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**TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE = 71**

### ELECTIVES FOR M.E ENERGY ENGINEERING

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MA7169 ADVANCED NUMERICAL METHODS

AIM:

OBJECTIVES:
To impart knowledge on numerical methods that will come in handy to solve numerically the problems that arise in engineering and technology. This will also serve as a precursor for future research.

UNIT I ALGEBRAIC EQUATIONS (9+3)

UNIT II ORDINARY DIFFERENTIAL EQUATIONS (9+3)
Runge Kutta Methods for system of IVPs, numerical stability, Adams-Bashforth multistep method, solution of stiff ODEs, shooting method, BVP: Finite difference method, orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method.

UNIT III FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATION (9+3)

UNIT IV FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS (9+3)
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 (9+3)

TOTAL (L – 45 + T – 15): 60 PERIODS

OUTCOME:
It helps the students to get familiarized with the numerical methods which are necessary to solve numerically the problems that arise in engineering.

REFERENCES
### AIM:
This Course is intended to build up necessary fundamentals of fluid Mechanics and Heat transfer relevant to Energy applications.

### OBJECTIVES:
- To understand the laws of fluid flow and Heat transfer
- To develop the skills to correlate the Physics with applications

### UNIT I BASIC EQUATION, POTENTIAL FLOW THEORY AND BOUNDARY LAYER CONCEPT

### UNIT II INCOMPRESSIBLE AND COMPRESSIBLE FLOWS

### UNIT III CONDUCTION AND RADIATION HEAT TRANSFER
Governing Equation and Boundary conditions, Extended surface Heat Transfer, Transient conduction – Use of Heisler’s charts, Conduction with moving boundaries, Radiation Heat Transfer, Gas Radiation

### UNIT IV TURBULENT FORCED CONVECTIVE HEAT TRANSFER

### UNIT V PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGER
Condensation on bank of tubes – boiling – pool and flow boiling, Heat exchanger – NTU approach and design procedure – compact heat exchangers

**TOTAL: 45 + 15 = 60 PERIODS**

### OUTCOME
Student will be able to use the concepts of Heat Transfer and fluid flow in the field of energy applications.

### TEXT BOOK:

### REFERENCES
AIM:
To introduce and apply advanced concepts of thermodynamics to engineering systems

OBJECTIVES:
- To understand and apply the concept of availability
- To understand the and calculate the behavior of real gases
- To predict the condition of systems and analyse them by the criteria of equilibrium
- To apply the concepts of advanced thermodynamics to combustion systems

UNIT I  AVAILABILITY ANALYSIS AND THERMODYNAMIC PROPERTY RELATION  10+3

UNIT II  REAL GAS BEHAVIOUR AND MULTI – COMPONENT SYSTEMS  10+3

UNIT III  CHEMICAL THERMODYNAMICS AND EQUILIBRIUM  10+3
First and second law analysis of reacting systems - Adiabatic flame temperature - entropy change of reacting systems. Criterion for reaction equilibrium. Equilibrium constant for gaseous mixtures and evaluation of equilibrium composition.

UNIT IV  COMBUSTION CHEMISTRY  8+3

UNIT V  COMBUSTION PROCESS and COMBUSTION CHAMBERS  7+3
Combustion in IC Engines and Gas turbines. Knocking and Detonation and control. Design principles of combustion chambers for IC Engines and Gas turbine. Arrangements of gas turbine combustion chambers for power and comparative analysis.

OUTCOME:
Students will able to
- Calculate the availability of the systems and cycles
- Analyse the engineering systems to improve and optimize its performance
- Understand the working and design principles of combustion systems

REFERENCES
2. Kuo, K.K., Principles of Combustion, John Wiley and Sons, 2005
AIM:
To introduce and apply advanced concepts of thermodynamics to engineering systems. To understand types and applications of various forms of energy sources and their environmental impacts.

OBJECTIVES:
- To explain concepts of various forms of non-renewable and renewable energy.
- To outline division aspects and utilization of renewable energy sources for both domestic and industrial applications.
- To analyze the environmental and cost economics of using renewable energy sources compared to fossil fuels.

UNIT I COMMERCIAL ENERGY
Coal, oil, natural gas, nuclear power, and hydro - their utilization pattern in the past, present, and future projections of consumption pattern, sector-wise energy consumption, environmental impact of fossil fuels, energy scenario in India, growth of energy sector, and its planning in India.

UNIT II SOLAR ENERGY
Solar radiation at the earth's surface, solar radiation measurements, estimation of average solar radiation, solar thermal flat plate collectors, concentrating collectors, solar thermal applications, heating, cooling, desalination, drying, cooking, etc., solar thermal electric power plant, principle of photovoltaic conversion of solar energy, types of solar cells, photovoltaic applications, battery charger, domestic lighting, street lighting, water pumping, etc., solar PV power plant, net metering concept.

UNIT III WIND ENERGY
Nature of the wind, power in the wind, factors influencing wind, wind data and energy estimation, wind speed monitoring, wind resource assessment, Betz limit, site selection, wind energy conversion devices, classification, characteristics, applications, offshore wind energy, hybrid systems, safety and environmental aspects, wind energy potential, and installation in India. Repowering concept.

UNIT IV BIO-ENERGY
Biomass resources and their classification, biomass conversion processes, thermochemical conversion, direct combustion, biomass gasification, pyrolysis, liquefaction, biochemical conversion, anaerobic digestion, types of biogas plants, applications, alcohol production from biomass, bio-diesel production, urban waste to energy conversion, biomass energy programme in India.

UNIT V OTHER TYPES OF ENERGY
Ocean energy resources, principle of ocean thermal energy conversion (OTEC), ocean thermal power plants, ocean wave energy conversion, tidal energy conversion, small hydro, geothermal energy, geothermal power plants, hydrogen production and storage, fuel cell, principle of working, various types, construction, and applications.

