REGULATIONS - 2015

DEPARTMENT OF
MECHANICAL ENGINEERING

CURRICULUM AND SYLLABI OF
M.E. – ENERGY ENGINEERING
### SEMESTER – I

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

* - *Studies to demonstrate simple basic concepts and aspects of various Energy Technologies have to be carried out by the students in the II semester which will be evaluated by the Internal Examiner.*
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FORMAT FOR COURSE CODE

1 5 E N 2 3 C

Compulsory Course
Course Sequence Number
Semester Number
Specialization Name
Year of Regulation

1 5 E N 0 1 E

Elective Course
Course Sequence Number
Specialization Name
Year of Regulation
COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1 : apply second law of thermodynamics for the various concepts and thermodynamic relations. (K3, A4)
CO 2 : elucidate the three modes of heat transfer for the various applications. (K2,S1,A2)
CO 3 : design and analyze the performance of heat exchanges. (K4, A4)

UNIT I REVIEW OF THERMODYNAMICS AND SECOND LAW ANALYSIS  15
Basic concepts of thermodynamics; irreversibility; Review of basic laws of thermodynamics and their consequences; Concept of Exergy and Entropy; Exergy for closed system; Entropy generation; entropy balance for closed system; behavior of gases; Equations of state.

UNIT II THERMODYNAMIC RELATIONS  15
Phase equilibrium; phase rule without chemical reaction; chemical potential of ideal gases; T-ds equations for simple compressible systems; Helmholtz and Gibbs functions; Maxwell relations; generalized relations for changes in enthalpy; entropy and internal energy; equations for specific heats; Clausius clapeyron equation; Joule-Thomson and Joule coefficients; applications of thermodynamic relations.

UNIT III CONDUCTION HEAT TRANSFER  15
Review of the basic laws of conduction; One dimensional steady state conduction with variable thermal conductivity and with internal distributed heat source; Extended surfaces-review and design considerations; Two dimensional steady state conduction; Unsteady state conduction; solutions using Groebber's and Heisler's charts for plates, cylinders and spheres suddenly immersed in fluids.

UNIT IV CONVECTION AND RADIATION HEAT TRANSFER  15
Review of convection and radiation heat transfer laws, Natural and forced convection; Heat transfer in turbulent flow; eddy heat diffusivity; Reynold's analogy between skin friction and heat transfer; von Karman; turbulent flow through circular tubes; Review of radiation principles; diffuse surfaces and the Lambert’s Cosine law; Radiation through non-absorbing media; Hottel's method of successive reflections.

UNIT V HEAT EXCHANGERS  15

REFERENCES
COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1 : recognize the basic principles of concept of various forms of renewable energy (k3)
CO 2 : develop knowledge on solar radiation principles and its conversion (k2)
CO 3 : interpret the concepts of extraction of Wind Energy, various Bio-Energy Conversion techniques (k4)
CO 4 : familiarize with the concepts of Hydrogen Energy and other forms of Renewable Energy (k3)

UNIT I SOLAR ENERGY
Solar radiation its measurements and prediction - solar thermal flat plate collectors concentrating collectors – applications - heating, cooling, desalination, power generation, drying, cooking etc - principle of photovoltaic conversion of solar energy, types of solar cells and fabrication. Photovoltaic applications: battery charger, domestic lighting, street lighting, and water pumping, power generation schemes.

UNIT II WIND ENERGY

UNIT III BIO-ENERGY
Biomass resources and their classification - chemical constituents and physicochemical characteristics of biomass - Biomass conversion processes - Thermo chemical conversion: direct combustion, gasification, pyrolysis and liquefaction - biochemical conversion: anaerobic digestion, alcohol production from biomass - chemical conversion process: hydrolysis and hydrogenation. Biogas - generation - types of biogas Plants- applications

UNIT IV HYDROGEN AND FUEL CELLS
Thermodynamics and electrochemical principles - basic design, types, and applications - production methods - Biophotolysis: Hydrogen generation from algae biological pathways - Storage gaseous, cryogenic and metal hydride and transportation. Fuel cell – principle of working - various types - construction and applications.

UNIT V OTHER TYPES OF ENERGY
Ocean energy resources - principles of ocean thermal energy conversion systems - ocean thermal power plants - principles of ocean wave energy conversion and tidal energy conversion – hydropower – site selection, construction, environmental issues - geothermal energy - types of geothermal energy sites, site selection, and geothermal power plants.

L: 45 TOTAL: 45 PERIODS

REFERENCES
15EN13C  ENERGY CONSERVATION IN THERMAL AND ELECTRICAL UTILITIES  L T P C  3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: recognize the combustion process and able to calculate the amount of air required
for combustion of solid, liquid and gaseous fuels. (K2, S1)
CO 2: evaluate the performance of boilers and suggest energy conservation strategies.
(K4, S3)
CO 3: workout and suggest prevention techniques for energy loses in steam circuits. (K4, A3)
CO 4: carryout performance evaluation of electric motors, fans and pumps. Further,
identify energy conservation opportunities. (K3, A2)
CO 5: identify the new generation lightings and operating principles of energy efficiency
devices. (K3, A2)

UNIT I  FUELS AND COMBUSTION
Introduction to fuels - properties of fuel oil, coal and gas - storage, handling and preparation of
fuels - principles of combustion - combustion of oil, coal and gas - draft system – combustion
controls - Agro-residue/biomass handling, preparation and combustion.

UNIT II  BOILERS AND COGENERATION
Combustion in boilers - performances evaluation – direct and indirect method- analysis of losses -
feed water treatment, blow down - boiler efficiency calculation - energy conservation opportunities.
Cogeneration - principles & operation – Power Ratio - economics of cogeneration scheme –
classification - heat balance - steam turbine efficiency.

UNIT III  STEAM SYSTEM
Properties of steam - assessment of steam distribution losses, steam leakages, steam trapping -
condensate and flash steam recovery system - identifying opportunities for energy savings. Steam
utilization - Performance assessment - thermo-compressor, steam pipe insulation - condensate
pumping - steam dryers.

