M.Tech (Environmental Science & Technology)

Total No. of Seats: 20

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 seats remaining vacant (if any) will be made on the merit in the entrance test to be conducted by the University.

Only those candidates, who have obtained a minimum of 20% marks (15% for SC/ST) in the entrance test, only are considered for the admission.

Eligibility Criteria:

BE/B.Tech. degree in any branch of Engineering or Technology (or)

M.Sc. in Chemistry/ Biochemistry/ Biotechnology/ Life Sciences (including Botany and Zoology)/ Atmospheric Sciences.

Syllabus for TU Entrance Examination:

The entrance examination will be assessing the exposure level of the student in the following subject areas:

Analytical, quantitative and verbal aptitude; Environment (land, water, air and climate) and human interactions with environment; Natural resources and their management; Environmental legislations and international conventions; Concept of sustainability; Structure, functioning and dynamics of natural ecosystems and sustainability; Agricultural and industrial systems and environment; Environmental sampling, analytical techniques and instrumentation; Water chemistry; Atmospheric chemistry; Basic microbiology (the microbial world; and metabolism, growth and energetic); Microbiology of water and wastewater; Water quality monitoring and modelling; Water and wastewater (including sewage) treatment; Fluid mechanics and hydrology; and Water supply/distribution and sewerage systems.

M.Tech Environmental Science and Technology

Program Objectives:

- 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 produce the graduates strong in Environmental Science and Technology fundamentals, and capable in addressing the diverse present and potential environmental problems
- To produce 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
PMA102	Research Methodology	2	0	2	3.0
PES101	Water and Wastewater Treatment Technologies -1	3	1	2	4.5
PES102	Atmospheric Sciences, Meteorology and Climate change	3	1	0	3.5
PES103	Environmental Sciences	3	1	2	4.5
PES104	Environmental Remote Sensing and GIS Analysis	3	0	2	4.0
PES105	Solid Waste Management	3	1	0	3.5
	Total	**17**	**4**	**8**	**23.0**

Second Semester

Course No.	Course Title	L	T	P	Cr
PES201	Water and Wastewater Treatment Technologies-II	3	1	2	4.5
PES202	Air Pollution and Control Engineering	3	1	2	4.5
__	Elective -1	3/2	1	0/2	3.5
	Elective – II	3/2	1	0/2	3.5
	Elective –III	3/2	1	0/2	3.5
	Elective – IV	3/2	1	0/2	3.5
	Total	**18**	**7**	**4**	**23.0**
Electives**					
PES203	Environmental Safety and Management				
PES204	Energy Conservation and Management				
PES205	Industrial Environment Management Systems				
PES206	Environmental Legislation and Impact Assessment				
PES207	Cleaner Technologies				

PES208	Water Quality Monitoring and Modelling
PES209	Air Quality Monitoring and Modelling
PES210	Environmental Hydraulics and Hydrology
PES211	Watershed Management

****** Electives are offered on the basis of preferences indicated by the students. 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
PES301	Seminar	-	-	-	2.0
PES390	Minor Project	-	-	-	4.0
PES091	Dissertation (Starts)	-	-	-	-

Fourth Semester

Course No.	Course Title	L	T	P	Cr
PES091	Dissertation	-	-	-	12.0

Total Credits: 64.0

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

PMA102 RESEARCH METHODOLOGY

L	T	P	Cr
2	0	2	3.0

Course Objectives:

- Ability to elaborate the concept of distribution function
- Ability 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, Mathematica including evaluation of statistical parameters and data interpretation, Regression Analysis, Covariance, Hypothesis testing and analysis of variance.

Course Outcomes:

- Acquiring skills for formulating research problems and hypotheses to be tested, and for the preparation and presentation of research/project proposals.
- Obtaining the knowledge of probability and data distribution functions and becoming capable of estimating mathematical expectations.
- Acquiring the skills of regression and correlation analysis, development of statistical models, and calibration, validation and use of the models.
- Becoming capable of design of experiments for investigations and hypotheses testing relating to research problems and projects.
- Getting acquainted 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 (2004) 2nd ed.*
2. *Walpole RE, Myers RH, Myers SL. and Ye K. Probability and Statistics for Engineers and Scientists, Pearson Education (2002) 7Th ed.*

PES101 WATER AND WASTEWATER TREATMENT TECHNOLOGIES – I

L	T	P	Cr
3	1	2	4.5

Course Objectives:

- To understand the science and technology of water treatment
- To know design, analysis, operation and control of routinely used water treatment units.
- To know the sampling and analysis techniques required for the monitoring of water treatment plants and for the characterization of the water.
- To understand the water quality guidelines, criteria and standards

Water – Quality, Standards and Criteria: Physical, chemical and biological water quality; Fecal coliform count; pH, acidity, alkalinity and hardness; Heavy metals and pesticide pollution; Sulfates, chlorides, nitrates, fluorides, iron, etc. pollution parameters; Water quality guidelines, criteria and standards.

Water Treatment Technologies: Water treatment for the municipal, industrial and irrigational use; Treatment of surface waters and ground waters; Water treatment technologies overview; Water treatment plants producing drinking water, process water, soft water, RO water and DM water.

Coagulation/Precipitation, Flocculation and Settling: Coagulation-flocculation; Coagulants and flocculating agents; Flash mixing tanks and flocculation tanks; Clarifiers and clariflocculators; Tube settlers and plate settlers.