TOTAL: 45 PERIODS
OUTCOME:
- Understanding of commercial energy and renewable energy sources
- Knowledge in working principle of various energy systems
- Capability to do basic design of renewable energy systems

REFERENCES

EY7104 ENERGY CONSERVATION IN THERMAL SYSTEMS L T P C
3 0 0 3

AIM:
This course is intended to introduce principles of energy auditing and to provide measures for energy conservation in thermal utilities

OBJECTIVES:
- To learn the present energy scenario and the need for energy conservation
- To understand the monitoring / targeting aspects of Energy
- To study the different measures for energy conservation and financial implications of various thermal utilities

UNIT I  INTRODUCTION

UNIT II  ENERGY MONITORING & TARGETING

UNIT III  PERFORMANCE STUDY OF THERMAL UTILITIES – 1

UNIT IV  PERFORMANCE STUDY OF THERMAL UTILITIES – 2
UNIT V PERFORMANCE STUDY OF THERMAL UTILITIES – 3


TOTAL: 45 PERIODS

OUTCOME:
1. Students will be familiar with Energy Conservation scenario in general and will be mastering the thermal energy auditing technologies / procedures
2. Financial aspects also will be made clear to them as far as Energy Conservation Schemes are concerned. In short, students will become knowledgeable on techno – economic aspects of Energy Conservation

REFERENCES

EY7111 ENERGY LABORATORY

AIM:
To make the student to feel/understand the magnitude of numbers being used in the energy sector

OBJECTIVES:
• Acquainting the students on the SOP adopted for quantification of various parameters
• Inculcate the habit of analyzing the numbers resulting from experimentation
• Create awareness on actual performance limits of renewable energy gadgets/ industrial utilities

Session 1 RENEWABLE ENERGY
1. Performance testing of Solar Hot Water Collector
2. Characteristics of Solar photovoltaic devices
3. Testing of biomass Gasifier in updraught/downdraught mode
4. Testing of biogas plant
5. Fuel characterization
   (proximate analysis, calorific value, viscosity, specific gravity etc.,)
6. Solar Radiation measurement

Session 2 ENERGY CONSERVATION
1. Boiler efficiency testing using direct and indirect method
2. Testing of steam turbine efficiency
3. Motor efficiency testing
4. Computation of pump & pumping system characteristics (pump curve, system curve and BEP)
5. Analysis of various luminaries and computation of their efficacy
6. Analysis on Blowers/fans characteristic curves
7. Comparison of discharge control techniques in rotating machineries using VFD, throttling, bypass, parallel/series operation, impeller trimming
8. Heat Exchangers
9. Effect of superheating, sub-cooling, condenser temperature and evaporator temperature on the COP of an AC system

Session 3
ALTERNATE ENERGY SYSTEMS
1. Fuel Cell
2. Synthesis of biodiesel
3. Performance evaluation of engine on biodiesel
4. Thermal Energy Storage Systems

TOTAL: 45 PERIODS

OUTCOME
- Students will be knowledgeable on the
- Procedure to be adopted for performance analysis and optimization of energy utilities
- Methodology to be adopted for the quantification of performance governing parameters

EQUIPMENTS REQUIRED
1. Solar water heater – 100 LPD
2. SPV Educational Kit
3. 20 kW, flexible draught gasifier
4. Biogas plant (fixed dome or floating drum)
5. Bomb calorimeter
6. Junker’s gas calorimeter
7. Viscometer
8. Hydrometer
9. Flash and fire point apparatus
10. Proximate analyser (Muffle furnace and micro weigh balance)
11. Solar Radiation Meters
12. Non-IBR boiler
13. Simple impulse steam turbine
14. 5 HP motor efficiency test rig
15. Pump efficiency test rig
16. Blower/fan efficiency test rig
17. Heat Exchangers (plate, pipe-in-pipe, shell and tube)
18. Vapour Compression Refrigeration Test Rig
19. Fuel cell – Educational Kit
20. Biodiesel synthesizing kit
21. 5 hp air or water cooling engine
22. PCM based energy storage system

EY7201
ENERGY CONSERVATION IN ELECTRICAL SYSTEMS

AIM:
This course is intended to study the basics of electrical energy usage and means of electrical energy conservation in all utilities including rotating machineries / Illumination.
OBJECTIVES:
- To study the concepts of power factor, load management etc.
- To study the various measures for energy conservation in electrical devices both static & rotating machineries
- To study the emission related aspects & also a couple of case studies related to ENCON

UNIT I  BASICS OF ELECTRICAL ENERGY USAGE  9

UNIT II  TRANSFORMERS & MOTORS  9

UNIT III  FANS / PUMPS / COMPRESSORS  11
Basics – Selection – Performance Evaluation – Cause for inefficient operation – scope for energy conservation – methods (General & Latest) adopted for effecting ENCON – Economics of ENCON adoption in all the 3 utilities

UNIT IV  ILLUMINATION & ENERGY EFFICIENCY DEVICES  8

UNIT V  CASE STUDIES & CO₂ MITIGATION  8
Case Study Evaluation for 3 / 4 Typical Sectors – PAT Scheme (an introduction) – CO₂ Mitigation & Energy Conservation & Cost Factor

OUTCOME:
1. Basics of Electrical Energy Conservation would be the major outcome of this.
2. In addition, technical aspects of Rotating Machineries (Pumps / Fans / Compressors) will be made clear to them enabling them to work on energy savings
3. Typical industrial case studies will make them to realize the economic potential of energy conservation

REFERENCES
AIM:
To design and analyse the performance of Turbo machines for engineering applications.

