THE VISION OF THE DEPARTMENT OF MECHANICAL ENGINEERING

The Department of Mechanical Engineering strives to be recognized globally for excelling in engineering education and research leading to innovative, entrepreneurial and competent graduates in Mechanical Engineering and allied disciplines.

THE MISSION OF THE DEPARTMENT OF MECHANICAL ENGINEERING

- Providing world class education by fostering effective teaching learning process that is supported through pioneering and cutting-edge research to make impactful contribution to the society.

- Attracting highly motivated students with enthusiasm, aptitude and interest in the field of Mechanical and allied Engineering disciplines.

- Expanding the frontiers of Engineering and science in technological innovation while ensuring academic excellence and scholarly learning in a collegial environment.

- Excelling in industrial consultancy and research leading to innovative technology development and transfer.

- Serving the society with innovative and entrepreneurially competent graduates for the national and international community towards achieving the sustainable development goals.
REGULATIONS – 2023: CHOICE BASED CREDIT SYSTEM
M.E. ENERGY ENGINEERING

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

The Energy Engineering program seeks to prepare PG students for productive and rewarding careers in the energy arena. The PEOs are listed below:

(i) Acquire knowledge and employability skills in energy sector with requisite skills facilitating quick progress in graduands career
(ii) Inclination towards advanced research for mitigating the shortcomings in energy systems.
(iii) Ascending as an energy consultant/entrepreneur for providing solutions towards improving the efficacy of energy systems.
(iv) Lead an ethical life by engaging in lifelong learning experiences for developing environmentally benign and economically affordable low carbon energy solutions for societal upliftment

PROGRAMME OUTCOMES (POs):

(i) Ability to independently carry out research/investigation and development work to solve practical problems
(ii) Awareness on energy (renewable and non-renewable) and environmental scenario at local, national and global level
(iii) Carry out energy benchmarking in Industries/Commercial Buildings, diagnosing the causes for deviation and suggestions for improving the performance
(iv) Expertise to use various simulation software related to energy systems to identify research gaps and ideate innovations
(v) Optimize energy systems with environmental consciousness for sustainable development.
(vi) Proficiency to document and present a comprehensive technical report on energy related aspects

PEO/PO Mapping:

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* To be carried out in an energy intensive industry (HT Consumer) during 2nd semester vacation
* Minimum period of training = 4 weeks & evaluation to be carried out on 1st week of 3rd sem
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Total credits for the programme = 26 + 18 + 15 + 12 = 71

Students are permitted to

(i) Study any 2 courses - equivalent to the subjects mentioned in the curriculum - in National Programme on Technology Enhanced Learning (NPTEL), Govt. of India

AND/OR

(ii) Study any 2 TECHNICAL courses for consideration under Program Electives amongst the core/elective courses offered in the University Departments

Prior approval of (1) Faculty Adviser, (2) Professor–i/c of PG Programme, (3) HoD – Dept. of Mech. Engg., and (4) Chairperson – Faculty of Mechanical Engineering is to be obtained for the above.
### FOUNDATION COURSES (FC)

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Total Credits: 26
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MA3155 ADVANCED NUMERICAL METHODS  

OBJECTIVES:
- To impart knowledge in understanding the advantages of various solution procedures of solving the system of linear and nonlinear equations.
- To give a clear picture about the solution methods for solving the BVPs and the system of IVPs.
- To acquire knowledge in solving time dependent one and two dimensional parabolic PDEs by using various methodologies.
- To strengthen the knowledge of finite difference methods for solving elliptic equations.
- To get exposed to the ideas of solving PDEs by finite element method.

UNIT I ALGEBRAIC EQUATIONS 12

UNIT II ORDINARY DIFFERENTIAL EQUATIONS 12
Runge Kutta Methods for system of IVPs, numerical stability, Adams-Bashforth multistep method, solution of stiff ODEs, shooting method, BVP: Finite difference method, collocation method, orthogonal collocation method, Galerkin finite element method.

UNIT III FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATION 12

UNIT IV FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS 12
Laplace and Poisson’s equations in a rectangular region: Five point finite difference schemes, Leibmann’s iterative methods, Dirichlet and Neumann conditions – Laplace equation in polar coordinates: finite difference schemes – approximation of derivatives near a curved boundary while using a square mesh.

UNIT V FINITE ELEMENT METHOD 12

TOTAL: 60 PERIODS

OUTCOMES:
At the end of the course, students will be able to
CO1 Get familiarized with the methods which are required for solving system of linear, nonlinear equations and eigenvalue problems.
CO2 Solve the BVPs and the system of IVPs by appropriate methods discussed.
CO3 Solve time dependent parabolic PDEs by using various methodologies up to dimension two.
CO4 Solve elliptic equations by finite difference methods.
CO5 Use the ideas of solving PDEs by finite element method.
REFERENCES:

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OBJECTIVE:
The major objective of this course is to introduce the advanced thermodynamic concepts which are useful in understanding fundamental concepts of availability, entropy generation, properties of matter and to apply in various Engineering problems involving energy transfer, chemical processing, etc. The course will focus on both energy producing and consuming thermodynamic cycle’s system energy and exergy analysis.

UNIT – I  FUNDAMENTAL LAWS, CLOSED and OPEN SYSTEMS  12
Zeroth, First and Second law of Thermodynamics, Fundamental equations for closed systems, Process, Relations, Second law efficiency for a closed system, Fundamental equations for open systems, Steady state operations, Flow in channel, turbine and compressors

UNIT – II  ENTROPY GENERATION  12

UNIT – III  THERMODYNAMIC PROPERTIES of MATTER  12

UNIT – IV  THERMODYNAMIC CYCLES  12

UNIT – V  ENERGY and EXERGY ANALYSIS  12

TOTAL: 60 PERIODS

OUTCOMES:
Upon completion of this course, the students will be able to:
CO 1  Understand the thermodynamic system, and apply various thermodynamic relations
CO 2  Analyze the entropy generation in various processes
CO 3  Predict the behavior of real gas and calculate the properties of gas mixtures
CO 4  Apply various thermodynamic cycles for various work producing and consuming systems
CO 5  Apply the thermodynamic knowledge for analyzing the energy and exergy concepts in different applications.
REFERENCES

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OBJECTIVE:
The main objective of the course is to impart knowledge to students on the concepts of fluid kinematics, boundary layer theory, incompressible and compressible fluid flow analysis. The course is also useful to enhance the student knowledge on various modes of heat transfer and the applications of heat transfer.

UNIT – I FLUID KINEMATICS AND BOUNDARY LAYER THEORY 12

UNIT – II INCOMPRESSIBLE AND COMPRESSIBLE FLOWS 12

UNIT – III CONDUCTION AND CONVECTION HEAT TRANSFER 12

UNIT – IV RADIATION HEAT TRANSFER 12
Surface radiation – View factor analysis, Gas Radiation - Radiative Transfer Equation (RTE), Radiation properties of a participating medium, Use of Hottel's Graph, Correction factor analysis - Inverse problems in radiation transfer.