Filtration Systems: Filtration theory and filter hydraulics; Slow sand filters; Rapid gravity filters; Pressure filters; Multimedia filters; Multigrade multistage roughing filters.

Disinfection: Chlorination; Ozonation; Membrane processes for disinfection; Slow-sand filters for disinfection.

Other Water Treatment Technologies: Ion-exchange process; Adsorption process; membrane processes (nanofiltration and reverse osmosis); Electroflocculation; Solar desalinization units (solar water stills); Defluoridation units and household level water purification systems.

Laboratory Work: Optimum pH and optimum dose of coagulants and coagulant aids; Precipitation removal of phosphorous; Breakpoint chlorination and MPN reduction; Adsorption isotherms and adsorption numbers; Ion-exchange resin capacity assessment; Filter hydraulics; Membrane processes for disinfection and TDS reduction.

Course Outcomes:

- Acquiring scientific and technological understanding on the physico-chemical operations and processes used in the treatment of water and wastewater.
- Knowing how to design, analyze, operate and control the routinely used physico-chemical water and wastewater treatment units.
- Understanding the water/wastewater characterization and the treatment units' monitoring required for their design, operation and control, and acquiring the related monitoring and analysis skills.

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 (2003) 3rd ed.*
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)*

PES102 ATMOSPHERIC SCIENCES, METEOROLOGY AND CLIMATE CHANGE

L	T	P	Cr
3	1	0	3.5

Course Objectives:

- To inculcate fundamental knowledge and understanding of atmospheric sciences
- Ability to understand effect of meteorological parameters on the dispersion of air pollutants
- Develop awareness of the global air pollution related issues.

Atmosphere Phenomena: Atmosphere and its functions; Profile and composition of atmosphere; Reactions in the lower and upper atmosphere; Different layers, their characteristics and temperature relationships; Gas laws governing the behaviour of pollutants in atmosphere, natural and anthropogenic sources of atmospheric pollutants; Precipitation and types of storms; Influence of solar radiations on earth atmosphere; Diffuse solar radiations - controlling factors; Distribution of sunshine hours, Weather forecasting and methods.

Meteorology: Micro and Macrometeorology; Fundamental parameters – Pressure, temperature, wind, humidity, radiation, atmospheric stability, turbulence and diffusion; 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.

Climate Change: Definition of Climate; Elements of climate; Climatic classifications; Climatic controls; Spatial and temporal patterns of climate parameters in India; Long term changes; Ice age and glacial chronology; Possible causes of climate change- External (Milankovitch variation and Solar activity) and Internal (natural and anthropogenic); Causes and consequences of global warming; ozone hole and consequence of ozone depletion; Montreal protocol; Kyoto protocol and recent conventions; Strategies for conservation of environmental changes induced by CO_2 rise; The concept of carbon sequestration; Clean Development Mechanism (CDM) and its operationalization, modalities and procedures for CDM Project.

Course Outcomes:

- Understanding of the basic phenomenon of atmospheric sciences
- Get acquainted with the sources, properties and ill-effects of important air pollutants in ambient (both outdoor and indoor)
- Learning of the techniques employed in the monitoring of particulates and gaseous pollutants in ambient air and stack gas
- Application of the effect of meteorological parameters in the dispersion of air pollutants
- Gaining knowledge about the air quality modelling and its applications
- Understanding the current environmental issues and remedial measures required to be adopted

Recommended Books

1. *Valdia KS, Environmental Geology, Tata-McGraw Hill (1987)*
2. *Boubel RW, Fox DL, Turner DB and Stern AC, Fundamental of Air Pollution, Academic Press (1994)*
3. *Perkins HC, Air Pollution, McGraw-Hill (2004)*
4. *Rao CS, Environmental Pollution Control Engineering, New Age International (2006)*
5. *Rao MN and Rao HVN, Air Pollution, Tata McGraw-Hill (2006)*
6. *De Nevers N, Air Pollution Control and Engineering, Mc Graw Hill (1993)*
7. *van Dam JC, Impacts of Climate Change and Climate Variability on Hydrological Regimes, Cambridge University Press (2003)*

PES103 ENVIRONMENTAL SCIENCES

L	T	P	Cr
3	1	2	4.5

Course Objectives:

- Provide information about the Chemical and biological aspects of environmental issues
- concern for one's own surrounding and sustainable living
- Develop capacity to act at own individual level to protect and management the environment that we all live and share

Environmental Chemistry: Stratospheric ozone chemistry; Atmospheric aerosol chemistry; Chemistry of green house gases, Chemical reactions in atmosphere; Atmospheric water; Soil texture and composition; Soil reactions; Nutrient and biogeochemical cycling; Structure and properties of water; Acid-base reactions in aqueous systems; Colloids in water.

Environmental Biology: Water organisms (microorganisms, plants and animals); Organisms of polluted water; Water organisms as sources of human health hazards and biological water quality; DO depletion and Eutrophication problems of water; Roles of water organisms in waste assimilation and treatment; Biotic community of soils and rhizospheres; Associations of soil organisms with plants; Role of soil organisms in the soil formation, fertilization, and soil structure and texture maintenance; Biological aerosols; Survival and spread of bioaerosols; Bioaerosols as sources of human health hazards.

