CURRICULUM STRUCTURE OF

MASTER OF TECHNOLOGY (2 Year 4 Semester) in RENEWABLE ENERGY

(Applicable from the academic session 2022-23)

Department of Renewable Energy Engineering

Under
School of Energy and Environmental Engineering

Maulana Abul Kalam Azad University of Technology,
West Bengal

(Formerly West Bengal University of Technology)

Haringhata-741249, Nadia, West Bengal, INDIA

DEPARTMENT OF RENEWABLE ENERGY ENGINEERING

MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WB

About the Department

To mitigate alarming depletion of fossil fuels and enormous pollution generated during energy harvesting from these fuels effectively, the world community has been compelled towards extensive exploration and efficient harnessing of clean, sustainable renewable energy resources. The vast area of renewable energy is becoming smarter and integrated extremely fast to clean and green energy revolution of the future. To cater to these innovative fields, a huge number of specialised technologists and engineers are needed globally for achieving proper development of the renewable energy sector. In view of the above, MAKAUT, WB has established the Department of Renewable Energy under the School of Energy and Environmental Science in the main campus of the University at Haringhata in the year 2019. The department was renamed as Department of Renewable Energy Engineering in the year 2021.

Vision:
To create proficient professionals by imparting world-class knowledge and originating innovative ideas through research in the field of new and renewable energy.

Mission:
- To evolve a top-quality education and updated technical skill system attenuated to the changing needs of the renewable energy sector.
- To endow students and researchers with modern concepts & adequate knowledge in order to equip them with industry ready with technical expertise.
- To inspire students and research scholars with creative ideas and aptitude for conducting industrial oriented research and development works.
- To promote entrepreneurial, managerial and leadership quality among the students.
- To strengthen academic, industrial, and social interaction through continuous active collaborations.

Thrust areas of the department:

- Efficient Renewable Energy Harvesting.
- Comprehensive Energy Management and Audit.
- Development of Newer & Smart Materials for the New & Renewable Energy sector.
- Renewable Energy based Devices & Appliances.
- Software based energy informatics & modelling.

Program Educational Objectives (PEOs)

Graduating Students of M. Tech. in Renewable Energy program shall be able to-

PEO 1: Pursue advanced education and research in the Renewable Energy sector leading to hands-on experience on practical problem solving skills.

PEO 2: Establish themselves as globally employable professionals in the academic and R&D institutions.

PEO 3: Emerge as ethically responsible citizens who are sensitive to and well aware of the energy issues and concerns with significant knowledge for sustainable development.

Program Outcomes (POs)

Graduating Students of M. Tech in Renewable Energy program will have-

PO1: Calibre to carry out R&D activities and research project oriented problem solving skills independently.

PO2: Expertise and skills required for energy auditing and management, development, implementation, maintenance of systems used in the renewable energy sector.

PO3: First-hand skills in the scientific and technological communications, and project preparation, planning and implementation of energy projects.

PO 4: An ability to pursue Ph.D. Program in relevant areas of Renewable Energy.

Program Specific Outcome (PSO):

PSO 1: Students will gather precise knowledge to design, analyse and evaluate the performance of Renewable and Non-renewable energy/environmental systems taking into consideration the Indian and Worldwide scenario.

PSO 2: Students are able to study in-depth w.r.t energy demand-supply mismatch with time, potential of renewable/ non-renewable energy sources, new technologies to make technical and economic improvement in the area of renewable energy.

PSO 3: Students can implement software skills in designing, evaluation and simulation using MATLAB, PV-SOL, HOMER, SAM, AUTO-CAD etc. for smooth operation and optimization of renewable energy resources like solar, wind, bio and hybrid systems.

Curriculum Structure

Semester- I							
Sl.No	**Category**	**Course code**	**Course name**	**L**	**T**	**P**	**Credit**
1	Program Core-I	PC-MRE 101	Energy & Power System Technology	3	0	0	3
2	Program Core-II	PC-MRE 102	Renewable Energy – I (Hydel, Biomass, Geo-Thermal and Wind Energy)	3	0	0	3
3	Program Elective-I	PE-MRE 103 I/II/III	Transport Processes & Thermodynamics/ Mathematical Methods & Data Analysis/ Digital Control and Optimization of Energy Systems	3	0	0	3
4	Program Elective-II	PE-MRE104 I/II/III	Industrial Energy Analysis/Waste to Energy/Energy Storage Technologies	3	0	0	3
5	Mandatory learning	MC-MRE 105	Research Methodology & Intellectual Property Rights	2	0	0	2
6	Audit course - I	AC-MRE106 I/II/III/IV	Value Education/ Stress Management by Yoga/ Constitution of India/Pedagogy Studies	0	0	0	0
Practical							
8	Lab-I	PC-MRE 191	Energy and Power System Technology Lab	0	0	4	2
9	Lab-II	PC-MRE 192	Renewable Energy - I Lab	0	0	4	2
			Total	14	0	8	18

Semester- II							
Sl.No	**Category**	**Course code**	**Course name**	**L**	**T**	**P**	**Credit**
1	Program Core- III	PC-MRE201	Renewable Energy – II (Solar Energy)	3	0	0	3
2	Program Core-IV	PC-MRE 202	Renewable Energy – III (Ocean Energy, Fuel Cells, Hydrogen Energy)	3	0	0	3
3	Program Elective-III	PE-MRE 203 I/II/III	Materials & Devices for energy conversion and storage/ Composite Materials for Energy applications/ Recent advances in Solar Photovoltaics	3	0	0	3
4	Program Elective – IV	PE-MRE 204 I/II/III	Distributed Generation and Smart Grids/ Energy Distribution Systems and Automation /Green Environment and Sustainability	3	0	0	3
5	Audit Course II	AC-MRE205 I/II/III/IV	English for Research Paper Writing / Disaster Management/ Statistics & Probability with R / Personality Development through Life Enlightenment Skills	0	0	0	0
6	Lab-III	PC-MRE 291	Renewable Energy - II Lab	0	0	4	2
7	Lab-IV	PC-MRE 292	Renewable Energy – III Lab	0	0	4	2
9	Minor Project	PW-MRE 281	Minor Project on Designing of Renewable Energy Systems with Seminar	2	0	0	2
			Total	14	0	8	18

Semester- III							
Sl. No	**Category**	**Course code**	**Course name**	**L**	**T**	**P**	**Credit**
1	Program Elective - V	PC-MRE 301 I/II/III	Renewable Energy management, Cost Analysis and Audit/ Energy Policy & Regulatory Compliance/ Environmental Risk and Impact Assessment	3	0	0	3
2	Open Elective (IT course)	OE- MRE(CS) 304 I/II/III	AI and Machine Learning / IOT and Smart Sensors/ Data Analytics	3	0	0	3
3	Major project	PW-MRE 381	Dissertation-I (Initiation and Progression)	0	0	20	10
			Total	6	0	20	16

Semester- IV							
Sl. No	**Category**	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credit**
1	Major Project	PW-MRE 481	Dissertation-II (Completion)	0	0	32	16
			Total	0	0	32	16

- Total credit- 68

- Each unit of all the credit courses will be covered under 12 class hours.

Detailed Syllabus

First Semester

Course Code: PC-MRE 101	Subject: Energy and Power System Technology	L-T-P: 3-0-0	Credits: 3

Course Outcome

Students will be able to-

CO:1 Relate the energy needs of modern society through viable engineering solutions. **(BL1)**

CO:2 Design economically viable and cutting-edge technology for industrial power solutions. **(BL6)**

CO:3 Explain properties of different types of fuels. **(BL4)**

CO:4 Outline the different components of a thermal power plant. **(BL2)**

CO:5 Use different types of electrical motors and generators according to the need. **(BL3)**

Course contents

UNIT- I :

Basic Introduction to Energy: Energy and power, forms of energy, primary energy sources, energy flows, world energy production and consumption, Key energy trends in India: Demand, Electricity, Access to modern energy, Energy production and trade, Factors affecting India's energy development: Economy and demographics Policy and institutional framework, Energy prices and affordability, Social and environmental aspects, Investment.

UNIT- II :

Classification of fuels, Calorific value. Solid Fuels, physical properties of Coal: proximate and ultimate analysis of Coal, Cleaning, washing, Pulverisation & briquetting of Coal, Storage of Coal. Theory of Coal Pyrolysis, Recovery of by-products Coal Chemicals

Origin of Crude oil, Constitutions of Crude oil, Characterization of Crude oil, drilling of Petroleum, fractionation of Crude oil in refineries, Thermal & Catalytic cracking and catalytic reforming processes, Coking, fluidized bed cracking. Properties and Testing logistic of petroleum products: Octane number, Cetane No, pour point, fire point, flash point, aniline point, Carbon residue

Classification of gaseous fuels, producer gas, blue and carburetted water gas, Coal gas, Blast furnace gas, natural gas, Coal bed methane, LPG & CNG.

Combustion stoichiometry, Combustion thermodynamic- problems, Kinetics of combustion, Combustion appliances

UNIT- III :

Basic concepts of power plants, types of power plants, thermal power stations, Various components of thermal power stations, power plant cycles, fuel handling, combustion, waste disposal methodologies, economizers, turbo alternators, heat balance and efficiencies, Economic operation of power generation: Generation cost curves; Economic

operation of thermal system; Plant Scheduling; Transmission loss and penalty factor, Hydro-Thermal Scheduling; Concept of Reserve and Constraints; Unit Commitment, Tariff.

UNIT- IV :

Magnetic materials, BH characteristics, ideal and practical transformer, equivalent circuit, losses in transformers, regulation and efficiency. Auto-transformer and three-phase transformer connections. Generation of rotating magnetic fields, Construction and working of a three-phase induction motor, Significance of torque-slip characteristic. Loss components and efficiency, starting and speed control of induction motor. Single-phase induction motor. Construction, working, torque-speed characteristic and speed control of separately excited dc motor. Construction and working of synchronous generators.

Reference:

1. P.K.Nag, Power plant Engineering, Tata McGraw Hill Publication.
2. D.P.Kothari, Power System Engineering, Tata McGraw Hill Publication.
3. D P Kothari, Advanced Power System, Tata McGraw Hill Publication.
4. Ali Keyhani, Design of Smart Power Grid Renewable Energy Systems, Wiley
5. Dr. Samir Sarkar. Fuels and combustion (3rd Edition)-
6. OP Gupta, Elements of fuel, furnaces and Refractories Khanna Publishers, University Press.
7. Brame & King. Fuel and Furnace

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	2	2	1	1	1	1	1
CO2	3	2	2	2	3	2	2
CO3	1	2	1	1	1	1	1
CO4	2	3	2	2	2	2	2
CO5	2	3	1	1	1	1	1
Avg	**2**	**2.4**	**1.4**	**1.4**	**1.6**	**1.4**	**1.4**

Course Code: PC-MRE 102	Subject: Renewable Energy I	L-T-P: 3-0-0	Credits: 3

Course Outcome

The students will be able to,

CO:1 Identify the types of Geothermal and Biomass energy, its surplus availability and critical characteristics. **(BL4)**

CO:2 Prioritise technologies available for conversion of geothermal and biomass energy and its economic implications. **(BL5)**

CO:3 Describe the process used in harnessing and implementation of wind energy. **(BL1)**

CO:4 Categorise hydraulic turbines in generating hydropower. **(BL4)**

Course contents

UNIT- I :

Classification of hydropower plants, small hydropower systems: overview of micro, mini, and small hydro systems; status of hydropower worldwide; advantages and disadvantages of Hydropower; Methods for determining head and flow, Types and Operational Aspects Classification of Hydraulic Turbines, Operational Aspects of Turbines Efficiency and selection of turbines; Weirs, Dam and Spillway, Surge Chambers, Penstock, Tailrace. Types of Hydro Projects, Planning & Management: Government Hydropower policies, environmental issues, SWOT-(Strength weakness opportunity threatening) of hydropower projects, type of clearance required for Hydropower project

UNIT- II :

Different processes of thermos-chemical conversion, direct combustion, chemical conversion, hydrolysis and hydrogenation, solvent extraction of hydrocarbon, bio crude, bio diesel and chemicals from biomass, bio-degradation, bio chemistry and process parameters of bio-methanation and Anaerobic digestion. Bio Conversion of substrates into methanol, ethanol, organic acids production, Kinetics and mechanism, Bio- hydrogen production: hydrolysis, fermentation. Biodiesel production, different types of raw materials, non-edible oil-seeds, Pyrolysis, mechanism of transesterification, fuel characteristics of biodiesel. Biogas production mechanism and technology, types of digesters, design of biogas plants, installation, operation and maintenance of biogas plants, biogas slurry utilization and management, biogas applications, cost benefit analysis of biogas for cooking, lighting, power generation applications, Feedstock for biogas, Microbial and biochemical aspects, operating parameters for biogas production, mathematical modelling of bio-methanation process, environmental and social impacts of biogas plants.