OBJECTIVES:
- To understand the energy transfer process in Turbomachines and governing equations of various forms.
- To understand the structural and functional aspects of major components of Turbomachines.
- To design various Turbomachines for power plant and aircraft applications

UNIT I INTRODUCTION

UNIT II CENTRIFUGAL AND AXIAL FLOW COMPRESSORS
Centrifugal compressor - configuration and working – slip factor - work input factor – ideal and actual work - pressure coefficient - pressure ratio. Axial flow compressor – geometry and working – velocity diagrams – ideal and actual work – stage pressure ratio - free vortex theory – performance curves and losses

UNIT III COMBUSTION CHAMBER

UNIT IV AXIAL AND RADIAL FLOW TURBINES

UNIT V GAS TURBINE AND JET ENGINE CYCLES
Gas turbine cycle analysis – simple and actual. Reheated, Regenerative and Intercooled cycles for power plants. Working of Turbojet, Turbofan, Turboprop, Ramjet, Scarmjet and Pulsejet Engines and cycle analysis – thrust, specific impulse, specific fuel consumption, thermal and propulsive efficiencies.

OUTCOME:
When a student completes this subject, he / she can
- Understand the design principles of the turbomachines
- Analyse the turbomachines to improve and optimize its performance

REFERENCES
EY7203 MEASUREMENT AND CONTROL FOR ENERGY SYSTEMS

AIM:
To impart the student on measurement and control techniques applicable to Energy systems

OBJECTIVES:
- To understand the principle and use of sensors for measurement of different thermal and electrical parameters.
- To understand the concept of control systems, modes, design and their applications

UNIT I MEASUREMENT CHARACTERISTICS
Introduction to measurements, Errors in measurements, Statistical analysis of data, Regression analysis, correlation, estimation of uncertainty and presentation of data, design of experiments – Experimental design factors and protocols

UNIT II MEASUREMENTS IN ENERGY SYSTEMS
Basic Electrical measurements, Transducers and its types, Signal conditioning and processing - Measurement of temperature, pressure, velocity, flow rate, thermo-physical and transport properties of solids liquids and gases, radiation properties of surfaces, vibration and noise - Computer assisted data acquisition, data manipulation and data presentation

UNIT III CONTROL SYSTEMS
Introduction, Open and closed loop control systems, Transfer function. Types of feedback and feedback control system characteristics – Effect of disturbances – dynamic characteristics

UNIT IV CONTROL COMPONENTS AND CONTROLLER
Process 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 DESIGNING OF MEASUREMENT AND CONTROL SYSTEMS

TOTAL: 45 PERIODS

OUTCOME:
1. Students will be familiar with various measurement techniques useful for the evaluation of Energy Conservation Schemes.
2. Control aspects also will be made clear to them as far as Energy Conservation Schemes are concerned.
3. In short, students will become knowledgeable on the design of measurement and control systems for thermal / electrical energy systems

REFERENCES
2. W. Bolten, Industrial Control and Instrumentation, University Press, 2004
4. S.P. Venkateshan, Mechanical Measurements, Ane Books Pvt Ltd, 2010
OBJECTIVES:

- During the seminar session each student is expected to prepare and present a topic on Energy related issues / technology, for a duration of about 30 minutes.
- In a session of three periods per week, 4 students are expected to present the seminar.
- A faculty guide is to be allotted and he / she will guide and monitor the progress of the student and maintain attendance also.
- Students are encouraged to use various teaching aids such as over head projectors, power point presentation and demonstrative models.

TOTAL: 30 PERIODS

FOCUS: USE OF STANDARD APPLICATION SOFTWARE FOR SOLVING HEAT TRANSFER PROBLEMS

1. Heat exchanger analysis – NTU method
2. Heat exchanger analysis – LMTD method
3. Convection heat transfer analysis – Velocity boundary layer
4. Convection heat transfer analysis – Internal flow
5. Radiation heat transfer analysis – Emissivity
6. Critical radius of insulation
7. Lumped heat transfer analysis
8. Conduction heat transfer analysis
9. Condensation heat transfer analysis

DYNAMIC LINKING OF MAT LAB AND REF PROP SOFTWARE

SIMPLE CFD PROBLEMS FOR PRACTICE

NOTE: The above exercises are only guidelines to maintain the standard for teaching and conduct of examination.

SIMULATION LAB – REQUIREMENT:

1. Software - Modeling software like ProE, Gambit, Ansys etc
   Analysis software like Ansys, fluent, CFX, etc
   Equation solving software like Matlab, Engg equation solver
1. Every students in a batch must be provided with a terminal
2. Hardware are compatible with the requirement of the above software.

TOTAL: 45 PERIODS
AIM:
To provide a comprehensive and rigorous introduction to energy system design and optimization from a contemporary perspective

OBJECTIVES:
• To learn to apply mass and energy balances for the systems enable to perform enthalpy
• Learn to calculate to size performance and cost of energy equipments turns modeling and simulation techniques and to optimize the energy system.

UNIT I  INTRODUCTION
Primary energy analysis - energy balance for closed and control volume systems - applications of energy analysis for selected energy system design - modeling overview - levels and steps in model development - Examples of models – curve fitting and regression analysis

UNIT II  MODELLING AND SYSTEMS SIMULATION
Modeling of energy systems – heat exchanger - solar collectors – distillation -rectification turbo machinery components - refrigeration systems - information flow diagram - solution of set of non-linear algebraic equations - successive substitution - Newton Raphson method- examples of energy systems simulation

UNIT III  OPTIMISATION TECHNIQUES
Objectives - constraints, problem formulation - unconstrained problems - necessary and sufficiency conditions. Constrained optimization - Lagrange multipliers, constrained variations, Linear Programming - Simplex tableau, pivoting, sensitivity analysis - New generation optimization techniques – Genetic algorithm and simulated annealing - examples

UNIT IV  ENERGY- ECONOMY MODELS

UNIT V  APPLICATIONS AND CASE STUDIES
Case studies of optimization in Energy systems problems- Dealing with uncertainty- probabilistic techniques – Trade-offs between capital and energy using Pinch analysis

OUTCOME:
1. Student will be able do to Simulation and Modeling of typical energy system
2. Able to analysis effect of constraints on the performance of energy systems
3. Has a potential to do design HEN net work and perform Energy-Economic Analysis for a typical applications

REFERENCES
AIM:
The course is intended to build up necessary background for the design of the various types of heat exchangers.