Environmental Biochemistry: Bioaccumulation; Biodegradation; Cometabolism; Bioremediation; Bioleaching; Biomethanation and microbial kinetics; Environmental degradation of polymers; Biopolymers and bioplastics.

Toxicology and Toxicological Chemistry: Toxicology – Chronic and acute; Dose-response concept; Biochemical pathways and reactions associated with toxicants; Evaluation of toxicity; Detoxification and repair mechanisms.

Laboratory Work: Analysis of environmental samples by Gravimetry, Titrimetry, DO meter, Conductimeter, Turbidity meter, Spectrophotometer, Flame photometer, AAS, pH/ISE meter, GC and Orset apparatus for various parameters; Toxicity testing: LC_{50}, LD_{50} and whole effluent toxicity; Culturing and microbial enumeration by dilution plate, multiple tube fermentation and membrane filtration techniques; Isolation purification and culturing of microorganisms from environmental samples; microbial growth kinetics.

Course Outcomes:

- Clarity of the basic concepts of structural and functional features of environmental systems
- Understanding of the soil chemistry, soil pollution and exchange of nutrients in various biogeochemical cycles
- Learning the significance of biological and biochemical mechanisms associated with functioning of environmental systems
- Gaining knowledge about the environmental biodegradation and bioremediation
- Learning of the concept of toxicity and its evaluation

Recommended Books

1. *Sawyer CN, McCarty PL and Parkin GF, Chemistry for Environmental Engineering and Science, McGraw Hill (2003)*
2. *Manahan SE, Fundamentals of Environmental Chemistry, CRC Press LLC (2008) 3rd ed.*
3. *Shaw IC and Chadwick J, Principles of Environmental Toxicology, Taylor& Francis ltd. (1998)*
4. *Gaudy AF and Gaudy ET, Microbiology for Environmental Scientists and Engineers, McGraw Hill (1980)*
5. *Pelczar MJ, ChanECS and Krieg NR, Microbiology, McGraw Hill (1996)*

6. *Kolwzan B, Adamiak W, Grabas K and Pawelezyk K, Introduction to Environmental Microbiology: Oficyna Wydawnicza Politechniki Wroclaweskiej, Wroclaw (2003)*
7. *Gray NF, Biology of Wastewater Treatment, Imperial College Press (2004)*

PES104 ENVIRONMENTAL REMOTE SENSING AND GIS ANALYSIS

L	T	P	Cr
3	0	2	4.0

Course Objectives:

- To introduce the fundamentals of remote sensing and geographical information systems
- Ability to apply principles and techniques of GIS and remote sensing in hydrology.

Introduction to Principle of Remote Sensing: Definition; Active and passive remote sensing; Aerial and space platforms.

Electromagnetic Radiation: EMR interaction with atmosphere; Atmospheric windows and their significance; Interaction with earth surface materials; Specular and diffuse reflection surfaces, Spectral reflectance curves and spectral signature; Spectral reflectance curves of water, soil and vegetation.

Satellite Programs and Sensors: Classification, description of multi spectral scanning – along and across track scanners; Satellite sensors; Resolution types; Description of sensors in Landsat, SPOT, IRS series.

Satellite Image Interpretation: Basic principles of image interpretation; Visual interpretation; Elements of image interpretation; Digital image processing; Supervised and unsupervised classification.

Introduction to GIS: Components, data types – spatial, attribute and metadata; Raster and vector data and their comparison; Data abstraction, maps and map scale.

Coordinate System: Datum; Geographical coordinate system; Projected coordinate system and their needs: Basic projection types; Polyconic and UTM projections.

Data Input and Editing: Raster and vector data formats; Georeferencing; Data input using scanner and on-screen digitization; Input using xy data; Data editing; Attribute data.

Spatial Analysis: Reclassification, overlaying, buffering, unions, intersections; DEM, DEM analysis, contour and cut-fill analysis; Process modeling using GIS, IDW, spline and kriging; Interpolation techniques

GPS and Keyhole Markup Language: Introduction to global positioning system and KML format

Remote Sensing and GIS Applications: LULC Classification; Flood plain mapping and zoning; Ground water studies; Erosion sedimentation studies; Watershed and drainage delineation.

Laboratory Work: Introduction to various types of remote sensing data; Introduction to image enhancement and classification techniques; Introduction to GIS software and understanding of GIS data and data formats; Preparation of groundwater contours and surfaces using groundwater wells data; Delineation of watershed and drainage pattern using digital elevation models; River shifting studies using remote sensing data and GIS; Flood plain zoning and mapping using remote sensing and GIS.

Course Outcomes:

- Gaining fundamental understanding of principles associated with remote sensing and satellite image interpretations.
- Capacity to interpret coordination, spathial analysis, GIS data and their applications
- Capacity to extrapolate GIS data of ground water mapping, erosion studies, watershed management and drainage

Recommended Books

1. *Lillesand T, Kiefer RW and Chipman J, Remote Sensing and Image Interpretation, Joh Wiley and Sons, (2007), 4th Ed.*
2. *Jensen JR, Introductory Digital Image Processing: A Remote Sensing Perspective, Prentice Hall (1996, 2nd Ed.*

3. *Schowengerdt RA, Remote Sensing Models and Methods for Image Processing, Academic Press (2007, 3rd Ed.*
4. *DeMers MN, Fundamentals of Geographical Information Systems, John Wiley & Sons (2009), 3rd Ed.*
5. *Chang K, Introduction to Geographical Systems, Tata McGraw-Hill (2008, 4th Ed.*