UNIT- III :

Availability of geothermal energy-size and distribution; recovery of geothermal energy, various types of systems to use geothermal energy; Power generation using geothermal heat, Sustainability of geothermal source, Geothermal heat pump and geothermal energy

scenario in India

UNIT- IV :

Current status and future prospects; wind energy in India; power available in the wind; Anemometers and wind directions; environmental benefits and problems of wind energy; factors influencing the cost of energy generation - site specific parameters, World Meteorological Organization (WMO) specification, and machine parameters, Wind energy conversion system (WECS): classification, characteristics, and applications; characteristics of wind rotor; wind turbine power and torque characteristics; types of rotors - horizontal and vertical axis wind turbine; Betz limit; Wind pumps - wind driven piston pumps, limitations, and performance analysis; atmospheric circulations, classification, factors influencing wind, wind shear, turbulence, wind speed monitoring, Wind pump basics: Its application and tip speed ratio calculation in withdrawing water; Dynamic wind pumps; Pulsating torque calculation.

References:

1. Kothari, Renewable Energy Sources and Emerging Technologies, PHI, Eastern Economy Edition,2012.
2. R.K.Rajpoot, Non-Conventional Energy Sources and Utilization, S.Chand Publication, New Delhi.
3. K.C. Khandelwal and S.S. Mahdi, Biogas Technology– A Practical Handbook, Tata McGrawHill,1986.
4. Rai, G.D, Non-Conventional Energy Sources, Khanna Publishers, New Delhi

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	1	1	2	1	1	1	1
CO2	2	1	2	2	2	2	1
CO3	2	1	1	1	1	2	1
CO4	1	2	2	1	2	2	2
Avg	**1.5**	**1.25**	**1.75**	**1.25**	**1.5**	**1.75**	**1.25**

Course Code: PE-MRE 103/I	Subject: Transport Processes & Thermodynamics	L-T-P: 3-0-0	Credits: 3

Course Outcome

The students will be able to,

CO:1 Describe comprehensive knowledge for determining the thermodynamic properties of the chemical reactions. **(BL1)**

CO:2 Find concepts and methodology needed to develop mass and energy balances. **(BL1)**

CO:3 Illustrate fundamental concepts of heat and mass transfer leading to the designing of heat and mass transfer equipment. **(BL3)**

CO:4 Solve steady and unsteady state problems of fluid mechanics. **(BL3)**

Course contents

UNIT- I : Fluid Mechanics:

Transport Theorem, introduction to momentum transfer, concept of continuum, viscosity and mechanisms of momentum transport, momentum flux, Newton's law of viscosity, shear stresses during laminar flow, Non-Newtonian fluids, Bingham model, Eyring model, Reiner-Philippoff model, convective momentum transport, shell momentum balances and velocity profiles in laminar flow between flat plates, rectangular channels, circular tubes and pipes, annulus, flow around a sphere, continuity equation for both Newtonian and non-Newtonian fluids, flow of falling films with constant and variable viscosity, equations of continuity in Eulerian and Lagrangian form, equations of motion-Euler and Navier Stokes, control volume approach, applications of these equations in steady and unsteady state problems

UNIT- II : Heat Transfer:

Modes of heat transfer, heat flux and Fourier's law of heat conduction, concept of thermal conductivity and diffusivity, shell energy balances and boundary conditions: heat sources: electrical, nuclear, viscous, chemical. Steady state heat conduction without heat generation for systems of different geometries e.g. composite walls, cylinders, spheres, having constant and variable thermal conductivities, conduction with generation: Poisson equation, conduction with temperature dependent generation, unsteady state heat conduction in finite and semi-infinite.

UNIT- III : Mass Transfer

Analogies among momentum, heat and mass transfer, dimensional analysis, derivation of important dimensionless groups and significance of dimensionless groups in momentum, heat and mass transport, simultaneous mass, heat, momentum transfer and their industrial applications, e.g. applications of momentum heat and mass transport concepts for detailed design and analysis of cooling towers, distillation columns, absorbers, reactors, dryers, application of energy balance in solar cells, fuel cells, biogas generation etc, case studies of several plants e.g. thermal power plants, refineries, petrochemical industries, pharmaceutical industries, textile industries, desalination plants, effluent treatment unit

UNIT- IV : Thermodynamics:

Concept of Macroscopic approach to thermodynamics, path and point functions. Intensive and extensive property, thermodynamic system and their types. Jule-Thompson Effect, Thermodynamic Equilibrium State.Quasi-static, reversible and irreversible processes, Displacement work and other modes of work.p-v diagram. Application of First law of thermodynamics, Steady flow energy equation applied to nozzle, diffuser, boiler, turbine, compressor, pump, heat exchanger, Heat Reservoir, source and sink. Heat Engine, Refrigerator, Heat pump, Equivalence of second law statements and its corollaries. Concept of entropy, Applications of 2nd Law of thermodynamics, Exergy destruction in heat transfer process, exergy of finite heat capacity body, exergy of closed and steady flow system; 1st and 2nd law Efficiency, Thermochemistry: Enthalpy, Heat of reaction at constant pressure and volume, Hess's Law of constant heat summation, Gibb's free energy, Nernst equation, Vapor Power cycles: Carnot vapor cycle, Rankine cycle, comparison of Carnot and Rankine cycle, Gas Power cycles: Otto and Diesel cycle, Dual cycle.

References:

1. B.R. Bird, W. E. Stewart, and E. N. Lightfoot ,Transport Phenomena, 2nd edtn, John Wiley & Sons.
2. W.M. Deen, Analysis of transport phenomena, 2nd ed, Oxford University Press.
3. P.K. Nag, Engineering Thermodynamics, McGraw- Hill Education.
4. Borgnakke & Sonntag, Fundamentals of Thermodynamics, Wiley India (P)Ltd.

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	2	1	1	1	1	1	1
CO2	2	2	1	2	1	2	2
CO3	2	3	2	1	1	1	1
CO4	3	3	2	2	1	2	2
Avg	**2.25**	**2.25**	**1.5**	**1.5**	**1**	**1.5**	**1.5**

Course Code: PE-MRE 103/II	Subject: Mathematical Methods and Modelling	L-T-P: 3-0-0	Credits: 3

Course Outcome

Students will be able to,

CO:1 Complete the fundamental requirements of knowledge of Mathematics for learning science and technology subjects. **(BL3)**

CO:2 Explain adequate knowledge of the distribution of various kinds of functions and their hypothetical testing. **(BL2)**

CO:3 Illustrate necessary analytic and technical skills to handle problems of mathematical nature as well as practical problems. **(BL3)**

CO:4 Design different simulation models for applied engineering applications. **(BL6)**

Course contents

UNIT- I :

Fourier transform, Laplace transform, Solution of differential equations by Laplace and Fourier transform methods, Applications of Laplace and Fourier transforms to Boundary value problems arising in Engineering Sciences, Solutions of Laplace, Wave and Heat Conduction Equations, Basic ideas of Discrete Fourier transform (DFT) and Finite Fourier transform (FFT), Z-transform, and Applications, Basic ideas of Discrete Fourier transform (DFT) and Finite Fourier transform (FFT), Z- transform, and Applications

UNIT- II :

Partial differential equations: first and second order equations time dependent boundary conditions Green function. Superposition principle: moving boundary problems: approximate methods of solution. Numerical methods for solutions of differential equations, linear and non-linear, analysis of convergence, error and stability.

UNIT- III :

Statistical Models - Concepts – Discrete Distribution- Continuous Distribution – Poisson Process- Empirical Distributions- Queueing Models – Characteristics- Notation Queueing Systems – Markovian Models- Properties of random numbers- Generation of Pseudo Random numbers- Techniques for generating random numbers- Testing random number generators, Generating Random-Variates- Inverse Transform technique Acceptance-Rejection technique – Composition & Convolution Method.

UNIT- IV :

Introduction – Simulation Terminologies- Application areas – Model Classification Types of Simulation- Steps in a Simulation study- Concepts in Discrete Event Simulation Example, Input Modelling - Data collection - Assessing sample independence – Hypothesizing distribution family with data - Parameter Estimation - Goodness-of-fit tests – Selecting input models in absence of data- Output analysis for a Single system – Terminating Simulations – Steady state simulations. ANOVA (one way & two way).usage of MATLAB. Econometric techniques used for energy analysis with case studies.Input-output analysis, Energy multiplier and implication of energy multiplier for analysis of regional and national energy policy.

References:

1. Jerry Banks and John Carson, Discrete Event System Simulation , PHI, 2005
2. Geoffrey Gordon, Erwin Kreyszig, System Simulation Advanced Engineering Mathematics, Wiley.
3. Mathematical Modelling: A Graduate Textbook, Seyed M. Moghadas, Majid Jaberi-Douraki
4. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, ISV John Wiley & Sons

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	1	1	1	1	1	1	1
CO2	1	2	1	1	2	1	1
CO3	2	1	1	1	1	2	1
CO4	3	2	1	1	2	1	2
Avg	**1.75**	**1.5**	**1**	**1**	**1.5**	**1.25**	**1.25**

Course Code: PE-MRE 103/III	Subject: Digital Control and Optimization of Energy Systems	L-T-P: 3-0-0	Credits: 3

Course Outcome

Students will be able to,

CO:1 Prioritise the control and optimization concepts for electric energy systems and the hardware and software infrastructure for monitoring, controlling, optimising and operating an electric energy system. **(BL5)**

CO:2 Compare the models and analytics for operating the system as an open market of electricity. **(BL4)**

CO:3 Design an optimization algorithm for operating an electric power system at optimal cost or at optimal voltage profile. **(BL6)**

CO:4 Use optimization and control concepts to formulate the inclusion of inverter interfaced generating resources for optimal voltage control. **(BL3)**

Course contents

UNIT- I:

The Power System Control Problem Control functions, Operational constraints System operating states, Vertically integrated operation, Independent system operation Analysis Techniques, The Power flow problem, Solution techniques, Large scale systems, Sparsity techniques, Security assessment, Contingency analysis, Power system equivalents

UNIT- II :

Review of Energy Management Systems, Real time modelling subsystem, Energy/economy functions and control, Security monitoring and control subsystem, Real Time modelling, The SCADA system, Communications, Computers, Network configuration, State estimation, Error detection, On-Line power flow

UNIT- III :

Description of control loops, Review of control theory, Automatic generation control, Frequency control, Interchange control, Economic dispatch, Pollution dispatch, Optimal power flow, Ancillary services under deregulation, Operations planning, Electric load forecast, Reactive power control, Supply management options and impact, Scheduling and control of energy storage, Unit commitment, Transmission loss evaluation and accounting

UNIT- IV :

System Security Monitoring and Control, Real time modeling, Security monitoring, Security controls, Simultaneous transfer capability analysis, Impact of deregulation

Reference:

1. P.K. Nag, Power plant Engineering, Tata McGraw Hill Publication.
2. D.P. Kothari, Power System Engineering, Tata McGraw Hill Publication.
3. D. P. Kothari, Advanced Power System, Tata McGraw Hill Publication.
4. Ali Keyhani, Design of Smart Power Grid Renewable Energy Systems, Wiley

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	2	2	2	2	2	1	1
CO2	1	2	2	1	2	1	2
CO3	3	2	2	2	2	2	3
CO4	2	3	2	1	2	1	2
Avg	**2**	**2.25**	**2**	**1.5**	**2**	**1.25**	**2**

Course Code: PE-MRE 104/I	Subject: Industrial Energy Analysis	L-T-P: 3-0-0	Credits: 4

Course Outcome

Students will be able to,

CO:1 Solve material balance calculations for a specific problem. **(BL3)**

CO:2 Identify fluid flow systems to select a pump/blower/compressor and estimate the efficiency of the operation. **(BL4)**

CO:3 Design energy models for small or medium sized industries. **(BL6)**

CO:4 Plan measures for improving energy efficiency. **(BL6)**

Course contents

UNIT- I:

Concepts of basis; mole fraction, mass fraction; Material balance without reaction – applications in renewable energy systems; Recycle and bypass calculations; Basics of energy balance – calculation of enthalpy in systems without reaction from mean/temperature- dependent heat capacity data, calculation of heat of reaction and adiabatic reaction temperature in reactive systems; Examples on combined material and energy balances in industrial processes

UNIT- II :

Heat transfer equipment fundamentals; methods for improving thermal and flow efficiency in heat exchangers – selection of suitable material of construction for tubes, optimizing shell and tube pressure drops; Energy efficiency analysis in boilers and furnaces; heat recovery in waste-heat boilers; heat recovery systems for gas turbines; efficiency analysis of wind turbine systems.