OBJECTIVES:
- To learn the thermal and stress analysis on various parts of the heat exchangers
- To analyze the sizing and rating of the heat exchangers for various applications

UNIT I  FUNDAMENTALS OF HEAT EXCHANGER

UNIT II  FLOW AND STRESS ANALYSIS

UNIT III  DESIGN ASPECTS

UNIT IV  COMPACT AND PLATE HEAT EXCHANGERS
Types – merits and demerits – design of compact heat exchangers, plate heat exchangers – performance influencing parameters – limitations

UNIT V  CONDENSERS AND COOLING TOWERS
Design of surface and evaporative condensers – cooling tower – performance characteristics

TOTAL: 45 PERIODS

OUTCOME
Able to design the heat exchanger based on the information provided for a particular application and do the cost economic analysis

TEXT BOOK:

REFERENCES
AIM
To expose the students to the fundamentals of electrical drives and their applications in electrical machines

OBJECTIVES:
- To understand the principle of conventional motor drives, concepts of various losses and harmonics effects in motors and superconductivity theory.
- To understand the concept of Solid State motor controllers and their applications

UNIT I CONVENTIONAL MOTOR DRIVES
Characteristics of DC and AC motor for various applications - starting and speed control - methods of breaking

UNIT II PHYSICAL PHENOMENA IN ELECTRICAL MACHINES
Various losses in motors-Saturation and Eddy current effects - MMF harmonics and their influence of leakage-stray losses - vibration and noise.

UNIT III SOLID STATE POWER CONTROLLERS
Power devices: Triggering Circuits, Rectifiers – Single Phase and Three Phase with R, RL and Freewheeling Diode, Choppers - Type-A, Type-B, Type C and Type D, Inverters - Single Phase and Three Phase with R, RL and Freewheeling Diode, AC Voltage Controllers

UNIT IV SUPERCONDUCTIVITY
Principle of Super conductivity, Super conducting generators-motors and magnets - Super conducting magnetic energy storage (SMES).

UNIT V SOLID STATE MOTOR CONTROLLERS
Single and Three Phase fed DC motor drives - AC motor drives - Voltage Control - Rotor resistance control - Frequency control - Slip Power Recovery scheme

OUTCOME:
The student will be able to understand
(i) The principle of conventional motor drives, concepts of various losses and harmonic effects in motors and superconductivity theory.
(ii) The concept of Solid State motor controllers and their applications.

REFERENCES
3. Rene Husson, Modelling and Control of Electrical machines, Elsevier Science Ltd, 2009
EY7002 POWER GENERATION, TRANSMISSION AND UTILIZATION  L T P C  3 0 0 3

AIM:
To expose the student to the different types of power generation techniques, electrical power transmission systems, characteristic and utilization of electrical drives

OBJECTIVES:
• To impart knowledge on Conventional Power Plants (Steam, Hydro, Nuclear and Gas Turbine plants) and Renewable Energy Power generation.
• To understand the Economics of Power generation and Utilization of Electrical Energy for Various applications.

UNIT I CONVENTIONAL POWER GENERATION  12
Steam power plant - Selection of site - Generated Layout - coal and Ash Handling - Steam Generating Plants - Feed Make Circuit - Cooling Towers - Turbine Governing - Hydro Power Plant - Selection of Site - Classification Layout Governing of Turbines - Nuclear Power Plants - Selection of Site - Classification Layout Governing of Turbines - Nuclear Power Plants - Gas Turbine Plants

UNIT II NON CONVENTIONAL POWER GENERATION  9
Wind power generation - characteristics of wind power - design of windmills - Tidal power generation - Single and two-basin systems - Turbines for tidal power - Solar power generation - Energy from biomass, biogas and waste

UNIT III ELECTRICAL POWER TRANSMISSION  9
Online diagram of transmission - substation and distribution systems - comparison of systems (DC and AC) - EHVAC and HVDC transmission - layout of substations and bus bar arrangements - Equivalents circuit of short, medium and long lines - Transmission efficiency - regulation - reactive power compensation - transmission - loss minimization.

UNIT IV UTILISATION OF ELECTRICAL ENERGY  9
Selection of Electrical Drives - Electrical characteristics and mechanical considerations - size, rating and cost, Transformer characteristics - illumination - laws of illumination - polar curve - incandescent - fluorescent and vapour lamps - Design of OLTC lighting Scheme of industry-electrical welding - energy efficient aspects of devices

UNIT V ECONOMICS OF POWER GENERATION  6
Daily load curves - load factor - diversity factor - load deviation curve - load management - number and size of generating unit, cost of electrical energy - tariff - power factor improvement

TOTAL: 45 PERIODS

OUTCOME:
The student will be able to understand
(i) The Operation of Conventional Power Plants (Steam, Hydro, Nuclear and Gas Turbine plants) and concepts of Renewable Energy Power generation.
(ii) The Economics of Power generation and Utilization of Electrical Energy for Various applications.