PES105 SOLID WASTE MANAGEMENT

L	T	P	Cr
3	1	0	3.5

Course Objectives:

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

Solid and Hazardous Wastes: Definition, sources and characteristics; Sampling and analysis techniques; Inventorying wastes; Strategies for waste minimization.
Municipal Solid Waste Management: Segregation and recycling and reuse of wastes; Collection, transportation and storage of municipal solid waste; Resource recovery from wastes; waste exchanges; Composting and vermi-composting of wastes; Municipal solid waste management programs; Disposal – siting and design.
Hazardous Waste Treatment and Disposal: Biological and chemical treatment of hazardous wastes; Solidification and stabilization of wastes; Incineration for the treatment and disposal of hazardous wastes; Land farming; Landfill disposal of hazardous waste; Bioremediation of hazardous waste disposal sites.
Special Waste Management: Biomedical wastes, E-waste.
Legal Requirements: Municipal solid waste rules; Hazardous waste rules; Biomedical waste rules; E-waste rules; Rules related to recycled plastics, used batteries, flyash, etc.

Laboratory Work: Biodegradable and combustible fraction of the solid waste/sludges and their calorific values; thermal, chemical and biological sludge stabilization; municipal solid waste sampling, segregation and analysis; Incineration ash analysis; Autoclaved material testing; E-waste processing; Composting and Vermicomposting.

Course Outcomes:

- Understanding and appreciating the environmental pollution and nuisense potential of municipal solid waste and of special category wastes.
- Become of aware of the regulatory requirements applicable to the handling and management of municipal solid wastes and special category wastes.
- Acquiring the knowledge of procedures, practices and technologies of management and handling (collection, reception, storage, treatment/processing, transportation and disposal) of solid wastes.
- Knowing about how sanitary landfills are designed, created, operated and closed, and about post-closure management of the landfills.

Recommended Books

1. *Pichtel J, Waste Management Practices: Municipal, Industrial and Hazardous, CRC Press (2005)*
2. *Kreith F and Tchobanoglous G, Handbook of Solid Waste Management, McGraw Hill (2002)*
3. *LaGrega M, Buckingham P and Evans J, Hazardous Waste Management, McGraw Hill (1994)*
4. *Freeman H, Standard Handbook for Hazardous Waste Management, McGraw Hill (1989)*
5. *Pollution Control Acts, Rules and Notifications Issued There under: Pollution Control Law Series, Central Pollution Control Board, New Delhi (1986)*

PES201 WATER AND WASTEWATER TREATMENT TECHNOLOGIES – II

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 sludges.

Wastewater Characteristics and Effluent Standards: Physical, chemical and biological parameters of water pollution; Solids (volatile and non-volatile solids; suspended, dissolved and colloidal solids); Biodegradable and non-biodegradable organic matter (DO, COD, BOD and BOD kinetics); Nutrients (TKN, total nitrogen, and total and ortho-phosphorus); Sulfides, phenols, cyanides, heavy metals and recalcitrant/toxic organic compounds; Effluent standards.

Overview of Wastewater Treatment Technologies: Preliminary, primary, secondary and tertiary treatment technologies; Overview of biological treatment technologies; Biological treatment technologies for the tertiary treatment.

Preliminary Treatment: Screens; Grit removal facilities – grit channels, vortex degritters and cyclonic degritters, aerated grit chambers; Effluent sumps and pumps; Equalization tanks – flow and strength equalization, and online and offline equalization tanks.

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

Biological Treatment: Activated sludge process and its modifications including SBR; Trickling filters and RBC units; SAF, FAB and MBBR technologies; UASB reactors and its modifications including anaerobic baffled reactor and anaerobic moving bed reactor; Waste stabilization pond systems and its modifications including vegetated ponds and constructed wetlands.

Other Treatment Technologies: Advanced oxidation processes; Biological nutrient removal; Filtration and chlorination; Membrane processes for TDS reduction; Wet oxidation process.

Laboratory Work: DO, BOD and COD measurements**;** BOD kinetic parameters; MLSS, MLVSS and SVI; ASP kinetic parameters; Biogas generation potential; Biodegradable fraction assessment; Settling column tests for primary and secondary clarifiers; Fenton/photocatalytic treatment process.

Course Outcomes:

- Acquire scientific and technological understanding on biological wastewater treatment processes
- Knowing how to design, analysis, operate and control the routinely used biological wastewater treatment units
- Understanding the wastewater characterization and the biological treatment units monitoring required for their design, operation and control, and acquiring the related monitoring and analysis skills.
- Understanding the facilities and provisions required 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 (2002) 4th ed.*
2. *Eckenfelder WW Jr., Industrial Water Pollution Control, McGraw Hill (2003) 3rd ed.*
3. *Biological Wastewater Treatment, Edited Volume Series, IWA (2008).*

PES202 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, Boundary layer theory, Energy transfer in fluid flow, Fluid flow measurement, Dynamics of particles in fluid, Properties of particles, Collection efficiencies of particles, Source reduction (Fuel substitution, Fuel pretreatment, Process modifications), Emission standards.

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

Particulate Emission Control: Stoke's law, Basic principles, Design and operation of settling chambers (Both laminar and turbulent flow), Cyclone and multiclones, Scrubbers, Bag houses and Electrostatic precipitators, Collection efficiency and Pressure drop calculations across air pollution control devices.