UNIT- III :

Energy efficiency of compression systems – basics of pumps, performance characteristics of centrifugal pumps, BEP in characteristic curve, analysis of series/parallel operation of centrifugal pumps, ways of avoiding cavitation; efficiency of fans and blowers; estimation of single stage and multistage compressor efficiency; estimation of piping losses; efficient design of piping networks by Hardy-Cross method.

UNIT- IV :

Efficiency analysis of electrical heating systems – resistance, induction, microwave and radiant heating; characteristics of industrial electrical heating techniques; Lighting control systems for improving energy efficiency of lighting; Efficiency analysis of D.C. motors and Induction motors; control arrangements for D.C. motors and Induction motors.

References:

1. B.K. Hodge, Analysis and Design of Energy Systems, PrenticeHall

2. Card D Shields, Boilers – Types, Characteristics and Functions, McGrawHill

3. I.G.C. Dryden, P. Thollander and J. Palm The Efficient Use of Energy, Butterworth Scientific

4. Improving Energy Efficiency in Industrial Energy Systems, Springer

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	2	2	2	1	2	2	1
CO2	2	2	2	1	1	2	1
CO3	3	2	2	2	2	2	2
CO4	2	3	2	2	2	2	2
Avg	**2.25**	**2.25**	**2**	**1.5**	**1.75**	**2**	**1.5**

Course Code: PE-MRE 104/II	Subject: Wastes to Energy	L-T-P: 3-0-0	Credits: 3

Course Outcome

The students will able to,

CO:1 Illustrate the processes through which energy can be generated from wastes. **(BL3)**
CO:2 Outline the overall energy balance equations for waste to energy conversion. **(BL2)**
CO:3 Solve technical problems related to waste to energy conversion. **(BL3)**
CO:4 Identify the areas where waste to energy application can be implemented. **(BL4)**

Course contents

UNIT- I:

Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste – MSW, Fuels derived from waste and their properties -- Calorific value and composition, General ideas of Conversion Devices – Incinerators, Gasifiers, digesters.

UNIT- II :

Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, biochemical conversion - anaerobic digestion, yields and applications. - Types of biogas Plants –Alcohol production from biomass - Bio diesel production.

UNIT- III :

Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation, Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation of all the above biomass combustors.

UNIT- IV :

Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - Urban waste to energy conversion - Biomass energy program in India.

References:

1. Desai, Ashok V, Non Conventional Energy, Wiley Eastern Ltd., 1990
2. Khandelwal, K. C. and Mahdi, S. S Biogas Technology – A Practical Hand Book Tata McGraw Hill Publishing Co. Ltd. 1983
3. C. Y. WereKo-Brobby and E. B. Hagan, Biomass Conversion and Technology, John Wiley & Sons, 1996.
4. Branchini Lisa, Waste-to-Energy, Springer International Publishing, 2015.

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	1	2	1	1	1	2	1
CO2	2	2	2	1	1	2	1
CO3	2	2	1	2	1	2	2
CO4	1	2	1	2	2	2	1
Avg	**1.5**	**2**	**1.25**	**1.5**	**1.25**	**2**	**1.25**

Course Code: PE-MRE 104/III	Subject: Energy Storage Technologies	L-T-P: 3-0-0	Credits: 3

Course Outcome

Students will be able to,

CO:1 Discuss the scientific principles underpinning the operation of energy storage systems. **(BL2)**

CO:2 Solve the intermittency of renewable energy sources such as solar and wind by utilising problem solving skills in energy storage engineering and grid integration. **(BL3)**

CO:3 Use energy storage knowledge to develop and conduct projects. **(BL3)**

CO:4 Decide which energy storage technology can be used according to the availability of resources. **(BL5)**

Course contents

UNIT- I :

Need of energy storage; Different modes of Energy Storage, Potential energy: Pumped hydro storage, Kinetic energy and Compressed gas system: Flywheel storage, Compressed air energy storage, Electrical and magnetic energy storag e: Capacitors, Electromagnets and Battery storage systems such as primary, secondary, Lithium, Solid-state and Molten solvent batteries Role of carbon Nano-tubes in electrodes; Chemical Energy storage: Thermo- chemical, Photo-chemical, Bio-chemical, Electro-chemical, Fossil fuels and Synthetic fuels and Hydrogen storage.

UNIT- II :

Sensible heat storage (SHS) mediums; Stratified storage systems; Rock-bed storage systems; Thermal storage in bui ldings; Earth storage; Energy storage in aquifers. Design, working and case studies of SHS system for industries Phase change materials (PCMs); Selection criteria of PCMs; Stefan problem; Solar thermal LHTES systems; Energy conservation through LHTES systems; LHTES systems in refrigeration and Air-conditioning systems; Enthalpy formulation; Numerical heat transfer in melting and freezing process. Design working and case studies of PCM system for industries.

UNIT- III :

Some areas of application of energy storage: Food preservation; Waste heat recovery
Solar energy storage; Greenhouse heating Power plant applications; Drying and heating for process industries.

UNIT- IV :

Magnetic and Electric Energy Storage Systems: Superconducting magnet energy storage (SMES) systems; Capacitor and batteries: Comparison and application, Super capacitor: Electrochemical double layer capacitor (EDLC), Principle of working, Structure, Performance and application, Role of activated carbon and carbon nano-tube.

References:

1. Narayan R, Viswanathan B, Chemical and Electrochemical Energy Systems, University Press (India) Ltd.
2. Sarangpani, S J A Kose k, La Conti A B, Handbook of Solid State Batteries and Capacitors, World Scientific Publications, N J, USA.
3. Newman J, Electro-chemical Systems, Prentice Hall, Engelwood Cliffs, NJ, USA.
4. Gileadi E, Electrode Kinetics for Chemists, Chemical Engineers and Material Scientist, VCH Publications, NY, USA.
5. Harris Peter J F, Carbon Nanotubes and Related Structures -New Materials for the Twenty-first Century, Cambridge University Press, UK.
6. Reich, Stefan, C Thomsen, Maultzsch J, Carbon Nanotubes – Basic Concepts and Physical Properties, John Wiley and Sons, Canada

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	1	2	2	3	2	2	2
CO2	3	1	1	2	3	3	3
CO3	2	3	2	2	3	1	2
CO4	3	2	3	1	1	3	2
Avg	**2.25**	**2**	**2**	**2**	**2.25**	**2.25**	**2.25**

Course Code: MC-MRE 105	Subject: Research Methodology and Intellectual Property Rights	L-T-P: 2-0-0	Credits: 2

Course Outcome

The students will able to,

CO:1 Outline research problem formulation **(BL2)**
CO:2 Find research related information **(BL1)**
CO:3 Describe research ethics **(BL1)**
CO:4 Create research team of high values **(BL6)**
CO:5 Use different methods of research evaluation **(BL3)**

Course contents

UNIT- I :

Introduction to research; Definitions and characteristics of research; Types of research; Main components of any research work. Analysis and Statement of the problem: Learning Objectives; Analyzing the problem; Formulating the problem statement. Literature review: Uses of literature review; Source of information; Aims & Objectives, Formulation and Scheduling of Objectives; Definitions; of the research objectives. Basic Quality Management tools and Acceptance Sampling, Numerical Problems

UNIT- II :

Development of Research Hypotheses, Data Collection — Primary and Secondary Data, Determination of Sample Size. Testing of Hypotheses, Null and Alternate hypothesis, One tailed and two –tailed test, Type I and Type II error, Steps in Testing Hypothesis, Basic concepts of Descriptive Statistics, Basic concepts of Design of Experiments. Numerical Problems

UNIT- III :

Basic Spreadsheet tools: Introduction to spread-sheet applications, features & functions, using formulae & functions, data storing, features for statistical data analysis, generating charts/graphs & other features. Basic Presentation tool: Introduction to presentation tool, features & functions, creating presentations Basic Concepts of Web Search: search engines using for research databases, Basics of Thesis writing editing tools. Writing style of Reference and Nomenclature

UNIT- IV :

Introduction to Detailed Project Report – Incorporating Technical, Marketing, Environment, Social, Financial Part. How to study DPR. Basic Concepts of Feasibility Analysis Basics of IPR, Methodology of filling patents, follow up action. Basics of Network Analysis and Scheduling, Numerical Problems.

References:

1. Kothari C.K. Research Methodoloy– Methods and Techniques, New Age International, New Delhi.
2. Krishnswamy, K.N, Shivkumar, AppaIyer and Mathiranjan M, Management Research Methodology; Integration of Principles, Methods and Techniques, Pearson Education, New Delhi
3. Ashok Kumar, Intellectual Property Rights, Allied Publishers, 1994.
4. Dr. R. Radhakrishnan and Dr. S. Balasubramanian, Intellectual Property Rights: Text and Cases, Excel Books India, 2008.

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	2	1	2	3	2	2	2
CO2	3	1	3	3	3	2	2
CO3	2	1	2	3	2	1	2
CO4	3	2	3	3	2	2	2
Avg	**2.5**	**1.25**	**2.5**	**3**	**2.25**	**1.75**	**2**

Course Code: PC-MRE 191	Subject: Energy and Power System Technology Laboratory	L-T-P: 0-0-4	Credits: 2

Course Outcome

Students will be able to,
CO:1 Explain practical knowledge about various power system components. **(BL2)**
CO:2 Use various testing procedures used in power systems. **(BL3)**
CO:3 Prioritise technologies on energy system instrumentations and control devices. **(BL5)**
CO:4 Justify the properties of different types of fuels. **(BL5)**
CO:5 Find different important parameters of fuels. **(BL1)**

Course contents

List of Experiments:

- Determination of Flash point of oil by ABEL apparatus.
- Determination of flash point and fire point of a fuel oil by Pensky-Martins apparatus.
- Determination of moisture content of fuel oil by Dean Stark apparatus.
- Determination of kinematic viscosity of oil by Redwood viscometer.
- Determination of calorific value of coal by bomb calorimeter.
- Proximate analysis of coal.
- Orsat analysis of combustion and flue gases.
- Determination of the generalized ABCD Constant of a transmission line.
- OC and SC test and Polarity test of a single phase transformer.
- Different methods of starting a 3 phase Induction Motor & their comparison.
- Speed control of 3 phase squirrel cage induction motor by different methods & their comparison.
- Study of the characteristics of a separately excited DC generator.
- Study of the characteristics of a DC motor

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	2	2	1	1	2	2	1
CO2	2	3	1	1	1	1	2
CO3	2	3	2	1	2	1	2
CO4	1	2	2	1	1	1	1
CO5	2	2	2	1	1	2	1
Avg	**1.8**	**2.4**	**1.6**	**1**	**1.4**	**1.4**	**1.4**

Course Code: PC-MRE 192	Subject: Renewable Energy Lab I	L-T-P: 0-0-4	Credits: 2

Course Outcome

Students will be able to,

CO:1 Relate first-hand knowledge regarding wind power generation. **(BL1)**

CO:2 Explain the working principle of hybrid renewable energy systems. **(BL2)**

CO:3 Outline the process of bio-diesel production. **(BL2)**

CO:4 Design hybrid renewable energy systems. **(BL6)**

Practical:

List of Practical:

1. Performance analysis of wind turbines.
2. Energy generation and Characterization of biogas of bio-digester.
3. Synthesis of bio-diesel and its characteristics.
4. Characterization and testing of rechargeable battery
5. Design and Analysis of Hybrid Renewable Energy System.

