M.Tech Environmental Science and 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 modeling; 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
PES105	Atmospheric Sciences, Meteorology and Climate change	3	1	0	3.5
PIN103	Environmental Remote Sensing and GIS	3	0	2	4.0
PES107	Environmental Sciences	3	1	2	4.5
PES108	Solid Waste Management	3	1	0	3.5
PES109	Water and Wastewater Treatment Technologies -1	3	1	2	4.5
	Total	**17**	**4**	**8**	**23.0**

Second Semester

PES204	Water and Wastewater Treatment Technologies-II	3	1	2	4.5
PES205	Air Pollution and Control Engineering	3	1	2	4.5
Electives					
	Elective -I	3	1	0	3.5
PES213	Environmental Safety and Management				
PES223	Watershed Management				
PET203	Energy Conservation and Management				
	Elective – II	3	1	0	3.5
PES224	Industrial Environment Management Systems				
PES225	Environmental Legislation and Impact Assessment				

	Elective –III	3	1	0	3.5
PES231	Cleaner Technologies				
PES241	Environmental Hydraulics and Hydrology				
	Elective – IV	2	1	2	3.5
PES232	Water quality Monitoring and Modelling				
PES233	Air Quality Monitoring and Modelling				

****** Electives are offered on the basis of preferences from each of the four 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
PES390	Seminar	-	-	-	4.0
PES392	Minor Project	-	-	-	12.0
PES491	Dissertation (Starts)	-	-	-	-

Fourth Semester

Course No.	Course Title	L	T	P	Cr
PES491	Dissertation	-	-	-	16.0

Total Credits: 78.0

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 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

Course Contents:

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 Learning Outcomes (CLOs):

The 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

PES105 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; to understand effect of meteorological parameters on the dispersion of air pollutants; and to develop awareness of the global air pollution related issues.

Course Contents:

Atmosphere Phenomena: Atmosphere and its functions; Profile and composition of 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; 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 Learning Outcomes (CLOs):

The students will be able to:

- interpret the basic phenomenon of atmospheric sciences
- demonstrate a detailed knowledge of study the effect of meteorological parameters in the dispersion of air pollutants
- comprehend the concepts of climate change and related protocols
- interpret modalities as well as procedures for CDM projects

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. *RaoMN 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)*

Evaluation Scheme:

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

PIN103: REMOTE SENSING AND GIS

L	T	P	Cr.
3	0	2	4.0

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

Course Contents:

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 and ERS satellite systems – Introduction, Stages of development, Sensory Characteristics, Orbit and Coverage's, various types of data product and its uses.

Data Processing: Initial data statistics. Pre-processing – Atmospheric, Radiometric and Geometric corrections.

Data analysis: Image Interpretation Elements, Keys and Aids. Basic Instrumentation - Visual analysis of data in application of remote sensing to various engineering fields

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

Data: Quality, measures of location errors on maps, Satellite-based positioning, Spatial data input, data preparation, Point data transformation

Analytical GIS capabilities; retrieval and classification; overlay functions, neighbourhood operations; network analysis; error propagation, Data visualization

Course Learning Outcomes (CLOs):

The student 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, John Wiley and Sons, (2004).*
2. *Campbell, J.B., Introduction to Remote Sensing, Taylor and Francis, (2002).*
3. *Nag. P. & Kudrat, M., Digital Remote Sensing, Concept Publication Company, (1998).*
4. *Jhanwar, M.L. and Chouhan, T.S., Remote Sensing and Photogrammetry – Principles and Applications, Vigyan Prakashan, Jodhpur, (1998).*

Evaluation Scheme:

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

PES107 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

Course Contents:

Environmental Chemistry: Stratospheric ozone chemistry; Atmospheric aerosol chemistry; Chemistry of green house gases, Chemical reactions in atmosphere; Structure and properties of water; Nutrient and biogeochemical cycling;

Environmental Biology: Water organisms as sources of human health hazards and biological water quality; DO depletion and Eutrophication problems of water; Associations of soil organisms with plants; Role of soil organisms in the soil formation, fertilization, and soil structure and texture maintenance; Biological aerosols; Bioaerosols as sources of human health hazards.

Environmental Biochemistry: Bioaccumulation; Biodegradation; Bioremediation; Biomethanation; Environmental degradation of polymers; Bioplastics.

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

Laboratory Work: Analysis of environmental samples by Gravimetry, Titrimetry, DO meter, Conductimeter, Turbidity meter, Spectrophotometer, Flame photometer, AAS, pH/ISE meter, GC; Culturing and microbial enumeration from water/soil samples; Isolation purification and culturing of microorganisms from environmental samples.