UNIT IV  ELECTRIC MOTORS, FANS AND PUMPS
Electric motor types - losses in induction motors - motor efficiency, factors affecting motor
performance - energy saving opportunities with energy efficient motors.
Fans and Pumps – types - performance evaluation - efficient system operation - flow control
strategies and energy conservation opportunities.

UNIT V  LIGHTING SYSTEM AND ENERGY EFFICIENCY DEVICES
Lighting sources - choice of lighting - luminance requirements and energy conservation avenues.
New generation luminaries - Light Emitting Diodes (LEDs) - high efficiency street lighting.
Maximum demand controllers – Automatic power factor controllers – Soft starters with energy
saver - electronic ballast - occupancy sensors – energy efficient lighting controls.

L: 45 TOTAL: 45 PERIODS

REFERENCES
15EN14C INSTRUMENTATION AND CONTROL FOR ENERGY SYSTEMS L T P C
3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: describe the basic characteristics of instruments for measurement of specific thermo physical properties and its applications. (k3)
CO 2: recognize the advanced measurement techniques (k2)
CO 3: interpret the concepts of system control and process parameters (k4)

UNIT I MEASUREMENT CHARACTERISTICS 9

UNIT II MEASUREMENT OF PHYSICAL QUANTITIES 9
Measurement of thermo – physical properties, instruments for measuring temperature - pressure and flow

UNIT III ADVANCE MEASUREMENT TECHNIQUES 9

UNIT IV CONTROL SYSTEMS 9

UNIT V DATA ACQUISITION AND PROCESSING 9
Multi Channel Data acquisition system – Architecture of data acquisition and computer control system - Compact Data loggers – Sensor based, Computerized data systems - Micro – computer interfacing - Intelligent instruments in use.

L: 45 TOTAL: 45 PERIODS

REFERENCES
15EN15C  INDUSTRIAL ENERGY MANAGEMENT  L T P C  3 0 0 3

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

CO 1 : realize the present energy scenario and the need for energy conservation and various energy conservation measures (K2, A2)

CO 2 : familiarize with various energy policies (National and International) & standards. (K2, A1)

CO 3 : comprehend the concepts of recovery system and perform energy analysis. (K2,A3)

CO 4 : conduct energy audit and optimize energy requirements. (K3, A4)

CO 5 : recognize the economics of energy conservation schemes in industrial energy management systems (k2, A1)

UNIT I  INTRODUCTION  9

UNIT II  ENERGY POLICIES  9
National energy policy in the last plan periods, Energy use and Energy supply, Overview of renewable energy policy and the Five Year Plan programmes, Basic concept of Input-Output analysis, Concept of energy multiplier and implication of energy multiplier for analysis of regional and national energy policy- Carbon Trading- Renewable Energy Certification - CDM

UNIT III  WASTE HEAT RECOVERY  9

UNIT IV  ENERGY CONSERVATION AND AUDITING  9
Definition, need, and types of energy audit; Energy management (audit) approach: Understanding energy costs, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements; Fuel & energy substitution. Energy auditing - types, methodologies, barriers. Energy audit instruments; Duties and responsibilities of energy managers and auditors - Energy audit questionnaire.

UNIT V  ENERGY MANAGEMENT  9

L: 45 TOTAL: 45 PERIODS

REFERENCES
15EN16C  ENERGY LABORATORY-I

COURSE OUTCOMES

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

CO 1: carry out the performance analysis and optimization of energy utilities
CO 2: familiarize with the parameters that affect the performance of energy systems
CO 3: analyze the characteristics of various fuels

RENEWABLE ENERGY

1. Performance testing of Solar Water Collector
2. Characteristics of Solar photovoltaic devices
   - Investigation of PV Characteristics – Amorphous Silicon.
   - Investigation of PV Characteristics – Amorphous Silicon – Shadow effect
   - Comparative Performance Analysis of Mono & Poly Crystalline Silicon PV cell
3. Testing of Gasifier
4. Properties of Fuels
   - Determination of Flash and Fire Point using Pensky Marten Apparatus
   - Determination of Flash and Fire Point using Abel Apparatus
   - Determination of Density and Dynamic Viscosity of oil using Redwood Viscometer
5. Solar Radiation measurement
6. Performance testing of Solar Air Heater
7. Performance testing of Solar Still
8. Performance Study on Concentric Collectors
9. Study of biogas plant

ENERGY CONSERVATION

1. Performance Test of Parallel flow and Counter flow Heat Exchanger
2. Energy consumption measurement of lighting systems
3. Performance Test on Vapour Compression Refrigeration Systems
4. Performance Test on Air conditioning Systems

ADVANCED ENERGY SYSTEMS

1. Thermal Storage Systems

P: 60 TOTAL: 60 PERIODS
15EN21C SOLAR ENERGY AND UTILIZATION L T P C 3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1 : predict and estimate solar energy potential and its availability (K4, A2)
CO 2 : examine various collecting techniques of solar energy and its storage (K4)
CO 3 : interpret PV technology principles and conversion of Solar energy into Electricity (K2, A1)
CO 4 : reveal the economical and environmental merits of solar energy for variety of applications (K2, A2)

UNIT I SOLAR RADIATION

UNIT II SOLAR COLLECTORS

UNIT III PHOTOVOLTAIC SYSTEMS
Conversion of Solar energy into Electricity - Photovoltaic Effect, Photovoltaic material - Solar Cell – Module – Silicon solar cell, Efficiency limits, Variation of efficiency with band-gap and temperature, Efficiency measurements, High efficiency cells, Recent developments in Solar Cells - PV systems - applications

UNIT IV ENERGY STORAGE
Sensible Heat Storage – Liquid media storage – Solid media storage – Latent heat storage - Phase change materials – Chemical storage

UNIT V INDUSTRIAL APPLICATIONS OF SOLAR HEAT

L: 45 TOTAL: 45 PERIODS

REFERENCES
15EN22C WIND ENERGY TECHNOLOGY

3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
- CO 1: comprehend the fundamentals of wind energy and its conversion system (K3)
- CO 2: disseminate with the wind measurement techniques (K4)
- CO 3: summarize the concepts of aerodynamics, wind farms and cycles (K4)
- CO 4: analyze the economics of wind energy systems (K4)