UNIT – V HEAT EXCHANGER AND HEAT PIPE 12

TOTAL: 60 PERIODS

OUTCOMES:
Upon completion of this course, the students will be able to:
CO 1 Identify, formulate, and analyze the governing equations for various engineering applications.
CO 2 Learn the flow concepts of incompressible and compressible flow.
CO 3 Solve the conduction and convection heat transfer problems.
CO 4 Understand the importance of radiation heat transfer in gases and inverse solution methods.
CO 5 Design a heat exchanger and heat pipe as per the industrial needs.
REFERENCES:

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OBJECTIVE:
The objective of this course is to provide a holistic view on combustion mechanism, devices used for combustion and emissions from combustion of different types of fuels.

UNIT – I  COMBUSTION
Combustion: Stoichiometry, thermodynamics, Nature and types of combustion processes, Mechanism, flame propagation, various methods of flame stabilization, ignition temperature, flash and fire points, calorific intensity, theoretical flame temperature. Combustion calculations, theatrical air requirements, flue gas analysis, combustion kinetics – $\text{H}_2$-$\text{O}_2$ reactions and $\text{HC}$-$\text{O}_2$ reactions, low-temperature combustion.

UNIT – II  SOLID FUELS
Solid fuels – Classification, preparation, cleaning, handling, analysis, ranking and properties – action of heat, oxidation, hydrogenation, carbonization, liquefaction, and gasification.

UNIT – III  LIQUID & GASEOUS FUELS

UNIT – IV  COMBUSTION DEVICES
Basic features of burner, types of solid, liquid, and gaseous fuel burners, design consideration of different types of burners, recuperative and regenerative burners, Pulverised fuel furnaces–fixed, entrained, and fluidized bed systems.

UNIT – V  EMISSION FROM COMBUSTION
Emission from combustion of solid fuel fired devices- Source, control, and measurement - Emission from combustion of liquid and gaseous fuel – Source, control and measurement, Flue gas analysis by chromatography and sensor techniques. fire and explosions in the production, storage, and utilization of both conventional and alternative fuels. Emission standards: Global and Indian

TOTAL: 60 PERIODS

OUTCOMES:
Upon completion of this course, the students will be able to:

CO1 Understand the mechanism of combustion and combustion calculations
CO2 Process and analyze solid fuels and apply appropriate testing methods
CO3 Recognise the different gaseous and gaseous fuel for suitable applications and know analysis of gaseous fuels.
CO4 Recognize and select the proper combustion devices for various fuels.
CO5 Acknowledge the sources of pollution from combustion of various fuel and suggest methods of control and monitoring.
REFERENCES:

Practical
1. Proximate analysis of a given biofuel
2. Estimation of calorific value of any solid fuels using bomb calorimeter
3. Computation of calorific value of liquid fuels using Junkers gas calorimeter
4. Combustion of fuel in boiler with different excess air
5. Evaluating and comparing the efficiency of conventional stove and improved (energy efficient) cook stoves
6. Testing of biomass Gasifier in updraught / downdraught mode
7. Study of biogas plant – fixed dome and floating drum model
8. Synthesis of biodiesel – energy and mass balancing
9. Performance evaluation of engine on biodiesel
10. Comparison of combustion and emissions of B0 and B100

TOTAL: 15 PERIODS

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OBJECTIVE:
Acquaintance with the Indian and Global energy scenario and to edify on the potential and prospects of various renewable energy technologies.

UNIT – I ENERGY AND ENVIRONMENT 9L

UNIT – II SOLAR ENERGY 9L+15P

UNIT – III WIND ENERGY 9L+3P

UNIT – IV BIO-ENERGY 9L+9P
Bio resources – thermochemical conversion: combustion, gasification, pyrolysis and carbonisation – Biochemical conversion: Biodiesel, Biogas, fermenting and Pelletisation – Applications

UNIT – V HYDRO, GEOTHERMAL & HYBRID ENERGY SYSTEMS 9L+3P
Small hydro - Tidal energy – Wave energy – OTEC – Geothermal energy – Hybrid systems – Environmental impacts

OUTCOMES:
Upon completion of this course, the students will be able to:

CO1 Comprehend on the Indian energy scenario
CO2 Design a Solar Thermal / PV system for any requirement
CO3 Estimate the available wind energy in a particular site
CO4 Suggest suitable conversion mechanism for generating power from Biomass
CO5 Elucidate on the technologies for harnessing power from ocean and geothermal energy.

REFERENCES:
Practical

1. Study of Direct and diffused beam solar radiation
2. Performance evaluation of Solar Flat Plate Collector
3. Determining the I-V characteristics of Solar PV panel
4. Performance evaluation of solar cookers (box type and concentrating type)
5. Determining the I-V Characteristics of a Fuel Cell
6. Performance evaluation of a green hydrogen generation and storage system
7. Performance evaluation of wind turbine
8. Performance evaluation of different turbines employed in hydro power plant
9. Study of Biomethanation plant
10. Study of Biomass briquetting plant

TOTAL: 15 PERIODS

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OBJECTIVE:
The primary goal of this course is to enrich the students understanding of different measuring instruments, methodologies, and the significance of error and uncertainty analysis. Additionally, this course will equip students with the skills required to design appropriate control unit for a range of thermal systems.

UNIT – I  BASICS OF MEASUREMENTS  9
Introduction, general measurement system, Signal flow diagram of measurement system, Inputs and their methods of correction, Presentation of experimental data, Errors in measurement, Propagation of errors, Uncertainty analysis, Regression analysis, Transient response – zeroth, first and second order measurement systems

UNIT – II  THERMOMETRY AND HEAT FLUX MEASUREMENT  9
Overview of thermometry, Thermoelectric temperature measurement, Resistance thermometry, Pyrometer, Other methods and Calibration procedure, Challenges in temperature measurements, Principles of Heat flux measurement.

UNIT – III  PRESSURE, FLOW AND THERMAL PROPERTY MEASUREMENT  9
Different pressure measurement instruments and their comparison, Transient response of pressure transducers, Flow Measurement, Flow obstruction methods, Magnetic flow meters, Interferometer, LDA, Other methods, Thermo-physical property measurement - Steady and Unsteady methods for solids, fluids and PCMs

UNIT – IV  CONTROL SYSTEMS, COMPONENTS, AND CONTROLLERS  9
Introduction, Open and closed loop control systems, Transfer function. Types of feedback and feedback control system characteristics – Control system parameters – DC and AC servomotors, servo amplifier, potentiometer, synchro transmitters, synchro receivers, synchro control transformer, stepper motors - Continuous, Discontinuous and Composite control modes – Analog and Digital controllers.