Course Learning Outcomes (CLOs):

The students will be able to:

- apply basic concepts of structural and functional features of environmental systems
- determine the chemistry of soils, pollutants and exchange of nutrients in various biogeochemical cycles
- interpret significance of biological and biochemical mechanisms associated with functioning of environmental systems
- apply analytical tools associated with environmental biodegradation and bioremediation
- apply analytical tools for determining extent of toxicity

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)*

Evaluation Scheme:

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

PES108 SOLID WASTE MANAGEMENT

L	T	P	Cr
3	1	0	3.5

Course Objectives:

To facilitate understanding of issues and approaches associated with solid, hazardous-solid and special waste management; and facilitate capability to assess legal requirements and strategies associated with management of municipal, hazardous and special solid wastes

Course Contents:

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; 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; 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 Learning Outcomes (CLOs):

The students will be able to:

- estimate the environmental pollution and nuisance potential of municipal solid waste and of special category wastes
- interpret the regulatory requirements applicable for handling and management of municipal solid wastes and special category wastes
- demonstrate the knowledge of procedures, practices and technologies of management and handling (collection, reception, storage, treatment/processing, transportation and disposal) of solid wastes

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)*

Evaluation Scheme:

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

PES109 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; andto understand the water quality guidelines, criteria and standards.

Course Contents:

Water – Quality, Standards and Criteria: Physical, chemical and biological water quality; Heavy metals and pesticide pollution; Water quality guidelines, criteria and standards.

Water Treatment Technologies: 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, flocculation tanks, clari-flocculators and settling tanks.

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

Disinfection: Chlorination; Ozonation; Membrane processes for disinfection.

Other Water Treatment Technologies: Ion-exchange process; Adsorption process; membrane processes (nanofiltration and reverse osmosis); 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 Learning Outcomes:

The students will be able to:

- decide on the scheme of treatment for water
- design, analyze, operate and control the routinely used physico-chemical water treatment units
- monitor the water treatment plants and characterize water samples

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)*

Evaluation Scheme:

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

PES204 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.

Course Contents:

Wastewater Characteristics and Effluent Standards: Physical, chemical and biological parameters of water pollution; DO, BOD and BOD kinetics; Nutrients; Effluent standards.

Overview of Wastewater Treatment Technologies: Preliminary, primary, secondary and tertiary treatment technologies.

Preliminary Treatment: Screens; Grit removal facilities; Effluent sumps and pumps; and 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; Waste stabilization pond systems and its modifications.

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

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 Learning Outcomes:

The students will be able to:

- decide on the scheme of treatment for wastewaters
- design, analysis, operate and control the routinely used biological 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 water and wastewater treatment sludges

Recommended Books

1. *Metcalf, Eddy ,Tchobanoglous, G., Burton, F.L., Stensel, H.D., Wastewater. Engineering – Treatment, Disposal and Reuse, Tata McGrawHill 4th ed. (2002)*
2. *Eckenfelder WW Jr., Industrial Water Pollution Control, McGrawHill 3rd ed. (2003)*
3. *Biological Wastewater Treatment, Edited Volume Series,IWA (2008).*

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

Course Contents:

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, 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.

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; Fluid flow measurement devices; Particulate collection efficiencies calculation in centrifugal separator; Efficiency calculation in gaseous removal devices like wet scrubbers; Adsorption, Field visits

Course Learning Outcomes (CLOs):

The students will be able to:

- apply the basic concepts of fluid and particle mechanics
- design industrial ventilation systems
- decide and design air pollution control devices for removal of particulates from flue gases
- 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

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.*

Evaluation Scheme:

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

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 hazardous materials and wastes;to know about the rules and regulations pertaining to the handling and management of hazardous materials and wastes; to understand the occupational health and safety management systems and their essential elements; and to impart awareness on noise pollution and control and on personal protection equipment.

Course Contents:

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

Course Learning Outcomes (CLOs):

The 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/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*

Evaluation Scheme:

S.N.	Evaluation Elements	Weightage (%)
1.	MST	20
2.	EST	40
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

PES223 WATERSHED MANAGEMENT

L	T	P	Cr
3	1	0	3.5

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

Course Contents:

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):

The 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	20
2.	EST	40
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

PES224 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.; and to acquire the knowledge and skills needed for the establishment, documentation, implementation, maintenance, and auditing of Environmental Management Systems

Course Contents:

Introduction: Industrial systems; Resource consumption, waste generation 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: 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: 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; ISO 19011 and environmental auditing; Audit activities and audit reports.