UNIT I WIND CHARACTERISTICS AND RESOURCES

UNIT II AERODYNAMICS OF WIND TURBINES

UNIT III MODERN WIND TURBINE CONTROL AND MONITORING SYSTEM

UNIT IV CONCEPT OF WIND FARMS
Wind Farms - Site Preparation-Installation and Operation Issues - Wind Farms in Electrical Grids-Typical Grid-connected Turbine Operation. Environmental concerns: Pollution free power; Noise; birds; Aesthetics, Radio waves, interference, Rainfall,

UNIT V ECONOMICS ANALYSIS

L:45 TOTAL: 45 PERIODS

REFERENCES
15EN23C BIO ENERGY ENGINEERING L T P C
3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: classify the types of biomass and its surplus availability. (K4)
CO 2: analyze the bio-chemical energy conversion processes and technologies
in terms of its technical competence and economic implications. (K3)

UNIT I INTRODUCTION 9
Biomass: types – advantages and drawbacks – Indian scenario – characteristics – carbon
neutrality – conversion mechanisms – fuel assessment studies

UNIT II BIO METHANATION 9
Microbial systems – phases in biogas production – parameters affecting gas production – effect
of additives on biogas yield – possible feed stocks. Biogas plants – types – design – constructional
details and comparison – biogas appliances – Burner, illumination and power generation – effect
on engine performance. Kinetics and mechanism - High rate digesters for industrial waste water
treatment.

UNIT III COMBUSTION 9
Perfect, complete and incomplete – equivalence ratio – fixed Bed, fluid Bed – fuel and ash
handling – steam cost comparison with conventional fuels. Briquetting: types of Briquetting –
merits and demerits – feed requirements and preprocessing – advantages – drawbacks

UNIT IV GASIFICATION 9
100 % Gas Engines – engine characteristics on gas mode – gas cooling and cleaning train.

UNIT V PYROLYSIS AND CARBONIZATION 9
Pyrolysis-Types – process governing parameters – differential thermal analysis – differential
scanning calorimetry – Typical yield rates. Effect of carbonisation temperature on yield and
composition of charcoal- Industrial safety in carbonization.

L: 45 TOTAL: 45 PERIODS

REFERENCES
industries”, John Wiley and Sons, 209
2006
Engineers and Scientists”, Taylor & Francis, 2005
6. IEEE Journals for Power, Energy, & Industry Applications
COURSE OUTCOMES

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

CO 1: simulate and predict the performance of various energy utilities
CO 2: analyze the effect of constraints on the performance of energy systems
CO 3: model and simulate various energy systems to optimize the performance

I Cycle (using ANSYS)

- Steady State Conductive Heat Transfer Analysis in a cubical block
- Analysis of Thermal Mixed Boundary for an infinitely long block
- Analysis of Transient Thermal Heat Conduction for an infinitely long block
- Study of temperature distribution along a Straight rectangular stainless steel cooling fin
- Determination of heat conducted by a Cooling Spine
- Laminar Flow Analysis in a 2D Duct
- Analysis of flow in a System of Pipes to compute the velocity distribution

II Cycle (using TRNSYS)

- Performance analysis of Solar Flat Plate Collecting System
- Performance analysis of Solar Evacuated Tube Collecting System
- Performance analysis of Spiral Flow Solar Water Heating System
- Performance analysis of Solar Air Heating System
- Cooling tower Analysis
- Performance analysis of Solar PV

P: 60 TOTAL: 60 PERIODS
15EN26C RESEARCH PAPER AND PATENT REVIEW – SEMINAR L T P C
0 0 4 2

The student will make at least two technical presentations on current topics related to the specialization. The same will be assessed by a committee appointed by the department. The students are expected to submit a report at the end of the semester covering the various aspects of his/her presentation together with the observation in industry visits.

P:60; TOTAL: 60 PERIODS
15EN01E  ELECTRICAL TECHNOLOGY FOR ENERGY SYSTEMS  L T P C
3  0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1 : realize the basic working principles of Generators.(K3)
CO 2 : classify the various types of Energy Saving Methods and storage concepts of
electricity (K3)
CO 3 : familiarize with the concepts of Electricity Transmission & Distribution (K3)
CO 4 : recognize the concepts of Wheeling and Power Evacuation of Wind & Solar
power (K4)

UNIT I  GENERATION OF ELECTRICAL ENERGY  9
Sources of Electrical Energy - Working Principle of Generator - Classification of A.C and D.C
Generators – Energy requirements – Maximum Demand – Types of Electrical load - Energy
Savings in three phase Induction motor.

UNIT II  ELECTRICAL ENERGY STORAGE  9
Introduction to Electrical Energy storage - Types of storage – Electrical Storage – Batteries –
Types – Selection of Batteries - Capacitor – Super capacitors. Sine wave Inverter

UNIT III  ELECTRICITY TRANSMISSION AND DISTRIBUTION  9
Introduction to Transmission – Sub transmission – Types of transmission – Losses in transmission –
Control strategies in Grid – Types of grid – Distribution – Types of Distribution - Transformer -
Working Principle.

UNIT IV  ELECTRICAL SYSTEM FOR WIND ENERGY SYSTEMS  9
Generators for wind energy applications – Types of generators - Grid Connected and self excited

UNIT V  ELECTRICAL SYSTEM FOR SOLAR ENERGY SYSTEMS  9
Introduction – Balance of System – Tracking – Types of tracking – MPPT - Converter –
Standalone System – Grid-Tied System – Data monitoring – Types - Remote – On-site monitoring

L: 45 TOTAL: 45 PERIODS

REFERENCES
2. S.N.Bhadra, D.Kastha and S. Banerjee, “Wind electrical systems”, Oxford University Press,
   2005
3. Chetan Singh Solanki “Solar Photovoltaic Technology and systems”, Prentice Hall of India,
   2013
   New Age International 2005.
   2011.
15EN02E  THERMAL ENERGY SYSTEMS FOR ELECTRICAL ENGINEERS

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: describe the fluid properties and concepts of fluid Mechanics (K2, A1)
CO 2: explain the basic concepts and laws of thermodynamics (K2, A1)
CO 3: apply the properties of steam in the analysis of steam power cycles (K3, A2)
CO 4: discuss the working principles of various compressors, refrigeration and air-conditioning systems (K2, A1)

