. Urban problems related to energy, water conservation, rain water harvesting, water shed management,

Course Learning Outcomes (CLOs):

On the completion of course, students will be able to:

- describe basic energy concepts
- analyse the consequences of today's energy consumption
- account for conventional energy technologies and the relationship between energy production, consumption and climate change
- reflect and evaluate the environmental impact of energy production through renewable sources of energy

Recommended Books

1. *Robert A. Ristinen and Jack J. Kraushaar Energy and the Environment, 2nd Edition (1998).*

2. *Tiwari G. N. and Ghosal M. K., "Fundamentals of Renewable energy Sources", Narosa Publishing House, New Delhi, (2007).*
3. *Rao. S. and Parulekar B. B., "Energy Technology", 4th edition, Khanna publishers, (2005).*
4. *John Andrews, Nick Jelley, Energy Science: Principles, technologies and impacts, Oxford Universities press. (2013),*
5. *Godfrey Boyle, Renewable Energy, power for a sustainable future Oxford University Press (2012).*
6. *Fang Lin You, Hong ye, Renewable Energy Systems, Advanced conversion technologies and applications CRC Press (2012).*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
4.	MST	30
5.	EST	50
6.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20

PES217 SANITATION AND PUBLIC HEATH

L	T	P	Cr
3	0	0	3.0

Course Objectives:

The aim of this module is to enable students to understand the principles and practices that should underlie water, sanitation and hygiene interventions, in order to maximise health and social benefits

Introduction: Concept and scope of environmental sanitation, public health with regard to Indian context

Contamination and Diseases: communicable disease- type. Modes of communication and method of control, non-communicable disease- lifestyle and genetic related disorders, prevention; Biological contamination of drinking water and associated and preventive strategy; Excreta-related Infectious Diseases and Effective Sanitation Barrier; Environment health problem and control

Sanitation Microbiology: General concept of sanitation and disinfection, Sanitation of industrial and food processing units, Safe location of animal houses, hospitals, industrial fermentation units etc., Bio safety in hospitals and laboratories, Regulations and measures; Sanitation of school, hospitals, jails, industries, places of entertainment (fairs, festivals, meals, etc.); Indoor sanitation: criteria for housing (lighting, ventilation, moisture and temperature)

Food and milk sanitation: food inspection, sanitation of eating and drinking establishments, essentials of milk sanitation, dairy barn and surrounding, milk pasteurization, collection and delivery of milk, health of workmen and health monitoring, GLP,GMP &HACCP.

On-site & Off-site Sanitation: Principle, method and practices, Sanitary latrine / Septic Tank-Soak Pit, Two-pit Pour-flush Toilet, VIP-Toilet, Eco-san toilet, Bio-toilet, Community and House-hold toilets, Biogas plants with composite waste (human waste, animal waste and agriculture residues). Behavioural change / awareness and motivation in use of toilet in rural areas; Off-site Sanitation: Principle, applicability, sewerage and sewage treatment; Public bathing place sanitation: Bathing place standards and bathing loads, equipment maintenance, swimmers itch, sanitation of swimming pools and outdoor bathing places, swimming pool water treatment and disinfection;

Waste water management in rural areas: Black water/ grey water, drainage, soak pit, soakway channel, small bore sewerage, kitchen garden

Initiative taken by Indian Government such as Swach Bharat Abhiyan, Central rural sanitation program, Rural Sanitation and Hygiene Strategy 2010-2022, Atal Mission for Rejuvenation and Urban Transformation (AMRUT)

Laboratory work: sanitary check of milk and food, Epidemiological studies, Sanitation facilities survey, Toilet inspection and survey, Water testing (physical / chemical / biological), Eco-sanitation related experiment

Course Learning Outcomes (CLOs):

On the completion of course, students will be able to:

- have a critical understanding of sanitation, water and hygiene interventions and of the ways in which such projects can impact on health in low income settings
- be able to discuss the wider social, economic, institutional and environmental contexts of public health and sanitation strategies
- appraise the existing evidence for the effectiveness of public health and sanitation interventions