UNIT – V  DESIGN OF MEASUREMENT AND CONTROL SYSTEMS  9
Data logging and acquisition - Integration of industrial instrumentation systems and monitoring, sensors for error reduction, elements of computer interfacing, timers and counters, designing measurement and control systems for specific applications, fault finding, and computer-based controls.

TOTAL: 45 PERIODS

OUTCOMES:
Upon completion of this course, the students will be able to:

CO1 Understand the concepts of errors in measurements, statistical analysis of data, regression analysis, correlation, and estimation of uncertainty.

CO2 Select appropriate sensors for measurement of specific parameters/properties with required accuracy.

CO3 Carry out calibration and evaluate measurement systems using uncertainty analysis

CO4 Distinguish between measurement and control systems, and use appropriate control system for an application

CO5 Construct a complete control system for a thermal application.

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OBJECTIVES:
To impart knowledge on
- Formulation of research problems, design of experiment, collection of data, interpretation and presentation of result
- Intellectual property rights, patenting and licensing

UNIT I  RESEARCH PROBLEM FORMULATION  9
Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II  RESEARCH DESIGN AND DATA COLLECTION  9
Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III  DATA ANALYSIS, INTERPRETATION AND REPORTING  9
Sampling, sampling error, measures of central tendency and variation; test of hypothesis-concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV  INTELLECTUAL PROPERTY RIGHTS  9
Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V  PATENTS  9
Patents – objectives and benefits of patent; concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES
Upon completion of the course, the student can
CO1: Describe different types of research; identify, review and define the research problem
CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data
CO3: Explain the process of data analysis; interpret and present the result in suitable form
CO4: Explain about Intellectual property rights, types and procedures
CO5: Execute patent filing and licensing

REFERENCES:
OBJECTIVE:
To understand the necessity of energy audits, its deliverables, performance evaluation, economics and energy conservation avenues in various Thermal & Electrical Utilities in the Industries

UNIT – I  ENERGY MANAGEMENT  9L+6P
Energy audit - need – types – methodology – barriers - analysis on energy costing and sharing - bench marking - billing parameters in TANGEDCO – DSM - instruments for energy audit – energy labeling

UNIT – II  BOILERS, FURNACES AND THERMIC FLUID HEATERS  9L+8P
Types - Performances evaluation via direct and indirect method – energy conservation avenues. Steam: Properties - Assessment of distribution losses - trapping - recovery systems

UNIT – III  HVAC AND WASTE HEAT RECOVERY  9L+8P

UNIT – IV  ELECTRICAL SYSTEMS  9L+8P
Energy conservation in Transformers – Cable loss estimation - Power factor improvement – Harmonics – quantification and remedial measures
Performance assessment and energy conservation avenues in:
- Motors - Fans - Blowers – Pumps – Air Compressors - Illumination Systems

UNIT – V  FINANCIAL MANAGEMENT  9L

TOTAL: 75 PERIODS

OUTCOMES:
Upon completion of this course, the students will be able to:
- CO1  Analyse EB bills and kVA demand of Industries for possible cost reduction
- CO2  Diagnose the cause for under performance of thermal utilities and suggest suitable remedial measures thereof
- CO3  Analyse the factors affecting the COP of a HVAC system
- CO4  Suggest measures for energy conservation in industrial electrical utilities
- CO5  Recommend Go/No-Go for energy conservation projects based on their economics

REFERENCES:
2. Guidebooks for National Certification Examination, Bureau of Energy Efficiency (BEE), Government of India

Practical

1. Study of energy audit instruments (flue gas analyser, calorimeter, pitot tube, digital pressure indicator, differential manometer, anemometer – vane type and thermal type, digital tachometer - contact/non-contact, stroboscope, hygrometer, temperature indicator - contact type and non-contact type, ultrasonic leak detector, ultrasonic flow meter, lux meter, energy manager, harmonic analyzer, KVA demand analyser)
2. Performance evaluation of boiler adopting direct and indirect method
3. Determining the efficiency of a simple impulse steam turbine
4. Assessment of performance of steam condensers
5. Determination of steam rate and heat rate of Rankine Cycle
6. Performance evaluation of air compressors and computing its specific energy consumption and cost of compressed air
7. Determining the characteristics of an induction motor and computing its efficiency adopting direct method
8. Determination of pump & pumping system characteristics (pump curve, system curve and BEP)
9. Comparison on the effect of different discharge control techniques in pumps (VFD, throttling and bypass mode) with respect to specific energy consumption
10. Analysis of various luminaries and evaluation of their efficacy
11. Determination of characteristic curves of blowers and comparison of its characteristics upon subjecting it to damper control at inlet and discharge.
12. Determination of range and effectiveness of cooling tower
13. Comparison on the effectiveness of shell and tube, pipe-in-pipe and plate heat exchangers
14. Estimation of CoP of a typical VCRS system at different condenser and evaporator temperatures

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EY3251 COMPUTATIONAL FLUID DYNAMICS FOR ENERGY SYSTEMS

OBJECTIVE:
To make students familiarize with the concepts of discretization techniques using finite difference and finite volume method for various transport phenomena related problems.

UNIT – I GOVERNING DIFFERENTIAL EQUATIONS AND DISCRETISATION TECHNIQUES

UNIT – II DIFFUSION PROCESSES: FINITE VOLUME METHOD

UNIT – III CONVECTION - DIFFUSION PROCESSES: FINITE VOLUME METHOD
One dimensional convection – diffusion problem, Central difference scheme, upwind scheme – Hybrid and power law discretization techniques – QUICK scheme. – Assessment of discretization scheme properties.

UNIT – IV INCOMPRESSIBLE FLOW PROCESSES: FINITE VOLUME METHOD
Discretization of incompressible flow equations – Stream Function – Vorticity methods - Pressure based algorithms, SIMPLE, SIMPLER, SIMPLEX & PISO algorithms.

UNIT – V TURBULENCE
Kolmogorov’s Theory - Turbulence - Algebraic Models, One equation model & k – ε, k – ω models - Standard and High and Low Reynolds number models.

TOTAL: 60 PERIODS

OUTCOMES:
Upon completion of this course, the students will be able to:

CO1 Know the differences between various discretization techniques.

CO2 Learn the finite volume based numerical method for solving diffusion heat transfer problems.

CO3 Learn the finite volume based numerical method for solving convection-diffusion heat transfer problems.