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	1	1	2	1	1	2	1
CO2	1	1	2	1	1	2	1
CO3	2	2	2	1	1	2	1
CO4	2	1	2	2	1	2	1
Avg	**1.5**	**1.25**	**2**	**1.25**	**1**	**2**	**1**

Second Semester

Course Code: PC-MRE 201	Subject: Renewable Energy II	L-T-P: 3-0-0	Credits: 3

Course Outcome

The students will able to,

CO:1 Illustrate the concepts of different solar cells modules and its uses. **(BL3)**
CO:2 Describe the working principle of the solar cell. **(BL1)**
CO:3 Design grid connected and standalone solar systems. **(BL6)**
CO:4 Explain the knowledge of different solar thermal applications. **(BL2)**
CO:5 Find the site-specific solar radiation profile and solar geometry related data. **(BL1)**

Course contents

UNIT- I : Solar Radiation and Geometry

Solar radiation: measurements and prediction; Solar energy conversion techniques to heat and electricity; Spectrum of electromagnetic radiation, sun structure and characteristics, extraterrestrial radiation, solar constant, air mass, beam, diffused and total solar radiation, spectral distribution; Heat transfer processes applicable to solar energy, solar radiation, and its analysis; Solar geometry covering all parameter related to the position of the sun with respect to observer; Instruments for measurement of solar energy (Pyranometer/pyrheliometer/ sunshine recorder/lux meter), solar radiation on the collector; Depletion of solar radiation - absorption, scattering; beam radiation, diffuse and Global radiation; measurement of solar radiation; solar time - local apparent time (LAT) and equation of time(E).

UNIT- II : SOLAR CELL AND MODULES

Photovoltaic effect - Principle of direct solar energy conversion into electricity in a solar cell. Semiconductor properties, energy levels, basic equations. Solar cell, p-n Junction, I-V characteristics of a PV module, maximum power point, cell efficiency, fill factor, effect of irradiation and temperature, solar Cell Parameters, Efficiency of Solar Cell, Solar PV Module, Rating of Solar PV Module, PV Module Parameters, Efficiency of PV Module, Measuring Module Parameters, Connection of PV Module in Series and Parallel, Estimation and Measurement of PV Module Power, Selection of PV Module

UNIT- III : PV SYSTEM DESIGN AND APPLICATION

Commercial solar cells - Production process of single crystalline silicon cells, multi crystalline silicon cells, amorphous silicon, cadmium telluride, copper indium gallium diselenide cells. Design of solar PV systems and cost estimation. Case study of design of solar PV lantern, stand-alone PV system - Home lighting and other appliances, solar water pumping systems, Classification - Central Power Station System, Distributed PV System, Standalone PV system, Grid Interactive PV System, small system for consumer applications, Hybrid solar PV system, Concentrator solar photovoltaic. System components

– PV arrays, inverters, batteries, charge controls, net power metres. PV array installation, operation, costs, reliability, Building-integrated photovoltaic units, grid -interacting central power stations, stand- alone devices for distributed power supply in remote and rural areas, solar cars, aircraft, space solar power satellites. Socio-economic and environmental merits of photovoltaic systems

UNIT- IV : SOLAR THERMAL

Principles of heat and mass transfer, Thermodynamics, Fluid static and dynamics, Electricity generation, distribution and use, Basic of Solar Thermal Conversion, Technology of Selective Coating, Solar collectors, efficiency and testing of flat plate collectors, solar water heater, solar passive heating and cooling system, Solar industrial heating system, solar refrigeration and air conditioning, solar cookers, solar furnaces, solar greenhouse, solar dryer, Solar distillation, Solar thermo mechanical systems. Fundamentals of solar collectors as devices to convert solar energy to heat. Non-concentrating low temperature flat-plate and evacuated tube collectors. Design and structures of collectors for heating liquids and air. Line-focusing and point-focusing concentrators: parabolic trough, parabolic dish, heliostat field with central receiver, Fresnel lenses, compound parabolic concentrator.Sun tracking mechanism, Application of non- collectors in low temperature solar thermal plants for space heating and cooling, drying, seawater desalination. Use of concentrating collectors for process heat production and power generation.

References:

1. S. A Kalogirou, Solar Energy Engineering: Process and Systems, Elsevier
2. S.P. Sukhatme and J. Nayak, Solar Energy: Principles of Thermal Collection and Storage, Third Edition, Tata McGraw Hill, 2008
3. C. S. Solanki Solar Photovoltaics – Fundamentals, Technologies and Applications, PHI Learning, 2011
4. J N Roy and D N Bose, Photovoltaic Science and Technology, Cambridge University Press (2018)
5. Gilbert M Master, Renewable and Efficient Electric Power System, IEEE Press

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	2	1	1	1	1	1	1
CO2	1	1	1	1	1	1	1
CO3	2	2	2	2	1	2	3
CO4	2	2	1	1	1	1	1
CO5	2	2	1	2	1	2	2
Avg	**1.8**	**1.6**	**1.2**	**1.6**	**1**	**1.4**	**1.6**

Course Code: PC-MRE 202	Subject: Renewable Energy III	L-T-P: 3-0-0	Credits: 3

Course Outcome

Students will be able to,

CO:1 Illustrate hydrogen production technologies with and without CO_2 production as a by-product. **(BL3)**

CO:2 Outline hydrogen storage and distribution technologies. **(BL2)**

CO:3 Explain basic electrochemical principles of the hydrogen fuel cells, basic fuel cell design concepts, fuel cell systems concepts. **(BL2)**

CO:4 Plan how fuel cells are used for everyday purposes: road, water and air transport vehicles, portable and stationary use. **(BL6)**

CO:5 Categorise different types of ocean and tidal resources. **(BL4)**

Course contents

UNIT:I Ocean and Tidal :

Ocean energy resources, ocean energy routes; principles of ocean thermal energy conversion systems; principles of ocean wave energy conversion and tidal energy conversion; Ocean power generation: tidal energy estimation, components of tidal power plant, wave area of determining energy, mathematical analysis of wave energy. Wave energy conversion machine. Working principle –OTEC, Anderson closed cycle OTEC system, thermoelectric OTEC

UNIT- II : Hydrogen and Production Techniques:

Hydrogen – physical and chemical properties, salient characteristics. Advantages of hydrogen as fuel, Production of hydrogen – steam reforming – water electrolysis – gasification and woody biomass conversion – biological hydrogen production – photo dissociation – direct thermal or catalytic splitting of water, Sea as a source of deuterium.

UNIT- III: Hydrogen Storage, Transport and Applications:

Hydrogen storage options – compressed gas – liquid hydrogen – Hydride – chemical Storage – comparisons, Hydrogen transport systems, hydrogen fuel internal combustion engine, safety measures, Applications of Hydrogen in fuel cell vehicles

UNIT- IV : Fuel Cells:

History – principle – working – thermodynamics and kinetics of fuel cell process – performance evaluation of fuel cell – comparison on battery Vs fuel cell, Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerits, Microbial fuel cells, biochemical fuel cell design, anode compartment, microbial cultures, redox mediators, cathode compartment, exchange membrane, basic power, power density and performance calculation. Waste water treatment effectiveness. Fuel cell usage for

domestic power systems, large scale power generation, automobiles, Space. Economic and environmental analysis on usage of Hydrogen and Fuel cells. Future trends in fuel cells.

References:

1. Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma (2005)
2. Bent Sorensen (Sørensen), Hydrogen and Fuel Cells: Emerging Technologies and Applications, Elsevier, UK (2005)
3. Kordesch, K and G.Simader, Fuel Cell and Their Applications, Wiley-Vch, Germany (1996).
4. Hart, A.B and G.J.Womack, Fuel Cells: Theory and Application, Prentice Hall, NewYork Ltd., London (1989)
5. Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA (2002).
6. Viswanathan, B and M AuliceScibioh, Fuel Cells – Principles and Applications, Universities Press (2006)
7. D.A.G.Rand and R.N.Dell, Hydrogen Energy-Challenges and Prospects, Royal Society of Chemistry Publication.
8. Kothari, Renewable Energy Sources and Emerging Technologies, PHI, Eastern Economy Edition,2012.
9. R.K.Rajpoot, Non-Conventional Energy Sources and Utilization, S.Chand Publication, New Delhi.

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	1	1	2	1	2	1	1
CO2	1	2	2	2	2	2	2
CO3	1	1	2	1	1	1	1
CO4	2	2	2	2	1	2	2
CO5	2	2	2	1	1	2	1
Avg	**1.4**	**1.6**	**2**	**1.4**	**1.4**	**1.6**	**1.4**

Course Code: PE-MRE 203/I	Subject: Materials and Devices for Energy Conversion and Storage	L-T-P: 3-0-0	Credits: 3

Course Outcome

The students will able to,

CO:1 Relate with the properties of different materials- metals and nonmetals ability. **(BL1)**

CO:2 Create photovoltaic material and its electronic properties for the solar energy application. **(BL6)**

CO:3 Predict the role of selection for the wind turbine material and its required properties. **(BL2)**

CO:4 Explain the concepts of advanced materials for solar cells. **(BL2)**

CO:5 Solve different material characteristics with various characterization instruments. **(BL3)**

Course contents

UNIT:I

Nanomaterial for renewable energy: Classification of nanomaterials –zero dimensional, one-dimensional, two-dimensional, three-dimensional; Synthesis of nanomaterials: Bottom up and top down approaches, colloidal method, chemical vapour deposition (CVD) methods, wet chemical methods, sol-gel synthesis, and mechanical exfoliation methods, physical vapour deposition (PVD), sputtering, plasma enhanced CVD (PECVD), hot wire CVD (HWCVD), Nano- structured materials with applications - quantum dots, nano-tubes, nano- wires, nano- crystals.

UNIT- II :

Materials for photovoltaic conversions, Si and non-Si materials, crystalline, semi crystalline, polycrystalline and amorphous materials; Nano, micro, and poly-crystalline Si for solar cells, mono-micro silicon composite structure; Technology for Si extraction, purification; Method of doping and junction fabrication; Cell fabrication and metallization techniques; Networking the PV cell; P-N junction, sources of losses and prevention, Concepts on high efficiency solar cells, tandem and multi-junction solar cells, photo-voltaic materials and photo-voltaic modules and their applications; Solar PV concentrator cells and systems, III- V, II-IV compound materials thin film solar cells.

UNIT- III:

Materials for wind turbines- blades, nacelles, and tower; Important properties of the blade, Metal and polymer-composite material for blade and tower; Rotor blade – properties and application; Erecting of the tower material, Support materials for wind tower, Corrosion issues; importance of nacelles in wind turbine and its component. Mechanical properties: flexural strength, bending moment, strength of material- yield strength, ultimate strength,

Young's modulus, Poisson's ratio, and fatigue; Universal testing machine (UTM); shear webs for wind turbine blades.

UNIT- IV :

Electronic and atomic structures of solar cell material; Atomic bonding in solids, crystal structure, microstructure, solidification, alloys; Description of optical and thermal materials for solar cell application. Material characterization: Scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD), Single crystal X-Ray diffraction, Ultraviolet visible spectroscopy, Raman spectroscopy, atomic force microscopy (AFM), and X-ray photoelectron spectroscopy (XPS); Pulse layer deposition (PLD), PV cell diode properties, PV cell series resistance, PV cell shunt resistance.

References:

1. William D. Callister, David G. Rethwisch, Materials Science and Engineering: An Introduction, Seventh Edition, John Wiley and Sons, 2007.
2. V. Raghavan, Materials Science and Engineering: A First Course, 5th Edition, Prentice Hall India, 2004.
3. B. S. Mitchell, An Introduction to Materials Engineering and Science for Chemical and Materials Engineers, John Wiley & Sons, 2004.
4. K.K. Chattopadhyay, A.N. Banerjee, An Introduction to Nanoscience and Nanotechnology, Prentice Hall India, 2009.
5. Charles P. Poole Jr. and Frank J. Owens, Introduction to Nanotechnology, John Wiley and Sons, 2008.
6. Guozhong Cao, Nanostructures and Nanomaterials-Synthesis Properties and Applications, Imperial College Press, 2004.
7. Anthony R. West, Solid State Chemistry and its Applications, 2nd Edition, John Wiley and Sons, 2014.
8. L.H.Van Black, Elements of Material Science and Engineering, Addison-Wesley, New York, 1989

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	3	2	3	3	2	2	2
CO2	3	3	2	2	3	3	2
CO3	2	1	2	2	2	1	3
CO4	2	2	1	2	2	2	2
Avg	**1.6**	**1.6**	**1.8**	**1.8**	**1.6**	**1.6**	**1.8**

Course Code: PE-MRE 203/II	Subject: Composite Materials for Energy Application	L-T-P: 3-0-0	Credits: 3

Course Outcome

The students will able to,

CO:1 Describe the behaviour of constituents in the composite materials. **(BL1)**
CO:2 Explain different types of reinforcement. **(BL2)**
CO:3 Use skills about different manufacturing methods of composite materials. **(BL3)**
CO:4 Create new applications of composite materials for energy applications. **(BL6)**
CO:5 Design new methodology to fabricate new composite materials. **(BL6)**

Course contents

UNIT:I

Definition, Classification and characteristics of Composite materials. Advantage and application of composites, Functional requirements of reinforcement and matrix phases, Effect of reinforcement (size,

UNIT- II :

Reinforcements: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kelvar fibers and Boron fibers, Al_2O_3, SiC Whiskers, Properties and applications of whiskers, particle reinforcements, Mechanical behaviour of composites: Rule of mixtures, Inverse rule of mixtures, Isostrain and Isostress conditions.