REFERENCES
OBJECTIVES:
- To provide knowledge about the stand-alone and grid connected renewable energy systems.
- To equip with required skills to derive the criteria for the design of power converters for renewable energy applications.
- To analyse and comprehend the various operating modes of wind electrical generators and solar energy systems.
- To design different power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems.
- To develop maximum power point tracking algorithms.

UNIT I INTRODUCTION
Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources: ocean, biomass, hydrogen energy systems: operating principles and characteristics of: Solar PV, Fuel cells, wind electrical systems - control strategy, operating area.

UNIT II ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION
Review of reference theory fundamentals - principle of operation and analysis: IG, PMSG, SCIG and DFIG.

UNIT III POWER CONVERTERS
Solar: Block diagram of solar photo voltaic system: line commutated converters (inversion-mode) - Boost and buck-boost converters - selection of inverter, battery sizing, array sizing.
Wind: three phase AC voltage controllers - AC-DC-AC converters: uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters - matrix converters.

UNIT IV ANALYSIS OF WIND AND PV SYSTEMS
Stand alone operation of fixed and variable speed wind energy conversion systems and solar system - Grid connection Issues - Grid integrated PMSG and SCIG Based WECS - Grid Integrated solar system.

UNIT V HYBRID RENEWABLE ENERGY SYSTEMS
Need for Hybrid Systems - Range and type of Hybrid systems - Case studies of Wind-PV - Maximum Power Point Tracking (MPPT).

TOTAL: 45 PERIODS

REFERENCES:
AIM:
To enlighten on various technological advancements, benefits and prospects of utilizing hydrogen/fuel cell for meeting the future energy requirements.

OBJECTIVES:
- To detail on the hydrogen production methodologies, possible applications and various storage options
- To discuss on the working of a typical fuel cell, its types and to elaborate on its thermodynamics and kinetics
- To analyze the cost effectiveness and eco-friendliness of Fuel Cells

UNIT I HYDROGEN – BASICS AND PRODUCTION TECHNIQUES
Hydrogen – physical and chemical properties, salient characteristics. Production of hydrogen – steam reforming – water electrolysis – gasification and woody biomass conversion – biological hydrogen production – photo dissociation – direct thermal or catalytic splitting of water

UNIT II HYDROGEN STORAGE AND APPLICATIONS

UNIT III FUEL CELLS
History – principle - working - thermodynamics and kinetics of fuel cell process – performance evaluation of fuel cell – comparison on battery Vs fuel cell

UNIT IV FUEL CELL – TYPES
Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerits

UNIT V APPLICATION OF FUEL CELL AND ECONOMICS
Fuel cell usage for domestic power systems, large scale power generation, Automobile, Space. Economic and environmental analysis on usage of Hydrogen and Fuel cell. Future trends in fuel cells

TOTAL: 45 PERIODS

OUTCOME:
- Fundamentally strong understanding on the working of various fuel cells, their relative advantages / disadvantages and hydrogen generation/storage technologies

REFERENCES
EY7004  ENERGY CONVERSION TECHNIQUES  

AIM:
To detail on the different technologies in general for converting one form of energy to another.

OBJECTIVES:
To analyze the working principle, pros and cons of
- Conventional energy conversion techniques
- Direct energy conversion systems
- Need and necessity of energy storage systems and their desirable characteristics & Fuel cells

UNIT I  CONVENTIONAL ENERGY CONVERSION CYCLES  

UNIT II  DIRECT CONVERSION OF THERMAL TO ELECTRICAL ENERGY  
Thermoelectric Converters –Thermionic converters – MHD – Ferro electric converter – Nernst effect generator

UNIT III  CHEMICAL & ELECTROMAGNETIC ENERGY TO ELECTRICAL ENERGY  

UNIT IV  ENERGY STORAGE SYSTEMS  
Energy Storage Technologies - Mechanical energy, Electrical energy, Chemical energy, Thermal energy

UNIT V  FUEL CELLS  

TOTAL: 45 PERIODS

OUTCOME:
Awareness on the existence of various mechanisms for conversion and storage of energy, their merits, constraints and drawbacks

REFERENCES

EY7005  SOLAR ENERGY TECHNOLOGIES  

AIM:
To understand the fundamentals of solar energy and its conversion techniques for both thermal and electrical energy applications
OBJECTIVES:
- To learn and study the radiation principles with respective solar energy estimation
- To learn about PV technology principles and techniques of various solar cells / materials for lister energy conversion
- To learn economical and environmental merits of solar energy for variety applications

UNIT I  SOLAR RADIATION AND COLLECTORS  9
Solar angles – Sun path diagrams – Radiation - extraterrestrial characteristics - measurement and estimation on horizontal and tilted surfaces - flat plate collector thermal analysis - testing methods- evacuated tubular collectors - concentrator collectors – classification - design and performance parameters - tracking systems - compound parabolic concentrators - parabolic trough concentrators - concentrators with point focus - Heliostats – performance of the collectors

UNIT II  SOLAR THERMAL TECHNOLOGIES  9

UNIT III  SOLAR PV FUNDAMENTALS  9

UNIT IV  SPV SYSTEM DESIGN AND APPLICATIONS  9
Solar cell array system analysis and performance prediction- Shadow analysis: reliability - solar cell array design concepts - PV system design - design process and optimization - detailed array design - storage autonomy - voltage regulation - maximum tracking - centralized and decentralized SPV systems - stand alone - hybrid and grid connected system - System installation - operation and maintenances - field experience - PV market analysis and economics of SPV systems

UNIT V  SOLAR PASSIVE ARCHITECTURE  9
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

OUTCOME:
1. Able to suggest and design a solar thermal based applications for a community
2. Will become expert in the design of solar photovoltaic based power systems for both domestic and industrial applications
3. Have the potential to apply the concept of utilization of solar energy for the said application in a economical way.