Recommended books:

1. *Joseph S, Environment Engineering & Sanitation, John-Wiley (1982).*
2. *Euhler VM and Steel EW, Municipal and Rural Sanitation, Tata McGraw-Hill (1972)*
3. *Park K, Text Book of Preventive and Social Medicine, Bhanot Publications; 23rd edition (2015).*
4. *Gurcharan Singh and Jagdish Singh, Sanitary Engineering Vol-II, Standard Publishers Distributors, (2012).*
5. *Birde G.S., Water Supply & Sanitary Engineering, Dhanpat Rai and Sons, Delhi (2007).*

Course Evaluation:

S.N.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Evaluations)	20

PES219: SUSTAINABLE MATERIALS AND GREEN BUILDINGS

L	T	P	Cr.
3	0	0	3.0

Course Objectives: To explain concepts of sustainability in the context of building and conventional engineered building materials, Exposing the student to concepts of embodied, Operational and Life Cycle Energy, Minimizing Energy consumption by optimal design.

Introduction: Embodied energy, Operational energy in Building and Life cycle analysis. Ecological foot print, Bio-capacity and calculation of planet equivalent, Green Performance rating, requirements of LEED, GRIHA.

Role of Materials: Alternative cements and cementitious material, Sustainability issues for concrete, Role of quality, minimization of natural resource utilization, geo-polymer concrete, concrete with alternative material for sustainability.

Operational energy reduction and net zero building: Optimization for design of building for energy efficiency, Radiation budget, Effects of trees and microclimatic modification through greening, Use of Building Integrated Photo Voltaic (BIPV) and other renewable energy in buildings.

Operational performance of building: Comparative energy performance, emission performance, Indoor air quality, Paints, Adhesive and sealants for use in building, Volatile organic content (VOC) emission issues and indoor air quality for Sustainability and Health hazard.

Course Learning Outcomes (CLOs):

On the completion of course, students will be able to:

- Design of building for energy efficiency
- Interpret and learn the use of Green Performance rating
- Processes the raw data and estimate operational energy in building
- Learn the sustainability issues with current building practices

Recommended Books

1. *Kubba, S, LEED Practices, Certification, and Accreditation Hand book, 1st ed. Elsevier, 2010.*
2. *Minsitry of Power, Energy Conservation Building Code 2018, Revised Version, Bureau of Energy Efficiency, 2018.*
3. *Architectural Energy Corporation, Building Envelope Stringency Analysis, International Institute for Energy Conservation, 2004.*
4. *Indian Building Congress, Practical Handbook on Energy Conservation in Buildings, 1 st ed. Nabhi Publication, 2008.*

5. *TERI-Griha's Green Design practices (www.teriin.org/bcsd/griha/griha.htm)*
6. *Leadership in Energy and Environmental Design (www.usgbc.org/LEED)*
7. *Article on Residential Green Choice(*www.austinenergy.com*)*
8. *Green Building Basics, California Integrated Waste Management Board (www.ciwmb.ca.gov/GREENBUILDING/Basics.htm#What)*
9. *Venkatarama Reddy, B. V., and. Jagadish, K., S. "Embodied energy of common and alternative building materials and technologies". Energy and Buildings., 35, 129-137,2003.*

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	50
3	Sessionals (May include assignments/quizzes/tutorial)	20

PES227 ENVIRONMENTAL BIOTECHNOLOGY

L	T	P	Cr
3	0	0	3.0

Course Objectives:

This course examines current applications of biotechnology to environmental quality evaluation, monitoring, and remediation of contaminated environments. The course envisages to provide a working knowledge of the principles, techniques and current applications of biotechnology to environmental quality evaluation, monitoring, remediation of contaminated environments and energy production.