Course Learning Outcomes (CLOs):

The students will be able to:

- identify and evaluate environmental aspects of any organization's activities, products and services
- understand legal and other environmental requirements applicable to organizations
- establish, document, implement, maintain and improve EMS in organizations

Recommended Books

1. *Freeman H,Industrial Pollution Prevention Handbook;McGraw-Hill Professional 1st Ed. (1994)*
2. *Edwards AJ, ISO 14001: Environmental Certification Step by Step; Butterworth-Henemann (2004).*
3. *Stapleton PJ, Glover MA and Davis SP, Environmental Management Systems: An Implementation Guide to Small and Medium-sized Industries; NSF International 2nd ed. (2001)*
4. *ISO 14004: 2004 - Environmental management systems – General guidelines on principles; systems and support techniques.*
5. *ISO 19011: 2011- Guidelines for auditing management systems.*
6. *ISO 17021: 2011 - Conformity assessment — Requirements for bodies providing audit and certification of management systems.*

Evaluation Scheme:

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

PES225 ENVIRONMENT 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.

Course Contents:

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; 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; Environmental sampling, analysis and reporting of results; Environmental standards; Overview of other key environmental regulations- Municipal solid waste rules; Biomedical waste rules; Hazardous waste, microorganisms, and chemicals 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; Baseline studies; and environmental data collection: Methods of Impact analysis- checklists; matrices; networks; overlays etc.,

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

Course Learning Outcomes (CLOs):

The 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)*
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).*

Evaluation Scheme:

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

PES231 CLEANER TECHNOLOGIES

L	T	P	Cr
3	1	0	3.5

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

Course Contents:

Introduction: 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.

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)

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.

Course Learning Outcomes (CLOs):

The 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	45
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

PES232 WATER QUALITY MONITORING AND MODELING

L	T	P	Cr
2	1	2	3.5

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

Course Contents:

Water Quality and Parameters: 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 Modeling: 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 (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 modeling softwares.

Course Learning Outcomes (CLOs):

The students will be able to:

- have good understanding and knowledge of water quality guidelines, criteria and standards
- implement water quality monitoring programs, develop water quality indexes and analyse & interpret water quality data
- modal water bodies for different water quality parameters, and run some of the conventional 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 modeling: rivers, streams and estuaries, New India Publishing Agency (2008)*
3. *Chapra SC, Surface water quality modeling, Waveland press (2008).*
4. *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	20
2.	EST	40
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

PES233 AIR QUALITY MONITORING AND MODELING

L	T	P	Cr
2	1	2	3.5

Course Objectives:

To facilitate acquiring basic skills of sampling and analytical techniques in air quality monitoring; and understanding of the air quality modeling and simulation techniques

Course Contents:

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; 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 Modeling; Dispersion and Receptor modeling 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; Preparation and analysis of samples in AAS and IC; Measurement of indoor air quality; Noise monitoring; Air modeling softwares - ISCST3; AERMOD, CalRoads, etc.

Course Learning Outcomes (CLOs):

The students will be able to:

- Interpret the guidelines for an air quality monitoring
- apply techniques employed in the monitoring of particulates and gaseous pollutants in ambient air
- comprehend monitoring of particulates and gaseous pollutants in stack gas
- predict ground level concentration of pollutants from a given source through air quality modeling

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; Modeling and Mitigation; Spon Press (2002); 3rd Ed.*
3. *Khare M, Air Pollution – Monitoring; Modeling; Health and Control; InTech Publishers (2012).*
4. *Brebbia CA,Power H and Tirabassi T, Air Pollution V: Modeling; Monitoring and Management; InTech (1997).*
5. *Zannetti P, Air Quality Modeling - Theories; Methodologies; Computational Techniques; and Available Databases and Software: Volume IV - Advances and Updates; EnviroComp Institute (2010).*

Evaluation Scheme:

S.N.	Evaluation Elements	Weightage (%)
1.	MST	20
2.	EST	40
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

PES241 ENVIRONMENTAL HYDRAULICS AND HYDROLOGY

L	T	P	Cr
3	1	0	3.5

Course Objectives:

To facilitate understanding of hydrological aspects of water resources; Understanding the principles of need based activities such as pumps, mixers related to water; and to develop competence to propose effective convergence and design features of water supply projects

Course Contents:

Introduction: Hydrological cycle; Water and climate change; Scope of hydrology.

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 Hardy Cross Method.

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 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; Valves and flow measurement devices; and Pumping stations and their design.

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

Hydrology: Precipitation/rainfall and measurement; Hydrological data analysis and storm water estimation – SCS technique, hydrograph, rational method; Storm sewer design; Ground water movement and governing equations; Yield determination of wells; and ground water recharging.