Gaseous Emissions Control: Basic principles, Design and operation of 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, Alternative fuels, Automobile emission control, Catalytic convertors, Gasoline and diesel powered vehicles, Jet engines, Electrical traction technology and Fuel cell technology.

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

Laboratory Work: Field visits (4); Particulate collection efficiencies calculation in centrifugal separator; Efficiency calculation in gaseous removal devices like wet scrubbers; Fume hood design; Stack Monitoring; Air quality Modelling; Measurement of vehicular emissions; Adsorption

Course Outcomes:

- Understanding the science of air pollution control technologies
- Gaining knowledge of air pollution control systems including source reduction and air pollution abatement strategies
- Learning the designing of hoods and ducts including stacks for ventilation
- Learning the designing and operational difficulties of various air pollution control devices for the removal of particulates and gaseous pollutants from both stationary as well as mobile sources
- Understanding the sources of air pollution and the remedial measures required for the air pollution control

Recommended Books

1. *Flagan RC and Seinfeld JH, Fundamentals of Air Pollution Engineering, Prentice Hall (1988).*
2. *Boubel RW, Fox DL, Turner B and Stern AC, Fundamental of Air Pollution, Academic Press (1994). 3rd ed.*
3. *Perkins HC, Air Pollution, McGraw Hill (2004).*
4. *Rao CS, Environmental Pollution Control Engineering, New Age International (2006).*
5. *Rao MN and Rao HVN, Air Pollution, Tata McGraw Hill (2006). 2nd ed.*

PES203 ENVIRONMENTAL SAFETY AND MANAGEMENT

L	T	P	Cr
2	1	2	3.5

Course Objectives:

- To understand the methods of identification, classification and characterization of different hazardous materials and wastes
- To know about the rules and regulations pertaining to the handling and management of hazardous materials and wastes
- To obtain basic understanding of the hazards identification and risk assessment techniques, and the emergency preparedness and response plans and programs
- To understand the occupational health and safety management systems and their essential elements.
- 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.

Regulations: Rules and regulations pertaining to the management and handling of hazardous chemicals; Hazardous wastes; Biomedical wastes; Hazardous microorganisms; Genetically engineered organisms or cells; Municipal solid wastes; E-wastes; Batteries and plastics.

Hazard Identification: Assessment of risk; Risk management; OSHAS 18001 and Occupational health and safety management systems.

Principles of Accident Prevention: Accident recording; Analysis; Investigation and reporting; On-site and off-site emergency preparedness and response plans; Rules and regulations dealing with chemical accidents.

Protection from Hazardous Materials: Personal protective equipment and clothing; Fire safety; Noise and vibrations; Principles of noise control.

Safety Management: Notification of sites; Safety reports; safety audits.

Laboratory Work: Material safety data sheets; On-site and off-site emergency plans; Environmental risk analysis; Safety audits; preparation of safety reports and notification of sites.

Course Outcomes:

- Understanding of the methods of identification, classification and characterization of different hazardous materials and wastes
- Knowledge of the rules and regulations pertaining to the handling and management of hazardous materials and wastes
- Ability of hazards identification and risk assessment, and development of emergency preparedness and response plans and programs
- Knowledge of the occupational health and safety management systems and their essential elements.
- Aware of the noise pollution problems and personal protection equipment.

Recommended Books/weblinks

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. *http://moef.nic.in/modules/rules-and-regulations*

PES204 ENERGY CONSERVATION AND MANAGEMENT

L	T	P	Cr
2	1	2	3.5

Course Objectives:

- To understand and appreciate the energy crisis and environmental concerns associated with the energy management, and the importance of energy conservation
- To know the techniques of energy analysis and the associated energy efficient technologies for the routinely used thermal and electrical energy systems
- To understand the energy management systems and their essential elements
- To acquire the knowledge and the basic skills for energy monitoring, energy bench marking, energy action planning and energy auditing

Introduction: Energy resources; New and renewable energy resources; Energy forms and energy technologies; Energy and environmental concerns; Energy scenario and energy crisis; energy resources management and energy conservation – principles; Potential areas industries; Agriculture and municipal for energy conservation; Conservation methods.

Energy efficient technologies in thermal systems: Fuels and combustion; Boilers and turbines; Cogeneration and combined cycles; DG sets; Circulating cooling water systems; Steam system and condensate systems and insulation; Heat exchangers; Multiple effect evaporations; Furnaces; Thermo-compressors and mechanical vapour compressors; Waste heat recovery and reuse.

Energy efficient technologies in electrical systems: Electrical motors and drives; Pumps; Fans and Blowers; Air compressors and compressed air systems; Buildings and space heating and lighting systems; HVAC systems.

Energy management: Supply side and demand side management; Energy conservation methods; Energy management systems; Energy monitoring; Energy review and energy bench marking; Energy action planning; Energy auditing.

Energy policy and legislation: Energy policy; Energy conservation act; 2001; Energy managers and energy auditors; Energy labeling and energy standards.

Laboratory Work: Energy Lens – Energy Management Software; and EnergyPlus Energy Simulation soft software.