REFERENCES

TOTAL: 45 PERIODS
AIM:
To understand the fundamentals of wind energy and its conversion techniques for electrical energy applications

OBJECTIVES:
- To understand the fundamentals of wind energy and its conversion system
- To learn gear coupled generator wind turbine components
- To learn modern wind turbine control & monitoring

UNIT I  WIND ENERGY FUNDAMENTALS & WIND MEASUREMENTS  9

UNIT II  AERODYNAMICS THEORY & WIND TURBINE TYPES  9
Airfoil terminology, Blade element theory, Blade design, Rotor performance and dynamics, Balancing technique (Rotor & Blade), 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 GENERATOR WIND TURBINE COMPONENTS AND THEIR CONSTRUCTION  9

UNIT IV  DIRECT ROTOR COUPLED GENERATOR ( MULTIPOLE ) [VARIABLE SPEED VARIABLE FREQ.]  9
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  9

TOTAL: 45 PERIODS

OUTCOME:
- Knowledge in conversion techniques of wind energy
- Learning of wind turbine components and their construction
- Understating of modern wind turbine control & monitoring
REFERENCES
7. Anna Mani : Wind Energy Data for India
8. C-Wet : Wind Energy Resources Survey in India VI

EY7007 BIO - ENERGY CONVERSION TECHNIQUES

AIM:
To disseminate the technologies for utilizing bio-energy and its manifold benefits compared to conventional fossil fuels.

OBJECTIVES:
- To detail on the types of biomass, its surplus availability and characteristics.
- Analyze the technologies available for conversion of biomass to energy in terms of its technical competence and economic implications.

UNIT I INTRODUCTION

UNIT II BIOMETHANATION

UNIT III COMBUSTION
Perfect, complete and incomplete combustion - stoichiometric air requirement for biofuels - equivalence ratio – fixed Bed and fluid Bed combustion – fuel and ash handling systems – steam cost comparison with conventional fuels

UNIT IV GASIFICATION, PYROLYSIS AND CARBONISATION

23
UNIT V LIQUIFIED BIOFUELS

History of usage of Straight Vegetable Oil (SVO) as fuel - Biodiesel production from oil seeds, waste oils and algae - Process and chemistry - Biodiesel health effects / emissions / performance. Production of alcoholic fuels (methanol and ethanol) from biomass – engine modifications

TOTAL: 45 PERIODS

OUTCOME:

• A practical understanding on the various biomass energy conversion technologies and its relevance towards solving the present energy crisis.

REFERENCES

1. Tom B Reed, Biomass Gasification – Principles and Technology, Noyce Data Corporation, 1981
2. David Boyles, Bio Energy Technology Thermodynamics and costs, Ellis Hoknood Chichester, 1984.
7. Iyer PVR et al, Thermochemical Characterization of Biomass, M N E S

EY7008 NUCLEAR ENGINEERING

L T P C
3 0 0 3

AIM:

To provide in-depth knowledge on Nuclear reaction materials reprocessing techniques and also to understand nuclear waste disposal techniques and radiation protection aspects.

OBJECTIVES:

• To describe fundamental study of nuclear reactions
• To learn nuclear fuels cycles, characteristics. Fundamental principles governing nuclear fission chain reaction and fusion
• To discuss future nuclear reactor systems with respect to generation of energy, fuel breeding, incineration of nuclear material and safety.

UNIT I NUCLEAR REACTIONS

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

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

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 - Hexone - TBP and thorax Processes - oxidative slaging 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 HOURS : 45 PERIODS

OUTCOME:
- Understanding fundamentals of nuclear reactions
- Knowledge in nuclear fission chain reaction and fusion
- Awareness about reprocessing of spent fuel and waste disposal

REFERENCES

EY7009  COMPUTATIONAL FLUID DYNAMICS FOR ENERGY SYSTEMS

AIM:
This course aims to introduce numerical modeling and its role in the field of heat and fluid flow, it will enable the students to understand the various discretisation methods and solving methodologies and to create confidence to solve complex problems in the field of heat transfer and fluid dynamics

OBJECTIVES:
1. To understand the method of modelling the flow and heat transfer phenomenon.
2. To develop finite difference and finite volume discretized forms of the CFD equations.
3. To understand the various numerical schemes to solve convection and diffusion equations.

UNIT I  INTRODUCTION  10
Numerical simulation – Advantages, Methods of classification of PDE’s, Elliptic, parabolic and hyperbolic equations, Initial and boundary conditions, Discretisation Methods, Finite Difference Expressions from Taylor’s series, Uniform and non-uniform Grids - Numerical Errors, Grid Independence Test.

UNIT II  CONSERVATION EQUATION  10
Mass, Momentum and Energy Equation three dimensions, Eulerian and Lagrangian Approach, Equation of State, Navier’s Strokes equation, Differential and Integral form of general transport equations.
UNIT III  
CONDUCTION HEAT TRANSFER  
Steady one-dimensional conduction, Two and three dimensional steady state problems, Transient one-dimensional problem, Two-dimensional Transient Problems - Finite difference and Finite Volume approach  

UNIT IV  
INCOMPRESSIBLE FLUID FLOW  

UNIT V  
TURBULENCE MODELS  
Algebraic Models – One equation model, K – ε Models, Standard and High and Low Reynolds number models, Prediction of fluid flow and heat transfer using standard codes  

TOTAL: 45 PERIODS  
OUTCOME:  
Student will be able to apply the concept of computational fluid dynamics in the Energy systems to predict the actual performance  

REFERENCES  

AIM  
To introduce the advances in operations and applications of different types of power plants  

OBJECTIVES  
• To make the students to understand the energy scenario and the environmental issues related to the power plants  
• Creating awareness to the students on the various utilities in the power plants and the avenues for optimizing them
UNIT I INTRODUCTION
Overview of Indian power sector – load curves for various applications – types of power plants – merits and demerits – criteria for comparison and selection - Economics of power plants.