CO4 Understand the discretization of incompressible flow governing equations

CO5 Recognize the impact of various turbulence modelling

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OBJECTIVE:
Learn the simulation analysis software(s) and get expertise with the computational procedure to study the behavior of various thermal energy systems and numerically solve the problems related to heat transfer & fluid flow

LIST OF EXPERIMENTS
1. Conduction heat transfer analysis
2. Convection heat transfer analysis – Internal flow & Velocity boundary layer
3. Radiation heat transfer analysis
4. Analysis of flow through a pipe
5. Boiling heat transfer analysis
6. Condensation heat transfer analysis
7. Heat exchanger analysis – NTU & LMTD method
8. Critical radius of insulation
9. Nozzle/Diffuser Analysis
10. Lumped heat transfer analysis
11. Simulation of Thermal Power Plant Cycles, Configuration, Instrumentation and Controls

OUTCOMES:
Upon completion of this course, the students will be able to:
CO1 Use modern software tools to simulate, analyze and optimize any thermal energy system
CO2 Investigate the various process parameters influencing the performance of the thermal system
CO3 Illustrate the outcomes in brief containing the details of the domain analyzed in the form of a detailed report

TOTAL: 60 PERIODS

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OBJECTIVE:
To understand, learn and apply the principles and practices of Energy Conservation in Industrial Utilities through hands on training.

GUIDELINES:
- Each student has to undergo Industrial training for a minimum period of four weeks during the upcoming summer vacation (i.e., between II and III Semester).
- The Internship has to be undergone continuously for the entire period.
- The Internship must be carried out in an energy intensive industry (HT Consumer).
- The End Semester Examination must be conducted at the start of III Semester.
- The mark will be based on the project report (Introduction; Project or Training details; Techno Economics; Discussion; and Conclusion) and their presentation followed by oral examination on the same by internal examiner.

TOTAL: -

OUTCOMES:
Upon completion of this course, the students will be able to:
CO1 Evaluate Specific Energy Consumption of industrial utilities
CO2 Suggest measures for energy conservation in industrial utilities.
CO3 Prepare and present a detailed project report professionally

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OBJECTIVE:
The main learning objective of this course is to prepare the students for identifying a specific problem for the current need of the society and or industry, through detailed review of relevant literature, developing an efficient methodology to solve the identified specific problem.

GUIDELINES:
- Each PG student shall work individually on a selected specific topic in the area of **ENERGY** which shall be approved by the Head of the Division under the supervision of a Faculty Member (Guide / Supervisor) who is familiar in the selected specific topic. The selected specific topic maybe theoretical and or experimental and or simulation and or case study. The students’ Project Work – Phase I shall be evaluated through Internal Examination and End Semester Examination.
- The Internal Examination must be conducted periodically (Zeroth, First, Second and Third) through Project Work Review Presentation Meetings followed by questions from the panel of Review Committee Members comprising of two expert faculty members and a project coordinator.
- At the end of the semester, a detailed report on the work done by the PG student must be submitted with the approval from the Guide/Supervisor and the Review Committee Members. The Project Work – Phase I Report must contain the Introduction with clear definition along with detailed review of relevant literature on the selected specific problem; an efficient methodology to solve the selected specific problem along with necessary hypothesis and or experimental setup and or simulation and or case study for carrying out the research project work along with preliminary results; discussions, relevant conclusions and future direction along with specified references.
- The End Semester Examination must be conducted through Project Work Presentation followed by questions from the panel of Examiners comprising an External Examiner and Project Coordinator as Internal Examiner.

TOTAL: 180 PERIODS

OUTCOMES:
Upon completion of this course, the students will be able to:
- **CO1** Demonstrate a sound technical knowledge in their selected project topic.
- **CO2** Select and identify the problem statement along with scope and boundary; assimilate detailed review of relevant literature; formulate an efficient methodology to solve the selected specific problem.
- **CO3** Propose engineering design solutions to complex problems using a systematic approach.

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OBJECTIVE:
The main learning objective of this course is to prepare the students for solving the specific problem for the current need of the society and or industry, through the formulated efficient methodology, and to develop necessary skills to critically analyse and discuss in detail regarding the project results and making relevant conclusions.

GUIDELINES:
- The student may continue to work on the Project Work – I’s selected topic as per the formulated efficient methodology under the same Faculty Member (Guide/Supervisor). The students’ Project Work – II shall be evaluated through Internal Examination and End Semester Examination.
- The Internal Examination must be conducted periodically (First, Second and Third) through Project Work Review Presentation Meetings followed by questions from the panel of Review Committee Members comprising of two expert faculty members and a project coordinator.
- At the end of the semester, a detailed report on the work done by the PG student must be submitted with the approval from the Guide/Supervisor and the Review Committee Members. The Thesis (Project Work – II Report) must contain the Introduction with clear definition along with detailed review of relevant literature on the selected specific problem; an efficient methodology to solve the selected specific problem along with necessary theoretical hypothesis and or experimentation and or simulation and or case study for carrying out the research project work along with complete results with critical analysis and detail discussions, followed by relevant conclusions, along with specified references.
- The End Semester Examination must be conducted through Project Work Presentation followed by questions from the panel of Examiners comprising an External Examiner and Project Coordinator as Internal Examiner.

OUTCOMES:
Upon completion of this course, the students will be able to:
- CO1 Demonstrate a sound technical knowledge in their selected project topic.
- CO2 Propose product design & development solutions to complex problems using a systematic approach.
- CO3 Demonstrate the knowledge, skills and attitudes of a professional engineer to take up any challenging practical problem in the field of engineering design and find optimum solutions to it.

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OBJECTIVE:
To impart knowledge on Combustion of biofuels and to elucidate on various Bio energy Conversion processes.

UNIT – I BIOMASS AVAILABILITY AND CHARACTERIZATION

UNIT – II COMBUSTION
Perfect, complete, and incomplete combustion – computation of stoichiometric air equivalence ratio – fixed Bed and fluid Bed combustion - fuel and ash handling systems – steam cost comparison with conventional fuels – Cofiring - Cogeneration

UNIT – III THERMOCHEMICAL CONVERSION OF BIOMASS
Gasification, Pyrolysis, Carbonization : Chemistry - Types – Comparison – process governing parameters – typical yield rates - Applications – Economics

UNIT – IV BIO CHEMICAL CONVERSION OF BIOMASS

UNIT – V MECHANICAL CONVERSION OF BIOMASS

OUTCOMES:
Upon completion of this course, the students will be able to:
CO1 Estimate the surplus biomass availability of any given area
CO2 Determine and compare the cost of steam generation from biofuels with that of coal and petroleum fuels
CO3 Analyse the influence of process governing parameters in thermochemical conversion of biomass
CO4 Design a biogas plant for a variety of biofuels
CO5 Synthesize liquid biofuels for power generation from biomass

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OBJECTIVE:
To impart knowledge on fundamentals of wind energy and wind turbine power generation system

UNIT – I WIND ENERGY FUNDAMENTALS & RESOURCE ASSESSMENT

UNIT – II WIND TURBINE AERODYNAMICS AND CLASSIFICATION
Airfoil terminology, Blade design, Rotor performance and dynamics, Balancing technique (Rotor & Blade), Materials of Construction, Types of loads: Sources of loads Vertical Axis Type, Horizontal Axis, Constant Speed Constant Frequency, Variable speed Variable Frequency, Up Wind, Down Wind, Stall Control, Pitch Control, Gear Coupled Generator type, Direct Generator Drive /PMG/Rotor Excited Sync Generator