Course Outcomes:

- Becoming aware of the energy crisis, and of environmental and sustainability concerns associated with the energy management.
- Appreciating the importance of energy conservation and having the knowledge of energy conservation strategies and methods.
- Understanding the Energy Management Systems (EnMS) and their essential elements.
- Becoming aware of the Energy Conservation Act, 2001, and of the legal energy requirements applicable to the routinely used thermal and electrical energy systems Aware
- Exposure to the most used energy planning and management softwares

Recommended Books

1. *Practical guide to energy conservation – a ready reckoner on energy conservation measures; Petroleum Conservation Research Association (2009).*
2. *Indian Energy Board-2012; World Energy Council.*
3. *Reay DA, Industrial energy conservation; Pergamon Press (1979).*
4. *White LC, Industrial Energy Management and Utilization; Hemisphere Publishers; (1988).*
5. *Eastop TD and Croft DR, Energy Efficiency for Engineers and Technologists; Longman - Scientific and Technical Series (1988).*

PES205 INDUSTRIAL ENVIRONMENT MANAGEMENT SYSTEMS

L	T	P	Cr
3	1	0	3.5

Course Objectives:

- To acquire the skills and understand the techniques for the identification and evaluation of environmental aspects of an organization's activities, products and services
- To understand the environmental management systems and their essential elements
- To acquire the knowledge and skills needed for the establishment, documentation, implementation, maintenance and improvement, and also auditing of Environmental Management Systems

Introduction: Industrial systems; Waste generation; Resource consumption and environmental pollution; Legal environmental requirements applicable to industrial facilities; Environmental functions of industrial facilities.

Environmental aspects: Process mapping approach for the identification of environmental aspects of industrial activities; Core industrial activities and environmental aspects; Support industrial activities and environmental aspects; Significant environmental aspects.

Management of environmental aspects: End of the pipe approach to waste management; Waste minimization through source reduction; Waste recycling and reuse; By-products and resources recovery from wastes; Waste treatment and disposal; Overview of waste treatment technologies; pollution prevention programs.

Environmental Management System (EMS) Approach: Importance of structured and systematic approach to management; Basic concepts of EMS approach; Essential elements of an EMS and ISO 14001; ISO 14000 series of standards and their relevance to EMS and to the environmental performance improvement.

Development; Implementation and Maintenance of EMS: EMS development and implementation project and plan; ISO 14004 standard; Identification of significant environmental aspects; Formulation of environmental policy and setting of environmental objectives and targets; Environmental management programs; Operational controls.

EMS auditing: EMS auditing; and audit program and procedures; Third party auditing and certification of the EMS; Surveillance audits; ISO 19011 and environmental auditing; Audit activities and audit reports; Non-conformances.

Course Outcomes:

- Enabling identification and evaluation of environmental aspects of an organization's activities, products and services
- Knowing and tracking of legal and other environmental requirements applicable to organizations
- Understanding the Environmental Management System (EMS) approach and knowing the essential elements of an EMS
- Enabling establishment, documentation, implementation, maintenance and improvement of EMS in organizations
- Understanding how the management systems are audited, and certified/registered

Recommended Books

1. *Eckenfelder WW, Industrial Water Pollution Control; McGraw Hill (2007) 3rd ed.*
2. *Freeman H, Industrial Pollution Prevention Handbook; McGraw-Hill Professional (1994); 1st edition.*
3. *Edwards AJ, ISO 14001: Environmental Certification Step by Step; Butterworth-Henemann (2004).*

4. *Stapleton PJ, Glover MA and Davis SP, Environmental Management Systems: An Implementation Guide to Small and Medium-sized Industries; NSF International (2001) 2nd ed.*
5. *ISO 14001: 2004 - Environmental management systems - Requirements with guidance for use.*
6. *ISO 14004: 2004 - Environmental management systems – General guidelines on principles; systems and support techniques.*
7. *ISO 19011: 2011- Guidelines for auditing management systems.*
8. *ISO 17021: 2011 - Conformity assessment — Requirements for bodies providing audit and certification of management systems.*

PES206 ENVIRONMENT LEGISLATION AND IMPACT ASSESSMENT

L	T	P	Cr
3	1	0	3.5

Course Objectives:

- Provide overview on environmental legislation and acts applicable for environmental pollution.
- Facilitate understanding on role of pollution control boards and their procedure.
- Provide understanding of various aspects related to EIA processes
- Inculcate capabilities to interpret environmental management plans and EIA documents

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; Review of Environment and Forest policies of Government of India; Pollution control boards – Powers; functions and Procedures.

Provisions of Water Act; Water-cess Act; Air Act; Environmental Protection Act; Public Liability Insurance Act as Applicable to Industry: Provisions relating to Environmental clearance; Consents from SPCB; Water cess; Entry and inspection; Environmental sampling; analysis and reporting of results; Environmental standards; Overview of other key environmental regulations- Municipal solid waste rules; Biomedical waste rules; Hazardous waste rules; Hazardous microorganisms rules; Hazardous chemicals rules; Chemical accident rules; Ozone depleting substances rules; Batteries rules.

Legal Aspects of EIA: EIA notification; Environmental clearance process - Screening; scoping; public consultation and appraisal; Objectives and scope of EIA; EIA process flow chart.

Project and the Environment Description: Environmental feasibility analysis; Identification of key issues; Baseline studies; environmental monitoring and environmental data collection: Methods of Impact analysis and evaluation- checklists; matrices; networks; overlays and GIS; and professional judgements etc.