UNIT I   BASIC CONCEPTS OF FLUID MECHANICS

UNIT II   BASIC CONCEPTS AND LAWS OF THERMODYNAMICS

UNIT III   STEAM BOILERS AND TURBINES
Formation of steam - Properties of steam – Use of steam tables and charts – Steam power cycle (Rankine) - Deviation of Actual Vapor Power Cycles from Idealized Ones, Reheat cycle, Regenerative cycle

UNIT IV   COMPRESSORS

UNIT V   REFRIGERATION AND AIR CONDITIONING
Refrigeration - Various methods of producing refrigerating effects (RE) – Vapour compression cycle: P-H and T-S diagram - Saturation cycles - Effect of subcooling and super heating – Other Refrigeration Systems (Qualitative treatment only)
Air-conditioning systems – Basic psychrometry - Simple psychometric processes - Types of airconditioning systems - Selection criteria for a particular application (qualitative treatment only).

L:45 TOTAL: 45 PERIODS

REFERENCES
15EN03E ADVANCED POWER PLANT ENGINEERING  L  T  P  C  
3  0  0  3  

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: analyze the steam and gas power cycles and its possible improvements. (K4, A2)
CO 2: realize the advances in hydro, nuclear and MHD power plants. (K2, A1)
CO 3: identify the economic feasibility and issues related to the power plants. (K2, A1)

UNIT I ANALYSIS OF STEAM POWER PLANTS (SPP)  9
Components of steam power plants, typical layout, Rankine Cycle – performance - energy analysis of Rankine cycle - cycle improvements – Ideal reheating Rankine cycle - The Ideal Regenerative Rankine Cycle - Open Feedwater Heaters - Closed Feedwater Heaters

UNIT II ANALYSIS OF HYDROELECTRIC POWER PLANTS (HEPP)  9
Components of HEPP, typical layout, Classification of Hydraulic Turbines - Pelton, Francis, Kaplan, Propeller, Deriaz and Bulb turbines – specific speed – hydraulic efficiency and comparison - Performance of turbines – Constant head characteristics, Constant speed characteristics and Constant efficiency curves.

UNIT III ANALYSIS OF GAS TURBINE POWER PLANTS  9

UNIT IV NUCLEAR AND MHD POWER PLANTS  9
Overview of Nuclear power plants - radioactivity - fission process- reaction rates - elastic scattering and slowing down - criticality calculations – critical heat flux - power reactors - nuclear safety. MHD and MHD - steam power plants.

UNIT V ECONOMIC ASPECTS OF POWER PLANT OPERATION  9
Load curves, load factor, diversity factors and their significance, Economic scheduling of power stations. Interest and depreciation, Costs of electrical energy, Methods of determining depreciation Tariff, characteristics and types of tariff. Economic efficiency - Payback period and Net-present value methods to assess financial efficiency of power plants.

L: 45 TOTAL: 45 PERIODS

REFERENCES
15EN04E ADVANCED THERMAL STORAGE TECHNOLOGIES L T P C
3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: familiarize with the various types of thermal storage systems and the storage materials (K2, A2)
CO 2: develop the model and analyze the sensible and latent heat storage units (K4, A3)
CO 3: recognize various applications of thermal storage systems (K2, A2)

UNIT I INTRODUCTION
Necessity of thermal storage – types-energy storage devices – comparison of energy storage technologies - seasonal thermal energy storage - storage materials.

UNIT II SENSIBLE HEAT STORAGE SYSTEM
Basic concepts and modeling of heat storage units - modeling of simple water and rock bed storage system – pressurized water storage system for power plant applications – packed beds.

UNIT III REGENERATORS

UNIT IV LATENT HEAT STORAGE SYSTEMS
Modeling of phase change problems – temperature based model - enthalpy model - porous medium approach - conduction dominated phase change – convection dominated phase change.

UNIT V APPLICATIONS
Specific areas of application of energy storage – food preservation – waste heat recovery – solar energy storage – green house heating – power plant applications – drying and heating for process industries.

L: 45 TOTAL: 45 PERIODS

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

CO 1: apply the concepts and principles in materials and engineering in the development and design of new product, to ensure quality assurance in the practice of material engineering. (K3)

CO 2: characterize the synthesized materials. (K2)

CO 3: gain fundamental understanding of electrical conduction (transport) in solids, major properties of bulk and nanostructured superconductors. (K2)

CO 4: create a scientific basis to ensure the safe and responsible development of engineered nanoparticles and nanotechnology-based materials and products (K5)

UNIT I ADVANCED MATERIALS AND TOOLS
Smart materials, exhibiting ferroelectric, piezoelectric, optoelectric, semiconducting behavior, lasers and optical fibers, photoconductivity and superconductivity, nanomaterials, synthesis, properties and applications.

UNIT II PHYSICAL METHODS FOR CHARACTERIZATION
X-ray diffraction, Powder diffraction, Single crystal X-ray diffraction, Electro-optical and related techniques like SEM, TEM, EDS, WDS/EPMA etc.; Spectroscopic techniques - Vibrational, UV-visible and Electron resonance spectroscopies. Thermal analysis (Differential thermal analysis, Thermogravimetric analysis, Differential scanning calorimetry)

UNIT III ELECTRONIC MATERIALS
Dielectric properties, Polarization mechanism, Frequency and Temperature effects, Electrical breakdown, Classification of ferroelectric materials, Piezoelectricity, Capacitor dielectric materials, Insulating materials and Pyroelectric materials, ceramic composites as capacitors & sensors.

UNIT IV SUPERCONDUCTIVITY
History and background of superconductivity, Superconducting phenomenon, low temperature Superconductors, Bardeen – Cooper and Schrieffer Theory (BCS), Cooper pair, High temperature Superconductivity. Applications of Superconductors.

UNIT V NANOMATERIALS AND NANOTECHNOLOGY
Top down and bottom up approaches, classification of nanomaterials, carbon nanotubes (CNT), particulate reinforced metal/ceramic/polymer nanocomposites, Characterization of nanomaterials, Applications of nanotechnology in medicine, automobile sector, Bragg reflector, Butterfly-wings, Different applications.