UNIT – III GEAR COUPLED WIND TURBINE POWER GENERATION SYSTEM

UNIT – IV DIRECT ROTOR COUPLED WIND TURBINE POWER SYSTEMS
Excited Rotor Synch. Generator / PMG Generator, Control Rectifier, Capacitor Banks, Step Up / Boost Converter (DC - DC Step Up), Grid Tied Inverter, Power Management, Grid Monitoring Unit (Voltage and Current), Transformer, Safety Chain Circuits

UNIT – V MODERN WIND TURBINE CONTROL & MONITORING SYSTEM

TOTAL: 45 PERIODS

OUTCOMES:
Upon completion of this course, the students will be able to:
CO1 Perform Wind resource estimation and Wind data analysis
CO2 Design Airfoil based Wind Turbine blades and analyze the rotor performance
CO3 Comprehend the various components used in gear coupled wind turbine power systems
CO4 Identify suitable generators and power electronic components for wind power systems
CO5 Develop algorithms for Wind turbine control and monitoring systems

REFERENCES:
7. NIWE: Wind Energy Resources Survey in India.

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OBJECTIVE:
To impart knowledge on the fundamentals of solar radiation, working principle of different types of solar thermal collectors, Solar PV system and Energy Storage

UNIT – I  FUNDAMENTALS OF SOLAR RADIATION  

UNIT – II  SOLAR THERMAL TECHNOLOGY  

UNIT – III  SOLAR PHOTOVOLTAIC TECHNOLOGY  

UNIT – IV  SOLAR ENERGY APPLICATIONS  

UNIT – V  SOLAR PASSIVE ARCHITECTURE  
Thermal comfort - bioclimatic classification – passive heating concepts: direct heat gain - indirect heat gain - isolated gain and sunspaces - passive cooling concepts: evaporative cooling - Radiative cooling - application of wind, water and earth for cooling; shading - paints and cavity walls for cooling - roof radiation traps - earth air-tunnel – energy efficient landscape design - thermal comfort

OUTCOMES:
Upon completion of this course, the students will be able to:
CO1 Perform Solar Radiation Resource assessment on a particular site. 
CO2 Design a solar thermal collectors for required applications 
CO3 Capacity prediction of SPV Modules and accessories for any given application 
CO4 Identify a relevant technology for harnessing solar energy for any desired application 
CO5 Suggest suitable technologies for passive solar heating and cooling of Buildings

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OBJECTIVE:
The objective is to impart comprehensive knowledge and understanding of various renewable energy sources, including hydro energy, OTEC system, tidal energy conversion systems, and wave energy converters. Specifically, to learn about their fundamentals, various types of hydro projects, components used in hydro power projects, construction and working of different types of OTEC systems and the different types of tidal energy conversion systems and wave energy converters.

UNIT – I  HYDRO POWER – BASICS  9

UNIT – II  COMPONENTS OF HYDRO POWER STATION  9
Major components of Hydropower Station: Dam - Details of desilting tank - Storage & Balancing reservoir - Pen Stock, Pipe Line & Tunneling - Surge Tank - Valve House – Turbines - Generator - Protection & Control equipment - Governors - Earthing and Grounding – Power Factor – Switchyards – Power Transformer

UNIT – III  OCEAN THERMAL ENERGY CONVERSION  9
OTEC: principle - types – efficiency – present status – limitations - environmental impacts

UNIT – IV  TIDAL ENERGY CONVERSION  9
Tides: formation – types – efficiency – present status – limitations – environmental impacts

UNIT – V  WAVE ENERGY  9

TOTAL: 45 PERIODS

OUTCOMES:
Upon completion of this course, the students will be able to:
CO1 Perform SWOT analysis for a typical Hydro power project
CO2 Detail the various components used in the Hydro power projects
CO3 Elucidate the pros and cons of an OTEC plant
CO4 Propose a suitable tidal energy scheme for the requirement
CO5 Analyse the pros and cons of wave energy converters

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OBJECTIVE
To gain knowledge and expertise in polygeneration systems, including energy systems integration, basic processes and components, performance estimation, methods, and applications in buildings and industries, for promoting sustainable development.

UNIT I ENERGY SYSTEMS AND INTERGRATION

UNIT II PROCESSES AND COMPONENTS OF POLYGENERATION SYSTEMS

UNIT III PERFORMANCE EVALUATION OF POLYGENERATION SYSTEMS
Natural gas, biomass and solar based polygeneration systems – Effective first law and Exergy efficiency – optimum design for plant and operation – Environmental benefits – Thermoeconomic analysis of polygeneration systems

UNIT IV POLYGENERATION SYSTEMS IN BUILDINGS

UNIT V POLYGENERATION SYSTEMS IN INDUSTRIES
Polygeneration concepts in Industries – Evaluation – Coal based Polygeneration Systems – Renewable energy polygeneration systems – Low grade industrial waste heat based polygeneration systems- Case Studies

TOTAL: 45 PERIODS

OUTCOMES
At the end of the course, student will be able to
CO 1 Analyze the energy systems and their integration for sustainable development
CO 2 Apply the basic processes and components of polygeneration systems
CO 3 Estimate the performance of various polygeneration systems
CO 4 Apply various methods of polygeneration systems and its application in buildings
CO 5 incorporate and analysis polygeneration systems in Industries

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OBJECTIVE
To acquire comprehensive knowledge and understanding of bio-energy systems, including the interpretation of various types of wastes for energy generation, biomass pyrolysis process and its applications, various types of biomass gasifiers and their operations, biomass combustors and their applications in energy generation, and the principles and features of bio-energy systems.

UNIT I INTRODUCTION - ENERGY FROM WASTE
Introduction to energy from waste: characterization and classification of waste as fuel – Agro-based, forest residues, industrial waste, Municipal solid waste; Conversion devices – Incinerators, gasifiers, digestors

UNIT II COMBUSTION
Densification of solids, Biomass stoves, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Efficiency improvement of power plant and energy production from waste plastics

UNIT III GASIFICATION

UNIT IV PYROLYSIS
Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT V OTHER PROCESS
Energy production from organic wastes through anaerobic digestion and fermentation, introduction to microbial fuel cells - Energy production from wastes through fermentation and transesterification - Cultivation of algal biomass from wastewater and energy production from algae

TOTAL: 45 PERIODS

OUTCOMES
CO1 Understand the various types of wastes from which energy can be generated
CO2 Gain knowledge on biomass pyrolysis process and its applications
CO3 Develop knowledge on various types of biomass gasifiers and their operations
CO4 Gain knowledge combustors and its applications on generating energy
CO5 Understand the principles of bio-energy systems and their features

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OBJECTIVE
To incorporate the knowledge of the green buildings, methods to evaluate the thermal performance of buildings.