UNIT- III:

Metal Matrix Composites: Al_2O_3 fibre reinforced aluminium alloy, Solid state diffusion, sintering and hot isostatic pressing, Properties and applications. Manufacturing of Ceramic Matrix Composites, Preparation of Carbon-Carbon composites, Properties and applications.

UNIT- IV :

Polymer Matrix Composites: Preparation of Glass fibre reinforced polymer composites, Carbon fibre reinforced polymer composites, Aramid or Kelvar fibre reinforced polymer composites, Nano clay- polymer composite.

References:

1. R.W.Cahn, Material Science and Technology, VCH, West Germany
2. WD Callister Jr, Materials Science and Engineering, An introduction, John Wiley & Sons. NY, Indian edition, 2007
3. Kamal K. Kar, Composite Materials: Processing, Applications, Characterizations, Springer, 2016.
4. Pulickel M. Ajayan, Linda S. Schadler, Paul V. Braun, Nanocomposite Science and Technology, John Wiley & Sons, 2006.

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	3	2	3	3	2	2	2
CO2	3	3	2	1	3	2	3
CO3	2	2	2	2	1	1	3
CO4	1	2	2	2	2	2	2
Avg	**2.25**	**2.25**	**2.25**	**2**	**2**	**1.75**	**2.5**

Course Code: PE-MRE 203/III	Subject: Recent Advancement in Photovoltaics	L-T-P: 3-0-0	Credits: 3

Course Outcome

The students will able to-

CO:1 Describe knowledge of new materials for solar cells. **(BL1)**
CO:2 Outline different new solar cell structures. **(BL2)**
CO:3 Prioritise different process technologies of advanced solar cells. **(BL5)**
CO:4 Design new solar cell structures for efficiency improvement. **(BL6)**
CO:5 Use new and modern technologies in developing solar cells to design new methodology to fabricate new composite materials. **(BL3)**

Course contents

UNIT:I

Advanced Concepts: Fundamental limits on conversion efficiency, Shockley-Queisser theory, Multiple Junction solar cells, Quantum dot solar cells, Intermediate band solar cells, Photon splitting and multi-application High efficiency c-Si solar cells, losses in solar cells; optical, electrical, ways to overcome the losses, concept of selective emitter, N-type and P-type cells, alternative surface recombination, alternative metallization, novel cell structures, metal wrap through cells, point contacts, buried contact cell, PERL cell, HIT cells, Thin film silicon cells

UNIT- II :

Concepts of thin film, thin film deposition techniques, CVD, PECVD, sputtering, Physics of amorphous and nano-crystalline Si and alloys transport properties, Defect density and recombination, Structural considerations, Optical properties, Staebler-Wronski effect, Single and multi-junction solar cells, Deposition and manufacturing techniques, From cell to module, Advanced Thin film solar cells (CdTe, CIGS), Electrical and optical properties of materials, solar cell structure, principle of operation, material deposition techniques, cell performance, Multi-junction III-V solar cells.

UNIT- III:

Introduction to III-V Compound semiconductors and Hetero- structures, Single junction III-V cell: Design considerations, Tandem cells: Design considerations, Characterization of multi- junction solar cells: special, requirements, Multi-junction Concentrator solar cells, synthesis techniques, pseudomorphic structures, Organic Solar cells, Physics of organic semiconductors, Transport properties Photo- conduction and Luminescence Defects, Hetero- junction solar cells, Small molecule and polymer cells, Physics of degradation of organic cells, Fabrication techniques and manufacturing Sensitized solar cells.

UNIT- IV :

Basic photoelectron chemistry, double layer concept, Band bending to flat, band transformation, semiconductor-liquid junction, charge and ion, transport, band bending/flat/slant in nanocrystalline materials, diffusion and ballistic transport, hot electron, photoelectrochemical solar cell, effect of electrolyte, Dye sensitized, solar cell, Charge transport mechanism, Characterization techniques, (Carrier lifetime, microwave conductivity, Kelvin probe SPV/CPD etc.), Solid state DSSC - problems and solutions, Semiconductor sensitized solar cells - advantages and disadvantages, solid state hole conductor, Nano- porous oxide semiconductor

References:

1. C. S. Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications, Prentice Hall of India,2011

2. H. J. Moller, Seminconductors for solar cells, Artech House Inc, MA, USA,1993

3. Sydney, M. Green, Silicon solar cells: advanced principles and practice, Bridge Printery,1995.

4. Barbec, V.Dyakonov, J.Parisi, N.S.Saricittci,, Organic photovoltaics: Concepts and realization, Springer-Verlag 2003

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	3	2	3	3	2	2	2
CO2	3	3	2	2	3	2	3
CO3	2	2	3	2	2	3	3
CO4	2	1	2	2	2	2	2
Avg	**2.5**	**2**	**2.5**	**2.25**	**2.25**	**2.25**	**2.5**

Course Code: PE-MRE 204/I	Subject: Distributed Generation and Smart Grid	L-T-P: 3-0-0	Credits: 3

Course Outcome

Students will be able to,

CO:1 Illustrate about different types of distributed generations. **(BL3)**
CO:2 Identify strategy, protection schemes, features of micro grid and smart grid. **(BL4)**
CO:3 Design modern microgrid systems. **(BL6)**
CO:4 Rate different components used in microgrids. **(BL5)**

Course contents

UNIT- I :

Need for Distributed generation, Renewable sources in distributed generation, Current scenario in Distributed Generation, Planning of DGs, Sitting and sizing of DGs optimal placement of DG sources in distribution systems, Grid integration of DGs

UNIT- II :

Technical impacts of DGs, Transmission systems Distribution systems De-regulation Impact of DGs upon protective relaying, Impact of DGs upon transient and dynamic stability of existing, distribution systems, Steady-state and Dynamic analysis, Economic and control aspects of DGs Market facts, issues and challenges Limitations of DGs, Voltage control techniques, Reactive power control, Harmonics Power quality issues, Reliability of DG based systems.

UNIT- III :

Introduction to micro-grids, Types of micro-grids: autonomous and non-autonomous grids Sizing of micro-grids, Modelling & analysis of Micro-grids with multiple DGs, Micro-grids with power electronic interfacing units, Transients in micro-grids, Protection of micro-grids, Case studies, Advanced topics

UNIT- IV :

Introduction to Smart Grid, Evolution of Electric Grid, Model Curriculum of Engineering & Technology PG Courses, Concept of Smart Grid, Definitions, Need of Smart Grid, Concept of Robust & Self Healing Grid, Present development & International policies in Smart Grid, Introduction to Smart Meters, Real Time Prizing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network(NAN).

References:

1. Ali Keyhani, Design of smart power grid renewable energy systems, Wiley, IEEE,2011.
2. Clark W. Gellings, The Smart Grid: Enabling Energy Efficiency and Demand Response, CRC Press ,2009
3. Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Smart Grid: Technology and Applications Wiley, 2012.
4. Kalpana Chauhan, Rajeev Kumar Chauhan, Distributed Energy Resources in Microgrids-Integration, Challenges and Optimization, Elsevier Science, 2019

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	1	2	2	1	1	1	1
CO2	2	2	1	1	1	1	2
CO3	2	2	2	2	1	2	2
CO4	1	2	1	1	1	1	1
Avg	**1.2**	**2**	**1.5**	**1.25**	**1**	**1.25**	**1.5**

Course Code: PE-MRE 204/II	Subject: Energy Distribution Systems and Automation	L-T-P: 3-0-0	Credits: 3

Course Outcome

Students will be able to-

CO:1 Compare the characteristics of distribution systems from transmission systems. **(BL4)**

CO:2 Outline distribution system based on forecasted data. **(BL2)**

CO:3 Identify and select appropriate sub–station location. **(BL4)**

CO:4 Design and evaluate a distribution system for a given geographical service area from alternate design alternatives. **(BL6)**

Course contents

Unit: I

Planning and forecasting techniques – Present and future – Role of computers- Load Characteristics- Load forecasting using ANN – Load management – tariffs and metering of energy.

Unit: II

Types – Three phase and single phase transformers – connections – causes and types of failures in distribution transformers, Distribution substations –Bus schemes –comparison of switching schemes- Substation location and rating- Types of feeders – voltage levels, Three phase primary lines – Copper loss – Distribution feeder costs – Loss reduction and Voltage improvement in rural networks

Unit: III

Reforms in power sector – Methods of improvement – Reconfiguration –Automation – Communication systems – Sensors –Basic architecture of Distribution automation system – software and open architecture – RTU and Data communication – SCADA requirement and application functions – Communication media for distribution system automation- Communication protocols for Distribution systems – IEC 61850 and IEEE 802.3 standards.

Unit: IV

Integrated sub–station metering system – Revenue improvement – issues in multi–year tariff and availability based tariff.

References:

1. Turan Gonen : Electric Power Distribution Engg., Mc-Graw Hill,1986.
2. James A Momoh: Electric Power Distribution, Automation, Protection and Control, CRC press.
3. A. S. PABLA : Electric Power Distribution, TMH, 2000
4. Juan Manuel Gers, Distribution Systems Analysis and Automation, Institution of Engineering and Technology, 2020.

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	1	2	1	1	1	1	1
CO2	2	2	2	1	1	2	1
CO3	1	2	1	1	1	1	1
CO4	2	2	1	1	1	2	2
Avg	**1.5**	**2**	**125**	**1**	**1**	**1.5**	**1.25**

Course Code: PE-MRE 204/III	Subject: Green Environment and Sustainability	L-T-P: 3-0-0	Credits: 3

Course Outcome

Students will be able to,

CO:1 Relate interaction between distinct systems, in the physical and natural world. **(BL1)**
CO:2 Describe sustainability and assess the ways that sustainability topics are approached by a diversity of academic disciplines. **(BL1)**
CO:3 Identify how globalised processes impact socio ecological systems. **(BL4)**
CO: 4 Imagine critical thinking skills to provide sustainable solutions and build resilient communities. **(BL6)**

Course contents

Unit: I

Climate Change Mitigation: Way and means, Concept of Carbon Sequestration, Carbon Sequestration projects, Carbon Sequestration Modalities and Procedures Global Carbon Cycle: Stocks and Fluxes of Carbon in terrestrial and marine ecosystems and anthropogenic impact. Policy Perspective: UNFCC, Role and Function of IPCC, Kyoto Protocol and its implication on Developed and developing countries, function of Kyoto Protocol.

Unit: II

Clean Development Mechanism (CDM) and its operation, modalities and procedures for CDM Project Forestry Perspective: Source or Sink of Carbon, Measuring of Carbon Dioxide
The Climate Mitigation potential of Forest and its evaluation, Land use, Land use Change and Forestry (LULUCF), Evolution of LULUCF in CDM. Emissions trading of clean development mechanism (CDM), Difficulties with the CDM, Financial issues with the CDM, prototype carbon funds (PCF), Carbon Credits and it's trading, carbon finance, and evaluation of Carbon Credit of solar energy Systems, Emissions trading under different article, Carbon footprints.

Unit: III

Introduction, need and concept, challenges of sustainable development, environmental acts and protocols, Global, regional and local environmental issues, Natural resources and their pollution, Global warming, climate change, Environmental Management Standards, ISO-14000 series, life cycle analysis, scope and goal, biomimicking, environmental legislation in India, wastewater treatment. Green Building, Green materials for building construction, management of waste, management of silage and sewage water, thermal comfort in buildings, green building certifications, sustainable transport, industrial ecology.

Unit: IV

Impacts of large scale exploitation of energy on ecosystem, land use etc. Concept of Sustainable city, Urban Planning, social responsibility, International Treaties and conventions, International Trade in Danger and Species, Bio-Diversity, Trans boundary movement of hazardous wastes, Climate Change.

References:

1. Hester R E and Harrison R M, Carbon Capture: Sequestration and Storage (Issues in Environmental Science and Technology)
2. Wilson Elizabeth and Gerard David, Carbon Capture and Sequestration Integrating Technology, Monitoring, Regulation.
3. Faure Michael, Gupta Joyeeta, Andries and Nentjes, Climate Change and the Kyoto Protocol: The Role of Institutions and Instruments to Control Global Change.
4. Bayon Ricardo, Hawn Amanda, Hamilton Katherine, Voluntary Carbon Markets.