REFERENCES
15EN06E ALTERNATIVE FUELS

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: get an insight into the availability of petroleum based fuels, their progress and its influence on environment. (K2, A1)
CO 2: explore the need, production and technology of utilizing different alternative liquid and gaseous fuels for transportation which include alcohol, biodiesel, CNG, LPG, DME, DEE and hydrogen (K2)

UNIT I OVERVIEW

UNIT II VEGETABLE OILS AND OTHER SIMILAR FUELS DERIVED

UNIT III NATURAL GAS AND LPG

UNIT IV HYDROGEN AS ALTERNATIVE FUEL

UNIT V BIOGAS FOR IC ENGINES

REFERENCES
7. IEEE Journals for “Power, Energy & Industry Applications”
15EN07E  ANALYTICAL CHEMISTRY  L T P C
3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: select a proper chromatographic technique to isolate the compound. (K1)
CO 2: apply the knowledge in solving problems / tasks in the field of electro analytical chemistry. (K3)
CO 3: interpret the data and qualitative estimation by wet chemical analysis. (K2)
CO 4: evaluate and access chemical reaction and kinetic properties between 0-1600°C for compound. (K5)
CO 5: extend the knowledge of radiochemical analytical technique. (K2)

UNIT I  CHROMATOGRAPHIC METHODS

UNIT II  ELECTRO ANALYTICAL TECHNIQUES
Conductometry and its applications – Potentiometry – pH metry and ion selective electrodes – Electrogravimetry – Cyclic Voltammetry and its applications – Amperometric titrations and applications.

UNIT III  WET CHEMICAL METHODS OF ANALYSIS

UNIT IV  THERMAL METHODS
Principle, theory, instrumentation and applications of thermogravimetry (TGA) – Differential thermal analysis (DTA) – Differential scanning calorimetry (DSC).

UNIT V  RADIOCHEMICAL METHODS

L: 45 TOTAL: 45 PERIODS

REFERENCES
COURSE OUTCOMES

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

CO 1: realize the importance of cogeneration in improving the overall efficiency and economy and limiting global warming (K3, A2)

CO 2: analyze the basic energy generation cycles (K4, A3)

CO 3: interpret the concepts of cogeneration, its types and probable areas of applications (K3, A1)

CO 4: identify the significance of waste heat recovery systems and carry out its economic analysis (A3, K2)

UNIT I INTRODUCTION


UNIT II COGENERATION TECHNOLOGIES


UNIT III ISSUES AND APPLICATIONS OF COGENERATION TECHNOLOGIES


UNIT IV WASTE HEAT RECOVERY SYSTEMS


UNIT V ECONOMIC ANALYSIS

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: elucidate the structure of the coordination compounds. (K5)
CO 2: apply the theories and identify the nature of hybridization. (K3)
CO 3: assign term symbols for any transition metal complexes. (K4)
CO 4: identify the reaction mechanism of metal complexes. (K3)
CO 5: describe the keyways by which the biological important metal ion catalysis. (K5)

UNIT I NOMENCLATURE OF METAL COMPLEXES

UNIT II THEORIES OF COORDINATION COMPOUNDS
Valence bond theory – Electroneutrality principle and back bonding – Crystal field theory (CFT) – Assumptions of CFT theory – Crystal field splitting of d-orbitals in different geometries – Octahedral, square planar and tetrahedral complexes – Molecular orbital theory of π- bonding.

UNIT III SPECTRAL TERMS OF METAL COMPLEXES
Russell-Saunders state – Quantum numbers – Spin-spin coupling, orbit-orbit coupling and spin-orbit coupling – Orgel diagrams – Tanabe-sugano diagram for d³ complex – Electronic spectra of d⁰, d¹, d², d³, d⁴, d⁵, d⁶, d⁷ complexes – Charge transfer spectra.

UNIT IV REACTIONS OF METAL COMPLEXES
Ligand substitution reactions – S N1, S N2 and S N1CB mechanism – Outer sphere mechanism – Inner sphere mechanism – Trans effect – Theories of trans effect – Applications of trans effect.

UNIT V BIOLOGICAL IMPORTANCE OF METALS
Biological importance of transition metals; Biological roles of Mn, Fe, V, Cu, and Zn in proteins and enzymes – Electron transfer reactions in ferredoxins – Catalysis – blue-copper proteins – Metalloenzymes.

REFERENCES
15EN10E  DESIGN AND OPTIMIZATION OF ENERGY SYSTEMS  L T P C  3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: perform the Simulation and Modeling of typical energy system (K3, A3)
CO 2: analyse the effect of constraints on the performance of energy systems (K4)
CO 3: design energy systems and perform Energy-Economic Analysis for typical applications (K4, A3)

UNIT I  INTRODUCTION
Engineering Design- Design as Part of Engineering Enterprise- Thermal Systems

UNIT II  BASIC CONSIDERATIONS IN DESIGN

UNIT III  MODELING OF THERMAL SYSTEMS
Types of Models - Mathematical Modeling - Physical Modeling and Dimensional Analysis - Curve Fitting

UNIT IV  ECONOMIC CONSIDERATIONS
Introduction - Worth of Money as a Function of Time-Series of Payments - Economic Factor in Design- Application to Thermal Systems

UNIT V  OPTIMIZATION

L: 45 TOTAL: 45 PERIODS

REFERENCES
7. IEEE Journals for Power, Energy & Industry Applications
15EN11E   DESIGN OF HEAT EXCHANGERS                          L T P C
                                             3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: realize the basic principles of Heat transfer & Heat Exchangers and applications
(K2, A2)
CO 2: classify various types of flows and disturbances (K2)
CO 3: design Shell & Tube and Double-Pipe Heat Exchanger, Compact and Plate Heat
exchanger, Condenser and performance analysis of Cooling Towers (K4, A3)

UNIT I   FUNDAMENTALS OF HEAT EXCHANGER                                9
Introduction – Modes of Heat transfer - Temperature distribution and its implications types – Heat
exchangers – Classification - Regenerators and Recuperators – Analysis of heat exchangers –
Logarithmic Mean temperature difference – Number of transfer Units – Applications.