UNIT I  INTRODUCTION
Climate and Building, Historical perspective, Aspects of green building design – Sustainable Site, Water, Energy, Materials and IEQ, ECBC Standards, GRIHA, LEED and Wellness Standards

UNIT II  LANDSCAPE AND BUILDING ENVELOPES

UNIT III  PASSIVE HEATING AND COOLING SYSTEMS

UNIT IV  THERMAL PERFORMANCE OF BUILDINGS

UNIT V  RENEWABLE ENERGY IN BUILDINGS

TOTAL: 45 PERIODS

OUTCOMES:
Upon completion of this course, the students will
CO 1  Be familiar with climate responsive building design and basic concepts
CO 2  Know the basic terminologies related to buildings
CO 3  be Able to apply the passive (air) conditioning techniques in buildings.
CO 4  Evaluate the performance of buildings
CO 5  Gets acquainted with Renewable energy systems in buildings

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OBJECTIVE
To edify the thermodynamic analysis of Refrigeration cycles, methods for evaluating the thermal load for Industrial and commercial applications and various refrigeration and HVAC systems used in the industries.

UNIT I  REFRIGERATION CYCLES – ANALYSIS  9

UNIT II  AIR CONDITIONING PROCESSES and SYSTEMS  9
Moist Air properties, use of Psychrometric Chart, Various Psychrometric processes, Air Washer, Adiabatic Saturation. Summer and winter Air conditioning, Enthalpy potential and its insights. Types of Air conditioning systems – Unitary type Units, Variable air Volumes, Central Plant, District Cooling Systems - Thermal distribution systems – Single, multi zone systems, terminal reheat systems, Dual duct systems.

UNIT III  THERMAL LOAD ESTIMATION  9

UNIT IV  SYSTEM COMPONENTS  9
Compressor- Types, performance, Characteristics, Types of Evaporators & Condensers and their functional aspects, Expansion Devices, and their Behaviour with fluctuating load, cycling controls, other components such as Accumulators, Receivers, Oil Separators, Strainers, Driers, Check Valves, Solenoid Valves Defrost Controllers, etc. Air Handling Units and Fan Coil units – Control of temperature, humidity, air flow and quality.

UNIT V  HVAC & R SYSTEM IN INDUSTRIES  9
Plant layout, Working fluids, Refrigeration Cycles and their control in Automobiles, Textile, Pharmaceutical, Dairy and Food Processing Industries

OUTCOMES:
Upon completion of this course, the students will
CO 1  Be familiar with refrigeration cycles and systems concepts.
CO 2  Know the basic thermodynamic process and systems of air conditioning.
CO 3  Be Able to estimate the heating and cold load for the building or industrial process.
CO 4  Know about the different components used in the units.
CO 5  Gets acquainted with HVAC&R systems in various industries.

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OBJECTIVE:
The objective of this course is to provide in-depth knowledge to students on energy transfer process, components, and performance of various turbo machines.

UNIT – I INTRODUCTION
Types and applications of Turbomachines – Application of Dimensional analysis to Turbomachines – Euler’s energy transfer equations – Velocity diagrams - Degree of reaction – Specific work and Efficiencies of Turbomachines – Losses in Turbomachines

UNIT – II CENTRIFUGAL AND AXIAL FANS
Centrifugal fan – types and stage parameters – performance and point of operation – fans in series and parallel – flow control methods.
Axial fan - stage parameters and types of stages – performance and point of operation – Propellers – slipstream and blade element theory.

UNIT – III CENTRIFUGAL AND AXIAL FLOW COMPRESSORS

UNIT – IV AXIAL AND RADIAL FLOW TURBINES
Axial flow turbines – impulse and reaction stage parameters – multi-staging – stage loading and flow coefficients. Degree of reaction – losses and efficiencies – performance characteristics

UNIT – V GAS TURBINE CYCLES AND HYDRAULIC TURBINES
Gas Turbine Cycles – open and closed cycle gas turbines – Improvements in Gas Turbine Cycles - Applications Thermodynamic analysis.

TOTAL: 45 PERIODS

OUTCOMES:
Upon completion of this course, the students will be able to:
CO1 Analyze the energy transfer process in thermodynamic systems
CO2 Calculate the performance of centrifugal and axial fans
CO3 Design and analyze centrifugal and axial flow compressor
CO4 Compute and analyze the performance of axial and radial flow turbines
CO5 Predict the performance of gas turbines and thermodynamic energy systems

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OBJECTIVE:
To impart knowledge on design aspects, rating, and thermal performance analysis of various types of heat exchangers.

UNIT – I  RATING AND PERFORMANCE EVALUATION OF HEAT EXCHANGER
Heat Exchanger codes and standards - Heat exchanger design methodology-Basic thermal design theory for recuperators - $\varepsilon$-NTU, $P$-NTU methods, Mean temperature difference method, Thermal design theory for regenerators- $\varepsilon$-NTU, $\Lambda\Pi$-NTU.

UNIT – II  STRESS AND FAILURE ANALYSIS

UNIT – III  DESIGN ASPECTS

UNIT – IV  EXTENDED SURFACE HEAT EXCHANGERS
Plate fin heat exchangers-Types, Geometric relationship, Rating and Sizing.
Tube fin heat exchangers-Types, Geometric relationship, Heat transfer and pressure drop.

UNIT – V  TWO PHASE FLOW HEAT EXCHANGERS AND COOLING TOWERS
Design of surface and evaporative condensers
Cooling tower – Thermal design, Influence of operating variables on performance, Heat and mass balance calculations.

TOTAL: 45 PERIODS

OUTCOMES:
Upon completion of this course, the students will be able to:
CO1  Design a heat exchanger for different applications.
CO2  Understand the significance of stress and failure analysis of heat exchangers
CO3  Understand the design aspects of different heat exchangers.
CO4  Perform rating and sizing of plate and tube heat exchangers
CO5  Design and carryout thermal performance analysis of two-phase flow heat exchangers and cooling towers

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OBJECTIVE:
The objective of this course is to enable the students to acquire knowledge on working principle, Energy analysis, Economic analysis, and Environmental impact of different types of power plants. Detail on the role of various utilities in coal based thermal power plants

UNIT – I  COAL BASED THERMAL POWER PLANTS  9

UNIT – II  DIESEL AND GAS TURBINE POWER PLANTS  9

UNIT – III  CHP AND MHD POWER PLANTS  9
MHD – Open cycle and closed cycle- Hybrid MHD & Steam power plants

UNIT – IV  HYDROELECTRIC & NUCLEAR POWER PLANTS  9
Hydroelectric Power plants – Classifications - essential elements – pumped storage systems – micro and mini hydel power plants.
General aspects of Nuclear Engineering, Components of nuclear power plants -Types of Fuel, Moderators, Coolants -Nuclear reactors & types – PWR, BWR, CANDU, Gas Cooled, Liquid Metal Cooled and FBR- Nuclear safety – Environmental issues.