EMP (Environmental Management Plan) and EIA Documentation: Principles; Elements of approach; anticipated environmental impacts; mitigation measures: Preparation of EIA documents; types of EIA documents; Structure and contents of the EIA document.

Course Outcomes:

- Becoming aware of the environmental legislation, environmental policies of the country and of the international environmental conventions and protocols.
- Knowing the environmental regulations applicable to the industry and other organizations with significant environmental aspects
- Knowing about the environmental requirements applicable to the environmental impact assessment, and about the environmental clearance process of developmental projects.
- Understanding 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)*
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).*

PES207 CLEANER TECHNOLOGIES

L	T	P	Cr
3	1	0	3.5

Course Objectives:

- Provide acquaintence with modern cleaner production processes and emerging energy technologies
- Provide understanding of the need and application of green and renewable technologies for sustainable development of the society

Introduction: Sustainability – Indicators; strategies and barriers; Industrialization and sustainable development; Cleaner production (CP) in achieving sustainability; Clean development mechanism (CDM).

Waste Management Hierarchy: 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.

Cleaner Production: Overview of CP Assessment Steps and Skills; Basic analysis of material and energy flows; Green procurement; Identifying and reducing losses; Increase of useful life of auxiliary materials; Improved control and automatisation; New and low waste technologies; Product modification; Good housekeeping; CP audits; Hazard analysis; Technical and Environmental Feasibility analysis.

Green Technology: 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); Green fuels.

Renewable and Emerging Energy Technologies: Introduction to renewable energy technologies- Solar; wind; tidal; biomass; hydropower; geothermal energy technologies; Emerging concepts; Biomolecules and energy; Fuel cells; Fourth generation energy systems.

Case Study: Industrial applications of CP; EMS; Environmental Audits; green energy and green process management; Sources and origin of different pollutants from an industry and implementation of cleaner technologies in controlling the menace of pollution.

Course Outcomes:

- Understanding of the basic concepts in source reduction and waste management
- Gaining training about steps and skills in cleaner production and their technical viability
- Learning the latest 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. *Paul LB, Pollution Prevention: Fundamentals and Practice, McGraw Hill International (2000).*
4. *World Bank Group (1998) Pollution Prevention and Abatement Handbook – Towards Cleaner Production, World Bank and UNEP; Washington D.C.*
5. *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).*
6. *Twidell JW and Weir AD, Renewable Energy Resources; Prentice-Hall (1995).*
7. *Rao S and Parulekar BB, Energy Technology: Non-conventional; Renewable and Conventional; Khanna Pub. (2005) 3rd Ed.*

PES208 WATER QUALITY MONITORING AND MODELLING

L	T	P	Cr
2	1	2	3.5

Course Objectives:

- To know water quality guidelines, criteria and standards, and water quality index
- To understand the water quality programs and their implementation
- To know the water sampling and analysis techniques
- To know the basics of water quality modelling
- To expose to some of the conventionally used water quality models

Water quality and parmeters: Physical; chemical and biological water quality parameters; General parameters; Biological water quality and fecal coliform count; Solids; Biodegradable and non-biodegradable organic matter; Nutrients; Heavy metals; and pesticides and recalcitrant/toxic organic compounds.

Water quality monitoring: Surface water and groundwater quality; Water quality standards and effluent standards; Water quality criteria and guidelines; Classification of water bodies; water quality monitoring programs; Water sampling and analysis techniques; Water quality index and use specific water quality index.

Water quality modelling: Introduction to water quality modelling; Modelling of Lakes and reservoirs; Rivers and streams; and Groundwater modelling; Modelling for common water quality parameters: DO; temperature; suspended solids; algae; nutrients; coliforms and toxics; Calibration; validation and use of water quality models (DO-BOD models; solute transport models; nutrients and eutrophication models; and toxic substances and sediments models).

Conventional water quality models: QUAL2E – QUAL2K; BASINS and WASP7.

Laboratory work: Water quality monitoring programs; Development and use of water quality indices; Use of water quality modelling softwares.

Course Outcomes:

- Having knowledge of water quality guidelines, criteria and standards, and water quality index
- Having good understanding on the water quality programs and their implementation including the water sampling and analysis
- Trained in the water sampling and analysis techniques, water quality data analysis and WQI calculations
- Having basic understanding of water quality modelling and exposure to some of the conventionally used water quality models.

Recommended Books

1. *Bartram J (Ed.), Water quality monitoring: A practical guide to the design and implementation of freshwater quality studies and monitoring programs, Taylor & Francis (2012).*
2. *Manivanan R, Water quality modelling: rivers, streams and estuaries, New india publishing agency (2008)*
3. *Marsili-Libelli S and Giusti E, Water quality modelling for small river basins, Elsevier (2008).*
4. *Chapra SC, Surface water quality modelling, Waveland press (2008).*
5. *Thomann RV and Mueller JA, Principles of surface water quality modelling and control, Harper & Row (1987).*
6. *Palmer MD, Water quality modelling: A guide to effective practice, World bank publications (2001).*

PES209 AIR QUALITY MONITORING AND MODELLING

L	T	P	Cr
2	1	2	3.5

Course Objectives:

- To acquire basic skills of sampling and analytical techniques in air quality monitoring
- To understand the air quality modelling and simulation techniques

Introduction: Overview of current air quality trends and challenges; Basic concepts; applications and importance of air quality Monitoring; Iso-kinetic sampling; Precision and accuracy of monitoring; Air Quality Guidelines and Standards.