UNIT II   FLOW AND STRESS ANALYSIS                                      9
in tubes – Fouling – Process – types of fouling – control strategies - thermal stresses – types -
shear stresses

UNIT III   DOUBLE PIPE AND SHELL AND TUBE HEAT EXCHANGER                9
Introduction to Double pipe heat exchangers – Types – Bare inner tube – finned inner tube -
Design – Applications - Shell and tube heat exchangers - Types – Design – sizing of heat
exchangers – Pressure drop calculations - Applications

UNIT IV   COMPACT AND PLATE HEAT EXCHANGERS                               9
Introduction to Compact and Plate heat exchanger - Types – merits and demerits – design of
compact heat exchangers, plate heat exchangers – performance influencing parameters -
limitations.

UNIT V   CONDENSERS AND COOLING TOWERS                                  9
Condensers – Types – Shell & tube – Plate condenser - Design - Cooling tower – types – Natural
draft – Mechanical draft - performance characteristics – Range and approach of a cooling tower

L: 45 TOTAL: 45 PERIODS

REFERENCES
   Sons, 2003
   CRC Press, 2002
5. IEEE Journals for “Power, Energy & Industry Applications”
15EN12E  ENERGY EFFICIENT BUILDINGS  L T P C
3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: describe the basic concepts of building and its environment (K3)
CO 2: discuss the principle of energy conscious in buildings (K3)
CO 3: explain the level of human comfort in Green buildings (K2)
CO 4: acquire the knowledge about the different climatic zones (K4)
CO 5: summarize the concept of Energy managements in building (K4)

UNIT I  GENERAL ASPECTS  9

UNIT II  ENERGY CONCIOUS IN BUILDINGS  9

UNIT III  HUMAN COMFORT  9

UNIT IV  CLIMATE ZONES  9
Introduction - Climatic zones and their characteristics - Factors affecting climate- Implications of climate on building design- Urban climate-Microclimate

UNIT V  ENERGY MANAGEMENT SYSTEM  9

L: 45 TOTAL: 45 PERIODS

REFERENCES
**15EN13E ENERGY SYSTEM MODELING AND PROJECT MANAGEMENT**

**L T P C**

3 0 0 3

**COURSE OUTCOMES**

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

CO 1: model and simulate energy systems. (K3)

CO 2: apply new generation optimization techniques for energy system simulation. (K3)

CO 3: perform economic analysis of various renewable energy systems. (K3)

CO 4: categorize management strategies for project evaluation. (K4)

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**UNIT I INTRODUCTION**

9

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

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**UNIT II MODELING AND SYSTEMS SIMULATION**

9

Modeling of energy systems – heat exchanger - solar collectors – distillation - rectification turbo machinery components - refrigeration systems - information flow diagram - solution of set of nonlinear algebraic equations - successive substitution - Newton Raphson method - examples of energy systems simulation

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**UNIT III OPTIMISATION TECHNIQUES**

9


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**UNIT IV ECONOMIC ANALYSIS**

9


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**UNIT V PROJECT MANAGEMENT**

9


**L: 45 TOTAL 45 PERIODS**

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**REFERENCES**

15EN14E FLUIDIZED BED SYSTEMS

L T P C
3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: comprehend the concepts of fluidization and heat transfer in fluidized beds. (K4)
CO 2: recognize the design principles and apply the same for industrial applications. (K4)

UNIT I FLUIDIZED BED BEHAVIOUR
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
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
Fluidized bed combustion and gasification – stages of combustion of particles – performance -
start-up methods. Pressurized fluidized beds.

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

UNIT V INDUSTRIAL APPLICATIONS
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.

L: 45 TOTAL: 45 PERIODS

REFERENCES
4. C. K. Gupta, D. Sathiyamoorthy, „Fluid bed technology in materials processing”, CRC
   Press, 1999
COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: identify hydrogen production methodologies, possible applications and various storage options (K3)
CO 2: converse about the working of a typical fuel cell, its types and to elaborate on its thermodynamics and kinetics (K2)
CO 3: analyze the cost effectiveness and eco-friendliness of Fuel Cells (K4)

UNIT I  FUEL CELL BASICS
Fuel cell definition, Difference between batteries and fuel cells, fuel cell history, components of fuel cells, principle of working of fuel cells Fuel cell thermodynamics - second law analysis of fuel cells, efficiency of fuel cells fuel cell electrochemistry - Nernst equation, Electrochemical kinetics, Butler-Volmer equation

UNIT II  FUEL CELL TYPES
Classification by operating temperature/electrolyte type, Fuel Cell Performance, Activation, Ohmic and Concentration over potential

UNIT III  FUEL CELL DESIGN AND COMPONENTS
Cell components, stack components, system components Overview of intermediate/high temperature fuel cells - Solid oxide fuel cells (SOFC), Molten carbonate fuel cells (MCFC), Phosphoric acid fuel cells (PAFC) Polymer Electrolyte fuel cells ,Heat and mass transfer in polymer electrolyte fuel cells, water management in PEFCs, Current issues in PEFCs, Direct methanol fuel cells (DMFC) - Electrochemical kinetics methanol oxidation, Current issues in MFCs, Fuel crossover in DMFCs, Water management in DMFCs, high methanol concentration operation, limiting current density

UNIT IV  HYDROGEN PRODUCTION METHODS
Production of hydrogen from fossil fuels, electrolysis, thermal decomposition, photochemical and photo-catalytic methods.

UNIT V  HYDROGEN STORAGE METHODS
Metal hydrides, metallic alloy hydrides, carbon nano-tubes, sea as source of deuterium.

L: 45 TOTAL: 45 PERIODS

REFERENCES
4. Xianguo Li, “Principles of Fuel Cells”, Taylor and Francis, 2005
15EN16E HYDRO POWER TECHNOLOGY L T P C 3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: reveal the basic concepts of aerodynamics, horizontal and vertical axis wind turbines, small hydro system components (K2, A1)
CO 2: design and develop prototype systems (K4, A3)
CO 3: select and analyze the particular turbine for specific need (K4, A2)

UNIT I HYDROLOGY 9
Overview of Hydropower systems-Preliminary Investigation- Rainfall and Run of measurements-Hydrographs- flow duration graph and mass storage graphs- Determination of site selection- types hydro electric power plants- General arrangements and Layouts- Preparation of Reports and Estimates-Review of World Resources-Basic Factors in Economic Analysis of Hydropower projects-Project Feasibility-Load Prediction and Planned Development.