UNIT – V  ENERGY, ECONOMIC AND ENVIRONMENTAL ISSUES OF POWER PLANTS  9
Load distribution parameters, connected load, maximum demand, demand factor, average load, load factor, diversity factor, load curve, Comparison of site selection criteria, relative merits & demerits.
Capital & Operating Cost of different power plants, Power tariff types.
Pollution control technologies including Waste Disposal Options for Coal and Nuclear Power Plants

TOTAL: 45 PERIODS

OUTCOMES:
Upon completion of this course, the students will be able to:
CO1  Perform thermodynamic analysis of steam power plant
CO2  Analyse gas power cycles of engines and suggest measures for improving the performance of gas turbine and diesel power plants
CO3 Assess the applicability and performance of a cogeneration system and MHD power plant.

CO4 Identify a suitable type of hydroelectric/nuclear power plant commensurate with the prevailing conditions

CO5 Carry out economic calculation in different power plants and select suitable pollution control technologies.

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OBJECTIVE:
Gain an understanding of the energy situation at both the national and global levels and utilize available resources to predict and model energy demand while considering current policies.

UNIT – I ENERGY STRUCTURE

UNIT – II FORECASTING MODEL

UNIT – III OPTIMIZATION MODEL

UNIT – IV PROJECT MANAGEMENT

UNIT – V ENERGY POLICY & SCHEMES

OUTCOMES:
Upon completion of this course, the students will be able to:
CO1 Gain knowledge on the National and Global energy scenario.
CO2 Use various techniques to perform Energy Forecasting and modeling.
CO3 Develop optimization model for energy planning.
CO4 Caliber to execute a project with detailed economic analysis.
CO5 Understand the National and state energy policies.

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OBJECTIVE:
To learn mass and energy balance principles for thermal energy systems, and model/simulate them to optimize parameters and conduct a detailed economic analysis.

UNIT – I INTRODUCTION
Overview of technologies and conventional methods of energy conversion, Workable and optimum systems, Steps in arriving at a workable system, Creativity in concept selection. Energy analysis – energy balance for closed and control volume systems – Modeling overview – levels and steps in model development.

UNIT – II MODELING AND SIMULATION

UNIT – III OPTIMIZATION TECHNIQUES

UNIT – IV ENERGY- ECONOMY MODELS

UNIT – V NUMERICAL METHODS

OUTCOMES:
Upon completion of this course, the students will be able to:

CO1 Apply mass and energy balances for the energy systems
CO2 Perform Simulation and Modeling of typical energy system
CO3 Use the optimization techniques to optimize the energy system.
CO4 Carry out Energy-Economic Analysis for any thermal application.
CO5 Gain knowledge in optimization of Energy system problems.

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OBJECTIVE:
Understand the design principles of any thermal energy system and develop a model to arrive at the optimal solution and study the dynamic behavior of the same with a tradeoff between capital and operating cost using pinch point analysis.

UNIT – I DESIGN CONCEPTS

UNIT – II MODELLING AND SYSTEMS SIMULATION

UNIT – III OPTIMIZATION

UNIT – IV DETERMINISTIC SEARCH METHODS
Non–linear least square minimization – Levenberg-Marquardt, Conjugate gradient algorithm – case studies with deterministic search algorithms.

UNIT – V STOCHASTIC SEARCH METHODS
Introduction to random search methods – advantages and disadvantages, Genetic Algorithm. Other advanced algorithms – simulated annealing, Particle Swarm Optimization.

TOTAL: 45 PERIODS

OUTCOMES:
Upon completion of this course, the students will be able to:
CO1 Understand basic design principles of the thermal systems and the type of models suitable for further analysis.
CO2 Carry out the Simulation and Modelling of typical thermal energy systems.
CO3 Analyze the effect of constraints on the performance of thermal energy systems.
CO4 Develop the dynamic analysis of the thermal system with control system feedback arrangement.
CO5 Design, optimize and perform the Energy–Economic Analysis for any thermal system.

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OBJECTIVE:

The objective of this course is to provide a holistic view on design of experiments and statistical analysis of experimental data obtained from laboratory or industrial processes.

UNIT – I INTRODUCTION TO RANDOM VARIABLES AND PROBABILITY FUNCTIONS

Introduction to probability, Bayes’ theorem, Random variables - discrete and continuous, mean and variance, probability distribution functions - Binomial, Poisson, Normal, Weibull, Lognormal, Student-t, Joint probability distributions - marginal and conditional probability, covariance and correlation, bi-variate normal distribution function.

UNIT – II SAMPLING DISTRIBUTIONS AND ANALYSIS OF STATISTICAL INTERVALS

Sampling distribution and central limit theorem, General concept of point estimation - unbiased estimators, variance of point estimator, method of point estimation - maximum likelihood, Bayesian estimation, Confidence intervals with known and unknown variance, choice of sample size, guidelines for constructing confidence intervals.

UNIT – III HYPOTHESIS TESTING: SINGLE AND MULTIPLE SAMPLES

Statistical hypothesis - tests of statistical hypothesis, General procedure for hypothesis tests

Single sample case: tests on the mean of a normal distribution with known and unknown variance, testing for goodness of fit.

Two sample case: inference on the difference in means of two normal distributions with known and unknown variance, inference on the variances of two normal distributions and population proportions.

UNIT – IV ANALYSIS OF SIMPLE AND MULTIPLE LINEAR REGRESSION MODELS

Empirical models, simple linear regression, least square estimators, prediction of new observations and adequacy checking, correlation between parameters.

Multiple linear regression model, prediction of new observations and adequacy checking, multicollinearity.

UNIT – V DESIGN AND ANALYSIS OF SINGLE AND MULTIPLE FACTOR EXPERIMENTS

Completely randomized single-factor experiment - analysis of variance, multiple comparisons following ANOVA, residual analysis, and model checking, determining sample size. Random effect model - fixed Vs random effects, ANOVA and variance components. Randomized Complete Block Design (RCBD) - design and statistical analysis, multiple comparisons, residual analysis and model checking, Two-factor factorial experiments, $2^k$ factorial design - blocking and confounding, fractional replication, response surface methods.

OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 Statistically analyse experimental data obtained from laboratory/industrial process

CO2 Structure engineering decision-making problems as hypothesis tests

CO3 Structure comparative experiments involving two samples as hypothesis tests

CO4 Develop empirical models from engineering data using linear regression, predict future observations, and establish a suitable prediction interval.