Microbial growth and Enzyme kinetics: Media design for growth, Kinetic models for cell growth, Design equations based on biochemical reactions, Substrate and product inhibited growth models, Factors affecting microbial growth, Enzyme kinetics, M.M kinetics, enzyme deactivation kinetics, Active and passive immobilization,

Microbiology of wastewater treatment systems: Microbiology of waste water treatment unit operations: Aerobic and Anaerobic processes; emerging biotechnological processes in waste – water treatment; Treatment schemes for waste waters of Dairy, pulp, dye, leather and pharmaceuticals, distillery process.

Solid and Hazardous Waste biotransformations: Sources and management (Composting, vermiculture and methane production); Hydrocarbons, substituted hydrocarbons, polyaromatic hydrocarbons; Microbial biotransformation of pesticides and xenobiotics in environment.

Bioremediation and Biorestoration: Bioremediation of contaminated soils and waste land in-situ and ex-situ bioremediation; Concepts and applications of phytoremediation.

Bioreactors and Fermentation: Bioreactor selection criteria and classification; Parameters for control; Design of ideal reactors; Single (Batch, Flow) and multiple reactors; Non-Ideal flow, RTD studies; Modelling of Non-ideal flow reactors; Design and operation of bioreactors;Scale-up studies.

Environmental genetics: Degradative plasmids, release of genetically engineered microbes in environment. Biosafety and Bioethics in Biotechnology**.**

Biofuels: Plant derived fuels, Energy crops, Biogas, Bioethanol, biohydrogen

Course Learning Outcomes (CLOs):

On the completion of course, students will be able to:

- explain the importance of microbial diversity in environmental systems, processes and biotechnology as well as the importance of molecular approaches in environmental microbiology and biotechnology
- describe existing and emerging technologies that are important in the area of environmental biotechnology
- describe biotechnological solutions to address environmental issues including pollution, renewable energy and water recycling
- analyse case-studies representative of key areas of environmental biotechnology

Recommended Books

1. *Scargg A., Environmental Biotechnology, Longman (1999).*
2. *Wainwright M., An Introduction to Environmental Biotechnology, Kluwer Academic Press (1999).*
3. *Rittmann B. and McCarty P., Environmental Biotechnology: Principles and Applications, McGraw-Hill (2006).*

Course Evaluation:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20

PES228 CONTAMINANT TRANSPORT

L	T	P	Cr
3	0	0	3.0

Course Objectives:

To provide understanding of basic mechanisms of contaminant transport through sub-surface and surface flows, mathematical representation of the contaminant transport through the governing equation and numerical simulation of governing equation.

Introduction: Types of contaminants, Sources, occurrence, significance and their harmful effects, Fate and transport of contaminants

Basics of contaminant transport phenomenon: diffusion, dispersion, advection, adsorption, inactivation, conservative and non-conservative pollutants, sources and sinks point and non-point. Transport of non-reactive and reactive constituent, Hydro-chemical behavior of contaminants, Governing Equations for flow and transport in surface and subsurface waters, chemical and biological process models

Numerical methods for solving governing equation: Finite Difference method, explicit vs. implicit methods, numerical errors, and stability.

Modeling seawater intrusion in coastal aquifers: Ghyben-Herzberg relation between fresh and saline water, Modeling of saltwater intrusion, density dependent groundwater flow and contaminant transport.

Course Learning Outcomes (CLOs):

On the completion of course, students will be able to:

- Demonstrate the mechanism of contaminant transport through sub-surface and surface flows.
- Apply concept of numerical modeling to solve the contaminant transport equation
- Demonstrate the mechanism and modeling of seawater intrusion into coastal aquifer

Recommended Books

1. *Freez A R and Cherry J A, Groundwater, Prentice Hall, (1979).*
2. *Bear, J and Verruijt, A. Modeling groundwater flow and pollution, D. Reidel Publishing Company, (1998).*
3. *Anderson M.P., and Woessner W.W., Applied Groundwater Modelling : Simulation of flow and advective transport, Academic Press, Inc., (1992).*

Course Evaluation:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2.	EST	50
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	20