Sampling and Monitoring Air Matrices : Scope; Purpose and Objectives of Air Quality Monitoring Programme; Preliminary information required for planning an air quality survey; Guidelines for planning a survey; Site Selection; Design of an air quality surveillance network; Period; frequency and duration of sampling; Averaging times.

Sampling Techniques: Ambient air quality monitoring – High volume sampler; Fine dust samplers; Gaseous monitoring kit; Stack monitoring – Flue gas analyzer; stack monitoring kits; orsat apparatus; Tail pipe emissions monitoring; Noise monitoring; Indoor air quality monitoring; On-line monitoring; Preservation; storage and transportation of environmental samples.

Analytical Techniques: Preparation of samples for analysis; Gravimetry; titrimetry; potentiometry (including ion analyzers); Colorimetry (UV-visible spectrometry); Metals and heavy metal detection techniques; OC/EC Analysis; Interpretation of Data; Air Quality Assessment and Reporting.

Air Quality Modeling: Basic Components of an Air Quality Simulation Model; Parameters of Air Pollution Meteorology; 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.

Laboratory Work: SO_x analysis by West and Geake method; NO_x analysis by Jacobs and Hochheiser method; Stack monitoring; Tail pipe emissions monitoring; Chemical characterization of aerosols using Ion Chromatography; Preparation and analysis of samples in AAS and IC; OC/EC analysis; Measurement of indoor air quality; Noise monitoring; Air modelling softwares - ISCST3; Aermod.

Course Outcomes:

- Learning of the techniques employed in the monitoring of particulates and gaseous pollutants in ambient air and stack gas
- Gaining knowledge about modelling of air quality through the use of different softwares.

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 (2002); 3rd Ed.*
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. *Zannetti P, Air Quality Modelling - Theories; Methodologies; Computational Techniques; and Available Databases and Software: Volume IV - Advances and Updates; EnviroComp Institute (2010).*

PES210 ENVIRONMENTAL HYDRAULICS AND HYDROLOGY

L	T	P	Cr
3	1	0	3.5

Course Objectives:

- Facilitate understanding of hydrological aspects of water resources
- Understand principles of need based activities such as pumps, mixers related to water
- Develop compentence to propose effective convergence and design features of water supply projects

Introduction: Hydrological cycle; Hydrosphere; Water compartments and water fluxes; Water and climate change; Scope for hydrology and water resources

Overview of Pipe Flow and Water Distribution System: Flow through pipes, hydraulic gradient and total energy line; Parallel, compound and equivalent pipes; Design of water distribution networks by Nomograms and Hardy Cross Method.

Overview of Open Channel Flow and Sewer Design: Types of flow in channels, most economical sections, Specific energy diagram; Hydraulic gradelines; Hydraulic jump, hydraulic elements of sewers, and design of sewers; Hydraulic Appurtenances

Hydraulic design: Hydraulic design of water and waste water treatment plants; Design of systems for disposal on land and for underground injection

Pumps and Pumping stations: Pumps and their classification, Pump performance curves, system head capacity curves and pump selection, Pumping stations and their design.

Aeration and Mixing: Aeration and mixing equipment, diffused aeration systems, air transfer calculations

Surface water hydrology: Precipitation/rainfall and measurement; Runoff coefficient; Hydrological data analysis and storm water estimation – SCS technique, hydrograph, rational method; Storm sewer design.

Ground water hydrology: forms of underground water, ground water movement and governing equations, yield determination of wells, ground water recharging.

Course Outcomes:

- Understanding the fundamentals of fluid mechanics and solving fluid problems
- Acquiring the ability to apply fluid mechanics to water supply and sewerage systems, to water and wastewater treatment plants, and to air pollution control systems
- Acquiring knowledge on the facilities and provisions (pumps, blowers, mixers, flow measurement devices) required for the handling of fluids (water, wastewater and gaseous emissions)
- Understanding the techniques and acquiring the skills on fluid flow measurement and quantification
- Acquiring the ability to apply fluid mechanics to storm water handling and management

Recommended Books

1. *Chow VT, Maidment DR and Mays LW, Applied Hydrology, Tata McGraw Hill, New Delhi (2010) 2nd Ed.*
2. *McGhee, Water supply and sewerage, McGraw Hill, New Delhi (1991), 6th Ed.*
3. *Wurbs RA and James WP, water resources Engg., PHI New Delhi (2002), 3rd Ed.*
4. *Nathanson, JA, Basic Environmental Technology, PHE (2003), New. Delhi, 4th Ed.*

PES211 WATERSHED MANAGEMENT

L	T	P	Cr
2	1	2	3.5

Course Objectives:

- Provide guidance on direction for assessment and development of water potential of regimes
- Facilitate understanding of approaches for maintenance of watershed based ecosystem
- 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.

***Laboratory work*:** Permeability; Percolation and leaching studies; Rainfall and storm data analysis; surface run off and hydrograph analysis; Vegetation analysis (productivity; dominance and diversity analysis).

Course Outcomes:

- Acquiring capabilities to demarcate and characterize watersheds
- Acquiring the capabilities to analyze the watersheds and understand the issues and concerns associated with them, and to frame the watershed management objectives
- Enabling to understand and analyze the hydrological and remote sensing data
- Having knowledge of the 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 and James 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)*