CO5 Design and conduct engineering experiments involving single and multiple factor.
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OBJECTIVE:
To understand the significance and need for various types of energy storage technologies and their uses for real world applications. This course will also enable students to understand the Green Energy Storage of Hydrogen and the challenges associated

UNIT – I INTRODUCTION TO ENERGY STORAGE

UNIT – II THERMAL ENERGY STORAGE SYSTEM

UNIT – III ELECTRICAL ENERGY STORAGE

UNIT – IV HYDROGEN ENERGY STORAGE

UNIT – V ALTERNATE ENERGY STORAGE TECHNOLOGIES

TOTAL: 45 PERIODS

OUTCOMES:
Upon completion of this course, the students will be able to:
CO1 Identify the energy storage technologies for suitable applications.
CO2 Apply the appropriate thermal energy storage methods suitably.
CO3 Introduce the concepts, types and working of various batteries.
CO4 Understand the use of Hydrogen as Green Energy for our Future.
CO5 Recognize and choose appropriate methods of Energy Storage and Hybrid Systems.

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OBJECTIVE:
The major objective of this course is to enhance the knowledge of the students about classifications, construction, working, analysis and applications of fuel cells. This course will also enable students to understand various production and storage techniques of Hydrogen.

UNIT – I OVERVIEW

UNIT – II CLASSIFICATION
Classification of Fuel Cells - Based on Temperature and Electrolyte - Description and working principles of various types of fuel cells - Components used - Fabrication - Applications - Merits and Demerits of PEMFC, DMFC, PAFC, AMFC, SOFC, MCFC and MFC - Recent Developments and Achievements.

UNIT – III THERMODYNAMIC AND KINETIC ASPECTS OF FUEL CELL

UNIT – IV HYDROGEN PRODUCTION, STORAGE AND SAFETY

UNIT – V APPLICATIONS AND CHALLENGES OF FUEL CELL

OUTCOMES:
Upon completion of this course, the students will be able to:
CO1 Get introduced to the concepts of fuel cell technology.
CO2 Recognize the need for development of various types of fuel cells and their scopes.
CO3 Understand and apply the principles of thermodynamics and reaction kinetics of fuel cell to increase the fuel cell efficiency.
CO4 Gain knowledge on the use of hydrogen as a source of green energy and understand the challenges associated.
CO5 Analyse the cost effectiveness and eco-friendliness of fuel cell technology and understand the impact on the application aspects.

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OBJECTIVE:
To understand the importance of Hydrogen as the Green energy and its need for Sustainable Growth. This course will also enable students to understand various productions, storage, utilization techniques, codes, standards of Hydrogen.

UNIT – I INTRODUCTION TO HYDROGEN ENERGY

UNIT – II PROPERTIES OF HYDROGEN

UNIT – III HYDROGEN PRODUCTION METHODS
Steam Reformation - Partial Oxidation - Reformation using alternate energy sources - Coal gasification - Biomass Conversion - Electrolysis - Photo dissociation and Photo catalytic Methods.

UNIT – IV HYDROGEN STORAGE METHODS

UNIT – V APPLICATIONS OF HYDROGEN ENERGY

OUTCOMES:
Upon completion of this course, the students will be able to:
CO1 Appreciate the need for Hydrogen energy towards SDG.
CO2 Study and understand the properties of hydrogen and its salient features in terms of risks and safety.
CO3 Introduce the conventional and non-conventional methods of production of Hydrogen.
CO4 Understand the methods of storing hydrogen in various ways.
CO5 Discuss the various Hydrogen Conversion Systems and their practical applications along with future scopes.

REFERENCES:
5. Ru-shiliu, Leizhang, Xueliang sun, “Electrochemical technologies for energy storage

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OBJECTIVE:
To understand the properties, synthesis, characterization, significance of nanomaterials for Energy Systems and to impart the knowledge on applications of nanomaterials in the field of Solar Energy, Hydrogen energy and Carbon capture.

UNIT – I INTRODUCTION TO NANOMATERIALS 9
Nanotechnology - Classification of Nanomaterials - Nanoscale and bulk materials - Comparison.

UNIT – II PROPERTIES OF NANOMATERIALS 9

UNIT – III SYNTHESIS AND CHARACTERIZATION OF NANOMATERIALS 9
Characterization Methods - XRD, SEM, TEM, AFM, FTIR and XPS.

UNIT – IV NANOMATERIALS FOR SOLAR CELLS AND FUEL CELLS 9

UNIT – V NANOMATERIALS FOR HYDROGEN STORAGE AND CARBON CAPTURE 9

TOTAL: 45 PERIODS

OUTCOMES:
Upon completion of this course, the students will be able to:
CO1 Appreciate the need for nanomaterials for energy systems.
CO2 Study and understand the properties of nanomaterials and their unique characteristics.
CO3 Introduce the synthetic methods and characterization of nanomaterials.
CO4 Understand the importance of nanomaterials for solar cells and fuel cells.
CO5 Discuss the scope of using nanomaterials for storing hydrogen and capturing carbon.

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EY3005 NUCLEAR ENGINEERING
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COURSE OBJECTIVE:
The objective of this course is to provide in-depth knowledge to students on fundamentals of power generation using various types of Nuclear Power Plant. In addition, this course is intended to impart knowledge to students about different types of nuclear waste disposal techniques and radiation protection methods.

UNIT – I NUCLEAR REACTIONS 9
Mechanism of nuclear fission - nuclides - radioactivity – decay chains - neutron reactions - the fission process - reactors - types of fast breeding reactor - design and construction of nuclear reactors - heat transfer techniques in nuclear reactors - reactor shielding

UNIT – II REACTOR MATERIALS 9
Nuclear Fuel Cycles - characteristics of nuclear fuels - Uranium - production and purification of Uranium - conversion to UF4 and UF6 - other fuels like Zirconium, Thorium – Beryllium

UNIT – III REPROCESSING 9
Nuclear fuel cycles - spent fuel characteristics - role of solvent extraction in reprocessing - solvent extraction equipment

UNIT – IV SEPARATION OF REACTOR PRODUCTS 9
Processes to be considered - 'Fuel Element' dissolution - precipitation process – ion exchange – redox - purex - TTA - chelation -U235 - Hexane - TBP and thorax Processes - oxidative slagging and electro - refining - Isotopes - principles of Isotope separation

UNIT – V WASTE DISPOSAL AND RADIATION PROTECTION 9
Types of nuclear wastes - safety control and pollution control and abatement - international convention on safety aspects - radiation hazards prevention

TOTAL: 45 PERIODS

OUTCOMES:
Upon completion of this course, the students will be able to:
CO1 Understand fundamentals of nuclear reactions
CO2 Have knowledge in characteristics of various nuclear fuels
CO3 Aware about reprocessing of spent fuel and waste disposal
CO4 Have knowledge about separation of reactor products
CO5 Aware about radiation protection methods

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