Course Learning Outcomes (CLOs):

The students will be able to:

- apply fluid mechanics to water supply and sewerage systems, to water and wastewater treatment plants, and to air pollution control systems
- comprehend facilities and provisions (pumps, blowers, mixers, flow measurement devices) required for the handling of fluids (water, wastewater and gaseous emissions)
- examine techniques and skills on fluid flow measurement and quantification
- apply concepts of fluid mechanics to storm water handling and management

Recommended Books

1. *Chow VT, MaidmentDR and MaysLW, 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 engineering, PHI New Delhi (2002), 3rdEd.*
4. *Nathanson, JA, Basic environmental technology, PHE (2003), New. Delhi, 4th Ed.*

Evaluation Scheme:

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

PET203 ENERGY CONSERVATION AND MANAGEMENT

L	T	P	Cr
3	1	0	3.5

Course Objectives:

The course is design to facilitate student to understand and appreciate the energy crisis and environmental concerns associated with the energy management, and the importance of energy conservation; and acquire the skills of energy efficiency analysis and energy management in the routinely used thermal and electrical energy systems.

Course Contents:

Introduction: Overview of non-renewable energy resources, and new and renewable energy resources; Overview of energy technologies; Energy crisis and environmental concerns; Principles of energy conservation and management.

Energy conservation and management in thermal systems: Fuels and combustion; Boilers, Internal combustion engines and furnaces; Waste heat recovery systems; Turbines and DG sets; Steam system and condensate systems; Insulation; Heat exchangers; Cooling towers and circulating cooling water systems.

Energy conservation and management 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 energy management; Energy monitoring and auditing; Energy management systems; application of Ed-Opt, Energy monitoring and auditing; EnergyPlus Simulation softwares.

Course Learning Outcomes (CLOs):

The students will be able to:

- correlate the energy crisis and environmental concerns with the energy efficiency, conservation and management
- apply techniques and skills for the energy conservation and management in the thermal and electrical energy systems
- apply tools associated with energy monitoring and auditing, and on the energy management systems
- apply skills acquired in energy planning and management softwares for data analysis and interpretation

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).*

Evaluation Scheme:

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

PES390 SEMINAR

L	T	P	Cr
-	-	-	4.0

Course Objective:

This course is focused to facilitate student to gain skills of collecting, interpreting and presenting information of interest through seminar and report presentation.

Course Learning Outcomes (CLOs):

The student will be able to

- Identify and understand assumptions and arguments that exist in the national and international literature in the identified area of work/topic
- evaluate and synthesize evidence in order to draw conclusions based on research gaps
- ask meaningful questions and originate plausible research and technical gaps and the implications of the expected outcomes

Evaluation Scheme:

1. Oral Presentation: A powerpoint presentation and discussion therein that will highlight the strength of the presenter in the concept, background, literature and gap/lacunae related to identified area/topic

   Max. Marks: 40

2. Report Writing: A technical report that will highlight the student's strengths in concept and literature base on the identified area/topic; and capability to present the information in appropriate scientific formats.

   Max. Marks: 60

PES392 MINOR PROJECT

L	T	P	Cr
-	-	-	**12.0**

Course Objective:

This course is focused to facilitate student to carry out minor projects within the scope of the dissertation projects, so as to acquire skills of problem identification, designing feasible and innovative solutions for the problem solving, and presentation of report.

Course Learning Outcomes (CLOs):

The student will be able to

- identify technical problems and research gaps in domain specific areas at place of work
- design and develop feasible solutions for the identified problems

Evaluation Scheme:

3. Oral Presentation: A powerpoint presentation and discussion therein that will highlight the strength of the presenter on the problem identification, understanding of limitations and feasibility appropriate to the place of work

   Max. Marks: 30

4. Report Writing: A technical report that will highlight the student's strengths in concept and technical base on the identified problems

   Max. Marks: 30

5. Mentor's feedback: Feedback of the mentor on the capacity of the student to identify problems and develop solutions

   Max. Marks: 40

PES491 DISSERTATION

L	T	P	Cr
-	-	-	**16.0**

Course Objective:

This course is focused to facilitate student to carry out extensive research and development project or technical project at place of work through problem and gap identification, development of methodology for problem solving, interpretation of findings, presentation of results and discussion of findings in context of national and international research. The overall goal of the dissertation is for the student to display the knowledge and capability required for independent work.

Course Learning Outcomes (CLOs):

The student will be able to

- gain in-depth knowledge and use adequate methods in the major subject/field of study.
- create, analyze and critically evaluate different technical/research solutions
- clearly present and discuss the conclusions as well as the knowledge and arguments that form the basis for these findings
- identify the issues that must be addressed within the framework of the specific dissertation as means for path forward
- be consciousness of the ethical aspects related to presentation of technical/research dissertation