UNIT II DEVELOPMENT OF PROTOTYPE SYSTEMS 9

UNIT III SELECTION AND ANALYSIS OF TURBINES 9
Measurement of pressure head, Velocity- Various parameters for finding out the potential of Hydro Energy- Selection of turbines based on Specific quantities- Performance characteristics – Testing of hydraulic turbines - Governing of Impulse and reaction turbines.

UNIT IV HYDRO POWER STATION OPERATION, MAINTENANCE AND TROUBLE SHOOTING 9

UNIT V SMALL, MINI AND MICRO HYDRO POWER PLANTS TURBINES 9
Introduction – Analysis of Small, mini and micro hydro turbines – Economical and Electrical Aspects of Small, mini and micro hydro turbines- potential developments – Design and reliability of Small, mini and micro hydro turbines – Case Study. A compulsory Seminar/ Assignment on Design/Case Study/Analysis/Application in any one the Small, Mini and Micro Hydro Power Plants and Components (viz..Turbines, Controls, and Storage etc.)

L:45 TOTAL: 45 PERIODS

REFERENCES
15EN17E        MATERIAL SCIENCES AND ENGINEERING                       L T P C
                                                                 3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: select advanced materials for various engineering applications. (K2)
CO 2: analyze the crystal structure by knowing the bonding of materials. (K4)
CO 3: interpret the magnetic, electrical and thermal properties of materials. (K2)

UNIT I     ADVANCED MATERIALS                                    9
Materials and Engineering, Types of materials - Metallic materials - Dual phase steels, High
strength low alloy (HSLA) steel, Transformation induced plasticity (TRIP) Steel, Advanced
structural ceramics, WC, TiC, Al2O3, SiC, Si3N4, and diamond – properties, processing and
applications - Future trends in materials usage

UNIT II    ATOMIC STRUCTURE AND BONDING                          9
Structure of atoms - Bohr’s atomic model-Sommerfeld’s extension of atomic structure; Electronic
structure - Electronic configuration and Quantum numbers; Shapes of s,p,d,f orbitals - Pauli’s
exclusion principle - Hund’s Rule of maximum multiplicity- Aufbau principle, Types of atomic and
molecular bonding – Octet rule - Primary Bonds - Ionic Bonds, Covalent Bonds, Metallic Bonds -
Secondary Bonds - Permanent Dipole Bonds, Fluctuating Dipole Bonds

UNIT III   CRYSTAL STRUCTURE AND CRYSTAL GEOMETRY                9
Space lattice, crystal systems and Bravais lattices, principal metallic crystal structures, Miller
indices, crystallographic planes and directions, comparisons of principle metallic crystal structures,
volume and density calculations, crystal structure analysis.

UNIT IV    PHASE DIAGRAM AND PHASE TRANSFORMATION                 9
Gibbs phase rule, Binary alloy system, Iron-iron carbide diagram, Heat treatment of steels and
other non ferrous materials Solidification, crystalline imperfections and diffusion in solids Electrical,
optical and mechanical properties of materials.

UNIT V     MAGNETIC PROPERTIES OF THE MATERIALS                   9
Magnetic Properties - Definition of Magnetic Properties, Types of magneticbodies, Diamagnetism
and Pascal’s Constant, Russell-Saunders or LS Coupling, Multiple width Large compared to kT,
Multiple width small compared to kT, Stereo chemical applications of Magnetic Properties of the
First Transition Series, Determination of magnetic susceptibility by Gouy’s Method, Derivation of
Van Vleck formula for Susceptibility.

L: 45 TOTAL: 45 PERIODS

REFERENCES
1. W.D.Callister, Jr., "Materials Science and Engineering", Wiley India Private Limited, 2007
   Hill series in materials science, 2003
15EN18E MATERIALS FOR ENERGY APPLICATIONS L T P C
3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
- CO 1: realize the properties and characteristics of materials used in energy applications (K2)
- CO 2: acquire the concepts and technologies for manufacturing the solar cells (K2)
- CO 3: summarize the various heat storage media viz., rock-bed, earth, Aquifers etc. (K2)

UNIT I MATERIALS 9

UNIT II PHYSICS OF SOLAR CELLS 9
Intrinsic, extrinsic and compound semiconductors, Electrical conductivity, Density of electrons and holes, Carrier transport: Drift, diffusion, Absorption of light, Recombination process, Materials for Photovoltaic's Conversion, Si and Non-Si materials, crystalline, semi-crystalline, Polycrystalline and Amorphous materials, p-n junction: homo and hetero junctions, Metal-semiconductor interface

UNIT III TECHNOLOGY FOR SI EXTRACTION 9
Purification, Method of doping and junction fabrication, Cell fabrication and metallization techniques: Preparation of metallurgical, electronic and solar grade Silicon, Production of single crystal Silicon: Procedure of masking, photolithography and etching, Design of complete silicon, GaAs, InP solar cell.

UNIT IV SENSIBLE HEAT STORAGE MATERIALS 9

UNIT V PHASE CHANGE MATERIALS, PIEZOELECTRICITY AND FERROELECTRICITY 9
Selection criteria of Phase change, Materials use in Solar heating or cooling, Research Status Optical properties, Interaction of solids with radiation, Luminescence, Photoconductivity.

L: 45 TOTAL: 45 PERIODS

REFERENCES
7. IEEE Journals for “Power, Energy & Industry Applications”
COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: comprehend the fundamentals of nuclear reactions (K3)
CO 2: infer nuclear fuels cycles, characteristics, fundamental principles governing nuclear
   fission chain reaction and fusion (K3)
CO 3: develop awareness on future nuclear reactor systems with respect to generation of
   energy, fuel breeding, incineration of nuclear material and safety. (K4)

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 - 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.