UNIT II STEAM POWER PLANTS

UNIT III DIESEL AND GAS TURBINE POWER PLANTS

UNIT IV ADVANCED POWER CYCLES

UNIT V HYDROELECTRIC & NUCLEAR POWER PLANTS
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 - Nuclear reactors & types – PWR, BWR, CANDU, Gas Cooled, Liquid Metal Cooled and Breeder reactor - nuclear safety – Environmental issues

OUTCOME:
Possible mitigation of anthropogenic emissions by optimizing the power plant cycles/utilities

REFERENCES

EY7010 STEAM GENERATOR TECHNOLOGY

AIM:
To understand the types, working of steam generator and their major components, along with design principles and calculations
OBJECTIVES:
- To educate the students on the types of boilers with their constructional and functional significance.
- To understand the working and design of fuel preparation units and boilers.
- To introduce the concept of boiler design, emission aspects

UNIT I  BASICS

UNIT II  FUELS & BOILER TYPES

UNIT III  COMPONENTS’ DESIGN
Furnace – Water Wall – Steam Drum – Attemperator - Superheaters – Reheaters – Air Preheaters – Economisers - Steam Turbines: Design Aspects of all these

UNIT IV  AUXILIARY EQUIPMENTS – DESIGN & SIZING
Forced Draft & Induced Draft Fans – PA / SA Fans – Water Pumps (Low Pressure & High Pressure) – Cooling Towers – Softener – DM Plant

UNIT V  EMISSION ASPECTS

TOTAL: 45 PERIODS

OUTCOME:
1. Familiarization with Boiler cycles, components and will have specialized knowledge in steam boiler performance evaluation
2. Emission related aspects in terms of CO2 NOx emission, mitigation etc will make them to realize the impact of Coal / fuel burning in the society

REFERENCES

EY7011  FLUIDIZED BED SYSTEMS

AIM:
To inspire the students with the theories of fluidization, heat transfer and design for various applications

OBJECTIVES:
- To introduce the concepts of fluidization and heat transfer in fluidized beds.
- To understand the design principles and apply the same for industrial applications.
UNIT I  FLUIDIZED BED BEHAVIOUR  12
Characterization of bed particles - comparison of different methods of gas - solid contacts. Fluidization phenomena - regimes of fluidization – bed pressure drop curve. Two phase and well-mixed theory of fluidization. Particle entrainment and elutriation – unique features of circulating fluidized beds

UNIT II  HEAT TRANSFER  6
Different modes of heat transfer in fluidized bed – bed to wall heat transfer – gas to solid heat transfer – radiant heat transfer – heat transfer to immersed surfaces. Methods for improvement – external heat exchangers – heat transfer and part load operations

UNIT III  COMBUSTION AND GASIFICATION  6
Fluidized bed combustion and gasification – stages of combustion of particles – performance - start-up methods. Pressurized fluidized beds

UNIT IV  DESIGN CONSIDERATIONS  9
Design of distributors – stoichiometric calculations – heat and mass balance – furnace design – design of heating surfaces – gas solid separators

UNIT V  INDUSTRIAL APPLICATIONS  12
Physical operations like transportation, mixing of fine powders, heat exchange, coating, drying and sizing. Cracking and reforming of hydrocarbons, carbonization, combustion and gasification. Sulphur retention and oxides of nitrogen emission Control

TOTAL: 45 PERIODS

OUTCOME:
When a student completes this subject, he / she can
- Understand the working principles, merits and limitations of fluidized bed systems
- Apply fluidized bed systems for a specific engineering applications
- Analyse the fluidized bed systems to improve and optimize its performance

REFERENCES

EY7012  ADVANCED ENERGY STORAGE TECHNOLOGIES  L T P C  3 0 0 3

AIM:
This course is intended to build up the necessary background to model and analyze the various types of energy storage systems

OBJECTIVES:
- To develop the ability to understand / analyse the various types of energy storage.
- To study the various applications of energy storage systems
## UNIT I  INTRODUCTION

Necessity of energy storage – types of energy storage – comparison of energy storage technologies – Applications

## UNIT II  THERMAL STORAGE SYSTEM

Thermal storage – Types – Modelling of thermal storage units – Simple water and rock bed storage system – pressurized water storage system – Modelling of phase change storage system – Simple units, packed bed storage units - Modelling using porous medium approach, Use of Transys

## UNIT III  ELECTRICAL ENERGY STORAGE

Fundamental concept of batteries – measuring of battery performance, charging and discharging of a battery, storage density, energy density, and safety issues. Types of batteries – Lead Acid, Nickel – Cadmium, Zinc Manganese dioxide and modern batteries for example (i) zinc-Air (ii) Nickel Hydride, (iii) Lithium Battery

## UNIT IV  FUEL CELL


## UNIT V  ALTERNATE ENERGY STORAGE TECHNOLOGIES

Flywheel, Super capacitors, Principles & Methods – Applications, Compressed air Energy storage, Concept of Hybrid Storage – Applications

**TOTAL HOURS : 45 PERIODS**

**OUTCOME:**

Able to analyze various types of energy storage devices and perform the selection based on technoeconomic viewpoint

**REFERENCES**

3. Electrochemical technologies for energy storage and conversion, Ru-shiliu, Leizhang, Xueliang sun, Wiley publications, 2012

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**EY7013  WASTE MANAGEMENT AND ENERGY RECOVERY**

**AIM:**
To motivate the students by highlighting the importance of waste management, high-grade energy generation from waste and hygienic waste disposal options