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	1	1	1	1	2	1	1
CO2	2	1	2	1	2	2	1
CO3	2	1	1	2	2	1	1
CO4	2	1	1	2	1	1	1
Avg	**1.75**	**1**	**1.25**	**1.5**	**1.75**	**1.25**	**1**

Course Code: PC-MRE 291	Subject: Renewable Energy Lab II	L-T-P: 0-0-4	Credits: 2

Course Outcome

Students will be able to,

CO:1 Find the data collection procedure for measuring solar radiation by Solar Pyranometer. **(BL1**)

CO:2 Explain the working of a Box Type Cooker. **(BL2)**

CO:3 Illustrate performance analysis of different modes of solar panels. **(BL3)**

CO:4 Complete the performance test of a solar pump. **(BL3)**

Practical:

List of Practical:

1. Study of solar radiation by Pyranometer.
2. Thermal Performance evaluation of box type solar cooker.
3. Performance evaluation and comparative study of different types of solar panel at fixed radiation.
4. Performance of PV panels in series and parallel.
5. Charging characteristics of battery with PV panel.
6. Study the effect of tilt angle on PV panels.
7. Study the effect of shadow on PV panels.
8. Study the effect of temperature on PV panels.
9. Performance evaluation of solar pump

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	2	2	1	1	2	2	1
CO2	2	2	1	1	1	1	1
CO3	1	2	2	1	1	2	1
CO4	1	2	1	1	1	2	1
Avg	**1.5**	**2**	**1.25**	**1**	**1.25**	**1.75**	**1**

Course Code: PC-MRE 292	Subject: Renewable Energy Lab III	L-T-P: 0-0-4	Credits: 2

Course Outcome

Students will be able to,

CO:1 Describe the working of an electrolyzer. **(BL1)**

CO:2 Find different performance parameters of electrolyzer. **(BL1)**

CO:3 Justify different laws related to electrolyzer and fuel cells. **(BL5)**

CO:4 Complete the efficiency test of a fuel cell. **(BL3)**

Practical:

List of Practical:

- Determination of Characteristic Curve of the Electrolyser.
- Calculation of Faraday Efficiency and Energy Efficiency of the Electrolyser.
- Characteristic Curves of the Fuel Cell connected in parallel and in series.
- Evaluation of Faraday Efficiency and Energy Efficiency of the Fuel Cell.
- Verification of Faraday's 1st Law using a Fuel Cell.

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	1	1	2	2	1	1	1
CO2	2	2	2	2	2	2	1
CO3	2	1	2	2	1	2	1
CO4	1	2	1	1	1	1	1
Avg	**1.5**	**1.5**	**1.75**	**1.75**	**1.25**	**1.5**	**1**

Course Code: PW-MRE 281	Subject: Minor Project on Designing of Renewable Energy Systems with Seminar	L-T-P: 0-0-4	Credits: 2

Course Outcome

Students will be able to,

CO:1 Design simulation techniques related to renewable energy. **(BL6)**

CO:2 Outline presentations for seminars. **(BL2)**

CO:3 Use skills and confidence for lecture delivery before a crowd. **(BL3)**

Overview:

In this sessional paper students have to model and design different systems related to renewable energy using software like PVSol, Homer, MATLAB, COMSOL etc. and submit project report. Evaluation of this paper will be done with respect to merit of project report and presentation.

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	2	1	1	2	2	2	2
CO2	2	1	2	2	1	1	1
CO3	1	1	1	2	1	1	1
Avg	**1.66**	**1**	**1.33**	**2**	**1.33**	**1.33**	**1.33**

Third Semester

Course Code: PE-MRE 301/I	Subject: Renewable Energy Management, Cost Analysis and Audit	L-T-P: 3-0-0	Credits: 3

Course Outcome

The students will be able to,

CO:1 Plan energy usage strategy with energy requirements and optimize input energy requirements. **(BL6)**

CO:2 Complete specific questionnaires and perform special tests for gathering data about energy usage for a particular energy system. **(BL3)**

CO:3 Identify the technologies pertaining to sustainable and renewable energy application. **(BL4)**

CO:4 Design energy efficient technologies for industries. **(BL6)**

CO:5 Illustrate the energy audit methodologies in regular practice of the industries. **(BL6)**

Course contents

UNIT- I:

A brief on green-house effect; Kyoto Protocol, Clean Development Mechanism (CDM); Afforestation and Reforestation projects, Reduced Emissions from Deforestation and Degradation (REDD); Life cycle analysis of CCS technologies; Pre and Post combustion capture; CO_2 trapping mechanism and geological storage; CO_2 fluid properties and interaction with rocks; Wettability, capillary pressure and relative permeability

UNIT- II :

Energy Audit, types of energy audit; Energy Audit approach: optimizing the input energy requirement; Energy audit instruments. Energy Management: Concept of energy management, energy demand and supply, economic analysis; Duties and responsibilities of energy managers, Energy conservation Act. Energy Conservation: Energy conservation in Household, Transportation, Agricultural, service and Industrial sectors

UNIT- III :

Concepts of Green Building, Energy Conservation Building Code (ECBC), Framed Construction, Masonry Construction, Fenestration and glazings, Resources for Building Materials, Alternative concepts, Green Composites for buildings: Concepts of Green Composites. Water Utilization in Buildings, Low Energy Approaches to Water Management. Rain water harvesting, Management of Solid Wastes, Management of Sullage Water and Sewage. Mosquito nuisances and its removal, Urban Environment and Green Buildings.

UNIT- IV :

Comfort in Green Building, Solar passive Architecture, Thermal Comfort in Buildings, Issues, Incidence of Solar Heat on Buildings- Implications of Geographical Locations, Concepts of Solar Passive Cooling and Heating of Buildings, Low Energy Cooling, Natural ventilation and Louvre system; Utility of Solar energy in buildings, Solar Panel on windows and roof, Applications of Illumination engineering, Use of LED, Case studies of Solar Passive Cooled and Heated Buildings. Approaches for Certification of Green Building.

References:

1. Stephen A.Rackley, Carbon Capture and Storage, 1st edition, Butterworth- Heinemann,2010.
2. Ursula Eicker, Low Energy Cooling For Sustainable Buildings, John Wiley and Sons Ltd, 2009.
3. C.B. Smith, Energy Management Principles, Pergamon Press
4. Yogi Goswami, Frank Kreith, Energy Efficiency and Renewable Energy Handbook, CRC Press, 2015.

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	1	3	2	1	2	2	1
CO2	2	2	2	1	2	2	1
CO3	1	3	2	1	2	1	1
CO4	2	3	2	2	1	2	2
CO5	2	3	1	1	1	1	1
Avg	**1.6**	**2.8**	**1.8**	**1.2**	**1.6**	**1.6**	**1.2**

Course Code: PE-MRE 301/II	Subject: Energy Policy and Regulatory Compliances	L-T-P: 3-0-0	Credits: 2

Course Outcome

Students will be able to,

CO:1 Identify the overall policy, regulatory and institutional framework on Renewable Energy. **(BL4)**

CO:2 Relate the main drivers that influence Renewable Energy policy formulation. **(BL1)**

CO:3 Identify different energy regulatory authorities across the globe. **(BL4)**

CO:4 Plan different projects according to the policies and regulations. **(BL6)**

CO:5 Decide new policies and regulation regarding renewable energy. **(BL5)**

Course contents

UNIT- I :

Introduction to overall policy environment on energy sector, policy formulation such as – per capita electricity Consumption, % electrification, GDP, total installed capacity, generation mix and the overall power sector structure, Entities – Consumers and their tariffs, generator, DISCOM, Regulators- Central Electricity Regulatory Commissions (CERC) & State Electricity Regulatory Commissions (SERC), Statutory bodies, SLDC, RLDC, NLDC, CTU, STU, CEA. Typical issues of Indian power sector – Cross Subsidization, Theft of electricity, Transmission losses etc

UNIT- II :

An Introduction to Indian Renewable Energy Policy, National Solar Missions, Wind Power, National Wind-Solar hybrid policy by MNRE; Regulatory Commissions, Grid Code, Green Corridor, Solar Parks, Hybrid Parks, Repowering, Offshore, Scheduling and Forecasting, Electricity Trading, Open Access, RPO Distributed Generation Regional Grid in the South Asian Region; Electrification and off grid status/scenario in India; Scenario evolving with competitive bidding. National Action Plan on climate Change.

UNIT- III :

Scope and challenges in implementing off grid solutions, Policy & regulatory Framework for rural electrification, Micro and Mini grids; Relevant policies and frameworks in other countries; Recent off grid programs, Govt. of India for enhancing the rural electrification through off-grid solutions; Decentralized Distributed Generation (DDG) scheme under Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY); Remote Village Electrification Program Village Energy Security Programme (VESP) Off grid programme under Jawaharlal Nehru National Solar Mission (JNNSM)

UNIT- IV :

International regulation of renewable energy; the role of international law and economics

in renewable power; Sustainable Energy for All (SE4ALL) Mission; Renewable energy and international trade law; A case study with the first Biogas Bottling Plant towards commercialization by Bio-energy Technology Development Group- BGFP; A case study with the 5MW solar project in Anantapura, AP, India highlighting the impact on local environment and related policy making.

References:

1. Dirk Abmann, Renewable Energy: A Global Review of Technologies, Policies and Markets Earthscan Publications, UK, 2007
2. Stellina Jolly, Amit Jain Climate Change: Changing Dimensions of Law and Policy, M D Publications Pvt. Ltd, India, 2009
3. Henrik Lund, Renewable Energy Systems: A Smart Energy Systems Approach to the Choice and Modelling of 100% Renewable Solutions , Academic Press, USA, 2014
4. Lawrence E. Jones, Renewable Energy Integration: Practical Management of Variability, Uncertainty, and Flexibility in Power Grids, Academic Press, USA, 2017

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	1	2	2	1	2	2	1
CO2	1	2	2	1	2	1	1
CO3	2	2	2	1	1	2	1
CO4	2	3	2	1	2	2	2
CO5	1	2	2	1	2	2	1
Avg	**1.4**	**2.2**	**2**	**1**	**1.8**	**1.8**	**1.6**

Course Code: PE-MRE 301/III	Subject: Environmental Impact and Risk Assessment	L-T-P: 3-0-0	Credits: 3

Course Outcome

Students will be able to,

CO:1 Identify the Basics of Environmental Engineering Principles needed for carrying out EIA. **(BL4)**

CO:2 Outline different technologies and Legislations/Rules. **(BL2)**

CO:3 Complete EIA Studies. **(BL3)**

CO:4 Justify the remedial measures needed to be taken for improvement. **(BL5)**

Course contents

UNIT- I :

Basics of environmental problems associated with Renewable Energy Engineering Sustainable technology and Renewable Energy Engineering, Genesis of environmental statutory body in India (Water act 1974). Legislative aspects, Environmental clearance for Renewable Energy Industries—Consent to Establish, Consent to Operate. Environmental standards and Threshold limits, EPA 1986.Air pollution aspects from conventional power plants, Sampling and analysis of air pollutants, Greenhouse effect and global warming, Carbon footprint, general discussion on its reduction by the use of renewable energy devices.

UNIT- II :

Problems of water pollution in renewable energy industries. Effluent treatment plant, trickling filter, RBDC and RBRC, oxidation ditches, WSP, Root zone and Reed bed treatments .Combined Sewage & Effluent treatment plant along with canteen waste for bio-gas generation.

UNIT- III :

Solid waste & E-waste management in Renewable Energy Industries: Sources and classification, public health aspects, Methods of collection and disposal methods. Recycling and reuse of components of renewable energy devices. Hazardous aspects associated with solar PV, Solar thermal, Hydro-power, Nuclear Power, Wind mill, OTEC, Geothermal energy, Bio-energy –case studies.

UNIT- IV :

Environmental Impact Assessment for renewable energy industries– Rain water harvesting, structural hazards, hazards associated with illumination engineering – CFL versus LED lights. Energy analysis and energy efficiency compliances. Case studies on use of renewable energy devices for reducing carbon footprint- Analysis of energy saving using solar PV and hybrid system—desalination, hot water production, sewage treatment in vehicular system, solar passive architecture and green building. Carbon trading, sequestration and carbon credit.

References:

1. Tiwari, G N & Ghosal, M K, Renewable Energy Resources—Basic Principles and Applications, Narosa Publishing House, New Delhi, 2006
2. APHA & AWWA Standard Methods
3. CPHEEO Manual 2015, GOI Publications
4. Charles H. Eccleston, Environmental Impact Assessment-A Guide to Best Professional Practices, CRC Press, 2011

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	2	1	2	1	2	1	1
CO2	2	2	2	2	2	2	1
CO3	1	2	2	1	1	1	1
CO4	2	1	2	2	1	1	1
Avg	**1.4**	**1.2**	**2**	**1.2**	**1.2**	**1**	**1**

Course Code: OE-MRE 302/I	Subject: Artificial Intelligence and Machine Learning	L-T-P: 3-0-0	Credits: 3

Course Outcome

The students will able to,

CO:1 Describe different methods and techniques of Artificial Intelligence. **(BL1)**
CO:2 Illustrate different application areas of Artificial Intelligence. **(BL3)**
CO:3 Identify the areas of renewable energy where AI can be implemented. **(BL4)**
CO:4 Use AI technology for upgradation of existing renewable energy systems. **(BL3)**

Course contents

UNIT- I :

What is AI (Artificial Intelligence)? : The AI Problems, The Underlying Assumption, What are AI Techniques, The Level Of The Model, Criteria For Success, Some General References, One Final Word Problems, State Space Search & Heuristic Search Techniques: Defining The Problems As A State Space Search, Production Systems, Production Characteristics, Production System Characteristics, And Issues In The Design Of Search Programs, Additional Problems. Generate And-Test, Hill Climbing, Best-First Search, Problem Reduction, Constraint Satisfaction, Means Ends Analysis

UNIT- II :

Knowledge Representation Issues: Representations And Mappings, Approaches To Knowledge Representation. Using Predicate Logic: Representation Simple Facts In Logic, Representing Instance And Isa Relationships, Computable Functions And Predicates, Resolution. Representing Knowledge Using Rules: Procedural Versus Declarative Knowledge, Logic Programming, Forward Versus Backward Reasoning.

UNIT- III :

Symbolic Reasoning Under Uncertainty: Introduction To No monotonic Reasoning, Logics For Non-monotonic Reasoning. Statistical Reasoning: Probability And Bays' Theorem, Certainty Model Curriculum of Engineering & Technology PG Courses [Volume -II] 289 Factors And Rule-Base Systems, Bayesian Networks, Dempster Shafer Theory

Fuzzy Logic. Weak Slot-and-Filler Structures: Semantic Nets, Frames. Strong Slot-and-Filler Structures: Conceptual Dependency, Scripts, CYC

UNIT- IV :

Game Playing: Overview, And Example Domain: Overview, Mini-Max, Alpha-Beta Cut-off, Refinements, Iterative deepening, The Blocks World, Components Of A Planning System, Goal Stack Planning, Nonlinear Planning Using Constraint Posting, Hierarchical

Planning, Reactive Systems, Other Planning Techniques. Understanding: What is understanding? What makes it hard? As constraint satisfaction
Natural Language Processing: Introduction, Syntactic Processing, Semantic Analysis, Semantic Analysis, Discourse And Pragmatic Processing, Spell Checking Connectionist Models: Introduction: Hopfield Network, Learning In Neural Network, Application Of Neural Networks, Recurrent Networks, Distributed Representations, Connectionist AI And Symbolic AI.

References:

1. Elaine Rich and Kevin Knight, Artificial Intelligence, Tata Mcgraw- Hill, 2005
2. Stuart Russel and Peter Norvig, Artificial Intelligence: A Modern Approach, Prentice Hall, 2009.
3. Ethem Alpaydin, Introduction to Machine Learning, MIT Press, 2020.
4. Jaime Guillermo Carbonell, Tom Michael Mitchell, Machine Learning-An Artificial Intelligence Approach, Morgan Kaufmann, 1990.

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	1	1	1	1	1	1	1
CO2	1	1	1	1	1	1	1
CO3	2	2	1	1	2	1	2
CO4	1	2	2	1	2	1	2
Avg	**1.25**	**1.5**	**1.25**	**1**	**1.5**	**1**	**1.5**

Course Code: OE-MRE 302/II	Subject: IoT and Smart Sensors	L-T-P: 3-0-0	Credits: 3

Course Outcome

The students will able to,

CO:1 Explain concepts on new internet based technology for modern society. **(BL2)**
CO:2 Identify different smart sensors useful for renewable energy application. **(BL4)**
CO:3 Design IoT based systems for renewable energy. **(BL6)**
CO:4 Solve existing problems of renewable energy systems through IoT. **(BL3)**

Course contents

UNIT- I :

The Internet of Things Today, Time for Convergence, Towards the IoT Universe, Internet of Things Vision, IoT Strategic Research and Innovation Directions, IoT Applications, Future Internet Technologies, Infrastructure, Networks and Communication, Processes, Data Management, Security, Privacy & Trust, Device Level Energy Issues, IoT Related Standardization, Recommendations on Research Topics.

UNIT- II :

IoT Applications for Value Creations Introduction, IoT applications for industry: Future Factory Concepts, Brownfield IoT, Smart Objects, Smart Applications, Four Aspects in your Business to Master IoT, Value Creation from Big Data and Serialization, IoT for Retailing Industry, IoT For Oil and Gas Industry, Opinions on IoT Application and Value for Industry, Home Management, e-Health

UNIT- III :

Sensors: Working Principles: Different types; Selection of Sensors for Practical Applications Introduction of Different Types of Sensors such as Capacitive, Resistive, Surface Acoustic Wave for Temperature, Pressure, Humidity, Toxic Gas etc , Important Characteristics of Sensors: Determination of the Characteristics Fractional order element: Constant Phase Impedance for sensing applications such as humidity, water quality, milk quality Impedance Spectroscopy: Equivalent circuit of Sensors and Modelling of Sensors Importance and Adoption of Smart Sensors

UNIT- IV :

Architecture of Smart Sensors: Important components, their features Fabrication of Sensor and Smart Sensor: Electrode fabrication: Screen printing, Photolithography, Electroplating Sensing film deposition: Physical and chemical Vapor, Anodization.
Interface Electronic Circuit for Smart Sensors and Challenges for Interfacing the Smart Sensor, Usefulness of Silicon Technology in Smart Sensor And Future scope of research in smart sensor Recent trends in smart sensor for day to day life, evolving sensors and their architecture

References:

1. Yasuura, H., Kyung, C.-M., Liu, Y., Lin, Y.- L, Smart Sensors at the IoT Frontier, Springer International Publishing
2. Vijay Madisetti and Arshdeep Bahga, Internet of Things (A Hands-on-Approach) VPT, 2014.
3. Cuno Pfister, Getting Started with the Internet of Things, OReilly Media,2011
4. Subhas Chandra Mukhopadhyay, Smart Sensors and Sensing Technology, Springer Berlin Heidelberg, 2008.

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	1	1	2	1	2	1	1
CO2	1	2	1	1	2	1	2
CO3	2	1	2	1	1	2	3
CO4	2	1	1	1	1	2	1
Avg	**1.5**	**1.25**	**1.5**	**1**	**1.5**	**1.5**	**1.4**

Course Code: OE-MRE 302/III	Subject: Data Analytics	L-T-P: 3-0-0	Credits: 3

Course Outcome

The students will able to,

CO:1 Describe the fundamentals of Big cloud and data architectures. **(BL1)**

CO:2 Explain HDFS file structure and Mapreduce frameworks, and use them to solve complex problems, which require massive computation power. **(BL2)**

CO:3 Use relational data in a Hadoop environment, using Hive and Hbase tools of the Hadoop Ecosystem. **(BL3)**

CO:4 Solve different data handling problems of renewable energy. **(BL3)**

Course contents

UNIT- I :

What is big data, why big data, convergence of key trends, unstructured data, industry examples of big data, web analytics, big data and marketing, fraud and big data, risk and big data, credit risk management, big data and algorithmic trading, big data and healthcare, big data in medicine, advertising and big data, big data technologies, introduction to Hadoop, open source technologies, cloud and big data, mobile business intelligence, Crowd sourcing analytics, inter and trans firewall analytics.

UNIT- II :

Introduction to NoSQL, aggregate data models, aggregates, key-value and document data models, relationships, graph databases, schema less databases, materialized views, distribution models, sharding, master-slave replication, peer- peer replication, sharding and replication, consistency, relaxing consistency, version stamps, map-reduce, partitioning and combining, composing map-reduce calculations.

UNIT- III :

Data format, analyzing data with Hadoop, scaling out, Hadoop streaming, Hadoop pipes, design of Hadoop distributed file system (HDFS), HDFS concepts, Java interface, data flow, Hadoop I/O, data integrity, compression, serialization, Avro, file-based data structures

UNIT- IV :

MapReduce workflows, unit tests with MR Unit, test data and local tests, anatomy of MapReduce job run, classic Map- reduce, YARN, failures in classic Map- reduce and YARN, job scheduling, shuffle and sort, task execution, MapReduce types, input formats, output formats, Hbase, data model and implementations, Hbase clients, Hbase examples, praxis. Cassandra, Cassandra data model, Cassandra examples, Cassandra clients, Hadoop integration. Pig, Grunt, pig data model, Pig Latin, developing and testing Pig Latin scripts.

Hive, data types and file formats, HiveQL data definition, HiveQL data manipulation, HiveQL queries.

References:

1. Michael Minelli, Michelle Chambers, and Ambiga Dhiraj, Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses, Wiley.
2. Tom White "Hadoop: The Definitive Guide" Third Edition O'Reilley.
3. Amit Kumar Tyagi, Data Science and Data Analytics-Opportunities and Challenges, CRC Press, 2021.
4. João Moreira, Andre Carvalho, André Carlos Ponce de Leon Ferreira Carvalho, Tomas Horvath, A General Introduction to Data Analytics, Wiley, 2018

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	1	1	1	1	1	1	2
CO2	2	2	1	1	2	2	2
CO3	1	1	2	2	2	1	1
CO4	1	1	2	1	2	2	1
Avg	**1.25**	**1.25**	**1.5**	**1.25**	**1.75**	**1.5**	**1.5**

Course Code: PW-MRE 381	Subject: Dissertation-I (Initiation and Progression)	L-T-P: 0-0-20	Credits: 10

Course Outcome

Students will be able to,
CO:1 Outline the basics of research. **(BL2)**
CO:2 Identify research problems. **(BL4)**
CO:3 Complete literature review. **(BL3)**

Overview:

Each student must carry out industrial training/internship/project in a reputed renewable energy based industry/research institute. Each student shall be required under the supervision of a faculty/ joint supervision of a faculty and an external expert to prepare an interim project work after carrying out investigation on an industrial research problem. The research work has to be carried out by the student himself, occasionally consulting his supervisor(s). The work has to be allotted to the student at the beginning of the 3rd semester. The interim report in duplicate has to be submitted in typed and bound form 7 days before commencement of the 3rd semester examination. Assessment would be made on the basis of the submitted report and the viva-voce examination conducted by a board of examiners constituted by the Departmental Academic Committee consisting of two faculty members and the supervisor and an external examiner with Head of the Department as Chairman during 3rd Semester examination.

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	2	1	1	3	1	2	2
CO2	2	1	2	3	2	1	2
CO3	2	2	2	3	1	1	1
Avg	**2**	**1.33**	**1.66**	**3**	**1.33**	**1.33**	**1.66**

Fourth Semester

Course Code: PW-MRE 481	Subject: Dissertation-II (Completion)	L-T-P: 0-0-32	Credits: 16

Course Outcome

Students will be able to,

CO:1 Plan intense research activity. **(BL6)**

CO:2 Illustrate data collected from the research results. **(BL3)**

CO:3 Create detailed reports on research. **(BL6)**

CO:4 Use modern techniques for modern research activities. **(BL3)**

Overview:

Each student shall be required to complete the research work that has been assigned to him at the beginning of 3rd semester under the supervision of a faculty / joint supervision of a faculty and an external expert. The research work has to be carried out by the student himself occasionally consulting his supervisor(s). The report in duplicate has to be submitted in typed and bound form 7 days before the commencement of the 4^{th} semester examination. Assessment would be made on the basis of the submitted report and seminar presentation followed by viva-voce examination conducted by a board of examiners constituted by the Departmental Academic Committee consisting of at least two faculty members, supervisor and an external examiner with Head of the Department as Chairman during 4^{th} Semester examination.