**OBJECTIVES:**
- To provide information on various methods of waste management
- To familiarize students with recent energy generation techniques
- To detail on the recent technologies of waste disposal and
- To make student realize on the importance of healthy environment
UNIT I CHARACTERISTICS AND PERSPECTIVES  

UNIT II UNIT OPERATIONS & TRANSFORMATION TECHNOLOGIES  
Separation & Processing : Size Reduction – Separation through Density Variation, Magnetic / Electric Field : Densification - Physical, Chemical and Biological Properties and Transformation Technologies – Selection of Proper Mix of Technologies

UNIT III WASTE DISPOSAL  

UNIT IV TRANSFORMATION TECHNOLOGIES AND VALUE ADDITION  

UNIT V HAZARDOUS WASTE MANAGEMENT & WASTE RECYCLING  

TOTAL: 45 PERIODS

OUTCOME:
1. Waste characterization, Segregation, Disposal etc will be made known
2. Technologies that are available for effective waste disposal along with pros / cons will become clearer to students
3. First hand information on present day waste related problems ( Hazardous Waste, Pharmaceutical Waste, Biomedical Waste etc ) that will be taught in this programme will make them understand the problem in a much sensible & realistic manner.

REFERENCES

EY7014 ENERGY EFFICIENT BUILDINGS  
L T P C 3 0 0 3

AIM: 
This course provides the concept of introducing energy efficient practices in building design and construction
OBJECTIVES:
- To learn the green buildings concepts applicable to modern buildings
- Acquaint students with the principle theories materials, construction techniques and to create energy efficient buildings

UNIT I INTRODUCTION
Conventional versus Energy Efficient buildings – Historical perspective - Water – Energy – IAQ requirement analysis – Future building design aspects – Criticality of resources and needs of modern living

UNIT II LANDSCAPE AND BUILDING ENVELOPES

UNIT III HEATING, VENTILATION AND AIR-CONDITIONING

UNIT IV ENERGY EFFICIENCY IN ELECTRICAL SYSTEM

UNIT V RENEWABLE SOURCES INTEGRATION
Introduction of renewable sources in buildings, Solar water heating, small wind turbines, stand alone PV systems, Hybrid system – Economics.

TOTAL: 45 PERIODS

OUTCOME:
Student will be able to do
(a) the energy audit in any type for buildings and suggest the conservation measures.
(b) Provide the renewable energy systems for the buildings

REFERENCES

TE7203 ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL L T P C
3 0 0 3

AIM:
To create awareness among the student community on anthropogenic degradation of environment and technologies available to limit the degradation.

OBJECTIVES:
- To impart knowledge on the atmosphere and its present condition, global warming and eco-legislations.
• To detail on the sources of air, water and noise pollution and possible solutions for mitigating their degradation.
• To elaborate on the technologies available for generating energy from waste.

UNIT I INTRODUCTION

UNIT II AIR POLLUTION
Pollutants - sources and effect – air pollution meteorology – atmospheric dispersion – indoor air quality - control methods and equipments - issues in air pollution control – air sampling and measurement.

UNIT III WATER POLLUTION
Water resources - water pollutants - characteristics – quality - water treatment systems – waste water treatment - treatment, utilization and disposal of sludge - monitoring compliance with standards.

UNIT IV WASTE MANAGEMENT

UNIT V OTHER TYPES OF POLLUTION FROM INDUSTRIES

TOTAL: 45 PERIODS

TEXT BOOKS:

REFERENCES

EY7015 ENERGY FORECASTING, MODELING AND PROJECT MANAGEMENT

AIM:
To impact knowledge on energy prediction for the future and to develop skills on the development of optimization model to meet the future energy demand

OBJECTIVES:
• To develop forecasting models and optimization models for energy planning.
• To equip the students in writing project proposals and making project cost estimation.
• To evaluate the limit cost of energy for various renewable energy systems
UNIT I  
ENERGY SCENARIO  
Role of energy in economic development and social transformation: Energy & GDP, GNP and its 
dynamics - Energy Sources and Overall Energy demand and Availability - Energy Consumption in 
various sectors and its changing pattern - Status of Nuclear and Renewable Energy: Present Status 
and future promise

UNIT II  
FORECASTING MODEL  
Forecasting Techniques - Regression Analysis - Double Moving Average - Double Experimental 
Smoothing - Triple Exponential Smoothing – ARIMA model - Validation techniques – Qualitative 
forecasting – Delphi technique - Concept of Neural Net Works

UNIT III  
OPTIMIZATION MODEL  
Principles of Optimization - Formulation of Objective Function - Constraints - Multi Objective 
Optimization – Mathematical Optimization Software – Development of Energy Optimization Model 
- Development of Scenarios – Sensitivity Analysis - Concept of Fuzzy Logic.

UNIT IV  
PROJECT MANAGEMENT  
Project Preparation – Feasibility Study – Detailed Project Report - Project Appraisal – Social-cost 
benefit Analysis - Project Cost Estimation – Project Risk Analysis - Project Financing – Financial 
Evaluation

UNIT V  
ENERGY POLICY  
solar mission - state solar energy policy - Framework of Central Electricity Authority (CEA), Central 
& States Electricity Regulatory Commissions (CERC & ERCs)

TOTAL: 45 PERIODS

OUTCOME:
- Knowledge in Energy prediction using various forecasting techniques
- Ability to develop optimization model for energy planning
- Understanding of National and state energy policies

REFERENCES
1. S. Makridakis, Forecasting Methods and applications. Wiley 1983
2. Yang X.S. Introduction to mathematical optimization: From linear programming to Metaheuristics, 
5. Armstrong, J.Scott (ed.) Principles of forecasting: a hand book for researchers and practitioners, 
Press, 2008