CO/PO Mapping

(3/2/1 indicates strength of correlation) 3-Strong, 2-Medium, 1-Low

	Program Outcomes (POs)						
COs	PO1	PO2	PO3	PO4	PSO 1	PSO 2	PSO 3
CO1	2	1	2	3	2	1	1
CO2	2	1	2	3	1	2	1
CO3	2	1	2	3	2	2	2
CO4	2	1	2	3	2	1	2
Avg	**2**	**1**	**2**	**3**	**1.75**	**1.5**	**1.5**

Audit Courses

Course Code: AC-MRE106/I	Subject: Value Education	L-T-P: 3-0-0	Credits: 0

Course Outcome

The students will able to,

CO:1 Gather knowledge on self-development.

CO:2 Learn the importance of Human ethics.

CO:3 Develop the overall personality towards a good human being.

Course contents

UNIT- I :

Values and self-development- Social values and individual attitudes, Work ethics, Indian vision of humanism, Moral and non- moral valuation. Standards and principles, Value judgments

UNIT- II :

Importance of cultivation of values, Sense of duty, Devotion, Self-reliance. Confidence, Concentration, Truthfulness, Cleanliness, Honesty, Humanity. Power of faith, National Unity, Patriotism. Love for nature, Discipline

UNIT- III :

Personality and Behaviour Development- Soul and Scientific attitude. Positive Thinking. Integrity and discipline, Punctuality, Love and Kindness, Avoid fault Thinking, Free from anger, Dignity of labour, Universal brotherhood and religious tolerance, True friendship, Happiness Vs suffering, love for truth, Aware of self-destructive habits, Association and Cooperation, Doing best for saving nature

UNIT- IV :

Character and Competence- Holy books vs. Blind faith, Self-management and Good health, Science of reincarnation, Equality, Non-violence, Humility, Role of Women, All religions and same message, Mind your Mind, Self-control, Honesty, Studying effectively

References:

1. Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi

Course Code: AC-MRE106/II	Subject: Stress Management by Yoga	L-T-P: 3-0-0	Credits: 0

Course Outcome

The students will able to-

CO:1 Develop a healthy mind in a healthy body leading to the improvement of social health.

CO:2 Improve work efficiency and analysis power.

Course contents

UNIT- I :

Definitions of Eight parts of yog. (Ashtanga)

UNIT- II :

Yam and Niyam : Do's and Don'ts in life. Ahinsa, satya, astheya, bramhacharya and aparigraha, Shaucha, santosh, tapa, swadhyay, ishwarpranidhan

UNIT- III :

Asan and Pranayam: Various yog poses and their benefits for mind & body, Regularization of breathing techniques and its effects- Types of pranayam.

References:

1. Yogic Asanas for Group Training- Part-I, Janardan Swami Yogabhyasi Mandal, Nagpur.

2. Vivekananda, S., Rajayoga or Conquering the Internal Nature, Advaita Ashrama (Publication Department), Kolkata.

Course Code: AC-MRE106/III	Subject: Constitution of India	L-T-P: 3-0-0	Credits: 0

Course Outcome

The students will able to,

CO:1 Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.

CO:2 Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.

CO:3 Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.

CO:4 Discuss the passage of the Hindu Code Bill of 1956.

Course contents

UNIT- I :

History of Making of the Indian Constitution: History, Drafting Committee, (Composition& Working)

UNIT- II :

Philosophy of the Indian Constitution: Preamble, Salient Features

UNIT- III :

Contours of Constitutional Rights & Duties: Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT- IV :

Organs of Governance: Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT- V :

Local Administration: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy

UNIT- VI :

Election Commission: Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women

References:

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Busi, S.N., B.R. Ambedkar Framing of Indian Constitution, 1st Edition, 2015.
3. Jain, M.P., Indian Constitution Law, 7th Edition, Lexis Nexis, 2014.
4. Basu, D.D., Introduction to the Constitution of India, Lexis Nexis, 2015

Course Code: AC-MRE106/IV	Subject: Pedagogy Studies	L-T-P: 3-0-0	Credits: 0

Course Outcome

The students will able to,

CO:1 Explain overall concept of Pedagogy

CO:2 Analyze different components of curriculum and their implementation

CO:3 Explain Outcome Based Education and it implementation

CO:4 Explain role of Technology in Pedagogy and it implementation

Course contents

UNIT- I :

Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology, Theories of learning, Curriculum, Teacher education, Conceptual framework, Research questions, Overview of methodology and Searching

UNIT- II :

Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries, Curriculum, Teacher education

UNIT- III :

Evidence on the effectiveness of pedagogical practices, Methodology for the in depth stage: quality assessment of included studies, How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change, Strength and nature of the body of evidence for effective pedagogical practices, Pedagogic theory and pedagogical approaches, Teachers' attitudes and beliefs and Pedagogic strategies.

UNIT- IV :

Organs of Governance: Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT- V :

Professional development: alignment with classroom practices and follow-up support, Peer support, Support from the head teacher and the community, Curriculum and assessment, Barriers to learning: limited resources and large class sizes

UNIT- VI :

Research gaps and future directions, Research design, Contexts, Pedagogy, • Teacher education Curriculum and assessment, Dissemination and research impact

References:

1. Ackers, J., Hardman, F., Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261, 2001.
2. Agrawal, M., Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379, 2004.
3. Akyeampong, K., Teacher training in Ghana- does it count? Multi-site teacher education research project (MUSTER) country report 1, DFID, London, 2003.
4. Akyeampong, K., Lussier, K., Pryor, J., Westbrook, J., Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282, 2013.
5. Alexander, R.J., Culture and pedagogy: International comparisons in primary education, Blackwell, Oxford and Boston, 2001.
6. Chavan, M., Read India: A mass scale, rapid, 'learning to read' campaign, 2003.

Course Code: AC-MRE205/I	Subject: English for Research Paper Writing	L-T-P: 3-0-0	Credits: 0

Course Outcome

The students will able to,

CO:1 Understand that how to improve your writing skills and level of readability

CO:2 Learn about what to write in each section

CO:3 Understand the skills needed when writing a Title

CO:4 Construct the good quality of paper at very first-time submission

Course contents

UNIT- I :

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness.

UNIT- II :

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction.

UNIT- III :

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

UNIT- IV :

Key skills needed when writing a Title; key skills needed when writing an Abstract, key skills needed when writing an Introduction, skills needed when writing a Review of the Literature.

UNIT- V :

Skills needed when writing the Methods, skills needed when writing the Results, skills needed when writing the Discussion, skills needed when writing the Conclusions.

UNIT- VI :

Useful phrases, how to ensure paper to be good for it to be possibly the first-time submission.

References:

1. Goldbort, R., Writing for Science, Yale University Press (available on Google Books), 2006.
2. Day, R., How to Write and Publish a Scientific Paper, Cambridge University Press, 2006.
3. Highman, N., Handbook of Writing for the Mathematical Sciences, SIAM, 1998.
4. Wallwork, A., English for Writing Research Papers, Springer, New York, 2011.

Course Code: AC-MRE205/II	Subject: Disaster Management	L-T-P: 3-0-0	Credits: 0

Course Outcome

The students will able to,

CO:1 Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.

CO:2 Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.

CO:3 Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.

CO:4 Critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in

Course contents

UNIT- I :

Introduction: Disaster: Definition, Factors and Significance; Difference between Hazard and Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT- II :

Repercussions of Disasters and Hazards:

Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts and Famines, Landslides and Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks and Spills, Outbreaks of Disease and Epidemics, War and Conflicts.

UNIT- III :

Disaster Prone Areas in India: Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides and Avalanches; Areas Prone to Cyclonic and Coastal Hazards with Special Reference to Tsunami; Post-Disaster Diseases and Epidemics.

UNIT- IV :

Disaster Preparedness and Management Preparedness: Monitoring of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data From Meteorological and other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT- V :

Risk Assessment Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival.

UNIT- VI :

Disaster Mitigation Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigation and Non-Structural Mitigation, Programs of Disaster Mitigation in India.

References:

1. Nishith, R., Singh, A.K., Disaster Management in India: Perspectives, Issues and Strategies, New Royal book Company.

2. Sahni, Pardeep Et. Al. (Eds.), Disaster Mitigation Experiences and Reflections, Prentice Hall of India, New Delhi.

3. Goel, S.L., Disaster Administration and Management Text and Case Studies, Deep & Deep Publication Pvt. Ltd., New Delhi.

Course Code: AC-MRE205/III	Subject: Statistics & Probability with R	L-T-P: 3-0-0	Credits: 0

Course Outcome

The students will able to,

CO:1 Demonstrate the language and core concepts of probability theory.
CO:2 Apply basic principles of statistical inference.
CO:3 Make use of programming language R to do statistics.
CO:4 Apply, examine, and conclude statistical information.

Course contents

UNIT- I :

Basic Statistical Concepts: Populations and Samples; Some Sampling Concepts; Random Variables and Statistical Populations; Basic Graphics for Data Visualization; Proportions, Averages, and Variances; Medians, Percentiles, and Boxplots; Comparative Studies; The Role of Probability; and Approaches to Statistical Inference

UNIT- II :

Introduction to Probability: Sample Spaces, Events, and Set Operations; Experiments with Equally Likely Outcomes; Axioms and Properties of Probabilities; Conditional Probability; and Independent Events Random Variables and Their Distributions: Describing a Probability Distribution, Parameters of Probability Distributions, Models for Discrete Random Variables, and Models for Continuous Random Variables

Jointly Distributed Random Variables: Describing Joint Probability Distributions, Conditional Distributions, Mean Value of Functions of Random Variables, Quantifying Dependence, and Models for Joint Distributions

UNIT- III :

Some Approximation Results: The LLN and the Consistency of Averages, Convolutions, and The Central Limit Theorem Fitting Models to Data: Some Estimation Concepts, Methods for Fitting Models to Data, and Comparing Estimators: The MSE Criterion

Confidence and Prediction Intervals: Introduction to Confidence Intervals, CI Semantics: The Meaning of "Confidence", Types of Confidence Intervals, The Issue of Precision, and Prediction Intervals Testing of Hypotheses: Setting Up a Test Procedure, Types of Tests, and Precision in Hypothesis Testing Comparing Two Populations: Two-Sample Tests and CIs for Means, The Rank-Sum Test Procedure, Comparing Two Variances, and Paired Data

Comparing k > 2 Populations: Types of k-Sample Tests, Simultaneous CIs and Multiple Comparisons, and Randomized Block Designs; Two-Factor Designs, Three-Factor Designs, and 2r Factorial Experiments

UNIT- IV :

Polynomial and Multiple Regression: The Multiple Linear Regression Model, Estimation, Testing, and Prediction, and Additional Topics

Statistical Process Control: The $\bar{X}$Chart, The S and R Charts, The p and c Charts, and CUSUM and EWMA Charts

References:

1.Michael, A., Probability & Statistics with R for Engineers and Scientists, Pearson, 2015.

2.Gupta, B. C., Guttman, I., and Jayalath, K. P., Statistics and Probability with Applications for Engineers and Scientists Using MINITAB, R and JMP, Wiley, 2020.

Course Code: AC-MRE205/IV	Subject: Personality Development through Life Enlightenment Skills	L-T-P: 3-0-0	Credits: 0

Course Outcome

The students will able to,

CO:1 Develop his personality and achieve the highest goal in life

CO:2 Lead the nation and mankind to peace and prosperity

CO:3 Help in developing versatile personality of students

Course contents

UNIT- I :

Neetisatakam-Holistic development of personality:
Verses- 19,20,21,22 (wisdom), Verses- 29,31,32 (pride & heroism), Verses- 26,28,63,65 (virtue), Verses- 52,53,59 (don'ts), Verses- 71,73,75,78 (do's)

UNIT- II :

Approach to day to day work and duties, Shrimad Bhagwad Geeta : Chapter 2-Verses 41, 47,48, Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17,23, 35, Chapter 18-Verses 45, 46, 48.

UNIT- III :

Statements of basic knowledge, Shrimad Bhagwad Geeta : Chapter2-Verses 56, 62, 68, Chapter 12 -Verses 13, 14, 15, 16,17, 18, Personality of Role model. Shrimad Bhagwad Geeta, Chapter2-Verses 17,Chapter 3-Verses 36,37,42, Chapter 4-Verses 18, 38,39, Chapter18 – Verses 37,38,63

References:

1. Srimad Bhagavad Gita, Swami Swarupananda Advaita Ashram (Publication Department), Kolkata.

2. Gopinath, P., Bhartrihari's Three Satakam (Niti-sringar-vairagya), Rashtriya Sanskrit Sansthanam, New Delhi.