L: 45 TOTAL: 45 PERIODS

REFERENCES
1. Raymond LeRoy Murray, “Nuclear energy: an introduction to the concepts, systems, and
COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: ensure the safe and responsible development of engineered nanoparticles and nanotechnology based materials and products. (K2)
CO 2: recognize the risks of nanomaterials for health and the environment (K2)
CO 3: explore, characterize and evaluate unique nanoscale packaging materials for thin film passive components. (k2)
CO 4: familiarize with semiconductors and devices including the P-N junction, and the transistors. (k2)

UNIT I  FUNDAMENTALS OF SOLID STATE ENGINEERING
Future of semiconductor device and research, Applications in food, energy, transportation, communication, entertainment, health and medicine etc. Necessity of innovative technology and prospect for future.

UNIT II  CRYSTALLINE PROPERTIES OF SOLID
Crystal lattice and seven crystal systems, the unit cell concept, The Weigner-Seitz cell, Bravais lattices, Space and point groups, Miller indices, reciprocal lattice, Brillouin zone.

UNIT III  SEMICONDUCTOR HETEROSTRUCTURES AND LOW-DIMENSIONAL QUANTUM STRUCTURES
Energy bands, Application of model solid theory, Anderson model for heterojunctions, Multiple quantum wells (MQWs) and super lattices, Two-dimensional nanostructure: quantum well, One-dimensional nanostructure: quantum wire, Zero-dimensional nanostructure: quantum dot, Optical properties of low-dimensional structures, Examples and applications in real world.

UNIT IV  FABRICATION OF NANOSTRUCTURES
Basic compound semiconductors, Bulk single crystal growth techniques, Epitaxial growth techniques, Physical vapor deposition and sputtering, Thermodynamics and kinetics of growths, Nan scale growth modes

UNIT V  CHARACTERIZATION TECHNIQUES
Structural, X-ray diffraction, Electron microscopy, Energy dispersive analysis using X-rays, X-ray photoelectron spectroscopy, Secondary ion mass spectroscopy, Rutherford backscattering, Scanning probe microscopy, Optical, Photoluminescence spectroscopy, Absorbance measurement, Raman spectroscopy, Fourier transform spectroscopy.

L: 45 TOTAL: 45 PERIODS

REFERENCES
15EN21E  PHYSICAL ORGANIC CHEMISTRY  L T P C
3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: draw mechanism, knowledge, reactivity and their structure in various molecular
rearrangement. (K3)
CO 2: recall reagents and predict products for a defined set of organic reactions and to
propose mechanism. (K2)
CO 3: determine the electronic structure of solids and crystal / (dis) order and defects. (K3)
CO 4: outline the mechanistic aspect for the important photochemical reaction. (K2)
CO 5: evaluate and choose appropriate reagent for selective functional group transformations
and to discuss the mechanism of important organic transformations. (K4)

UNIT I   MOLECULAR REARRANGEMENTS  9
Types of rearrangements, Nucleophilic, electrophilic and free radical reactions – Wagner -
Meerwein – Pinacol-Pinacolone – Benzil-Benzielic acid – Demjanov – Baeyer Villiger and Curtius
rearrangements.

UNIT II  NAME REACTIONS  9
Mechanism of the following reactions: Aldol condensation – Perkin reaction – Stobbe
condensation – McMurry reaction – Fries rearrangement – Sandmeyer reaction – Schmidt
rearrangement – Sonogashira coupling reaction – Kolbe reaction.

UNIT III  SOLID STATE  9
Structure of Solids – Crystalline and amorphous solids – Basic crystal systems – Crystal structures
of sodium chloride, zinc blende, wurtzite, rutile – Schottky defects – Frenkel defects – Optical and
electrical properties of semiconductors – Photovoltaic effect.

UNIT IV  PHOTOCHEMISTRY  9
Introduction to photochemical reactions – Cis-trans isomerisation – Paterno-Buchi reaction –
Norrish type I & II reaction – Photo reduction of Ketones – Photochemistry of arenes – Barton
reaction – Photophysical process.

UNIT V  REAGENTS IN ORGANIC SYNTHESIS  9
Reagents for organic synthesis and functional group transformations: Lithium aluminum hydride –
Gilman’s reagent – Sodiumborohydride – LDA – DCC – Von Rudloff reagent – Lemieux-Johnson

REFERENCES
   2004.
   2014.
15EN22E       SOLAR ARCHITECTURE       L T P C
                          3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
   CO 1: elaborate the current trends in solar architecture and following key concepts:
          Solar Passive Architecture and heat transfer in buildings (K3)
   CO 2: recognize the Natural Heating/Cooling concepts for Building, Earth to Air Heat
          exchanger, Thermal Comfort Requirements (K4)
   CO 3: outline the concept of Energy Conservation & Concept of Zero Energy Buildings
          (K2)

UNIT I      INTRODUCTION  9

UNIT II     PASSIVE HEATING AND COOLING CONCEPTS  9

UNIT III    THERMAL ANALYSIS AND DESIGN FOR HUMAN COMFORT  9
Thermal comfort, Criteria and various parameters, Psychometric chart, Thermal indices, Climate and comfort zones, Concept of sol-air temperature and its significance, Calculation of instantaneous heat gain through building envelope, Calculation of solar radiation on buildings, Building orientation, Introduction to design of shading devices, Overhangs, Factors that affect energy use in buildings, Ventilation and its significance, Air-conditioning systems.

UNIT IV     HEAT TRANSMISSION IN BUILDINGS  9
Surface co-efficient: air cavity, internal and external surfaces, overall thermal transmittance, Wall and windows, Heat transfer due to ventilation/infiltration, internal heat transfer, solar temperature, Decrement factor, Phase lag, Day lighting, Estimation of Building loads: Steady state method, network method, numerical method, correlations.

UNIT V      PASSIVE SOLAR DESIGNS OF BUILDING  9
Thumb rules for design of buildings and building codes, Typical design of selected buildings in various climatic zones, Simulation Software’s for carrying out thermal design of buildings and predicting performance.

L: 45 TOTAL: 45 PERIODS

REFERENCES
5. DS Lal “Climatology”, Sharda Pustak Bhawan, Allahabad, 2003
8. IEEE Journals for “Power, Energy & Industry Applications”
COURSE OUTCOMES

Upon completion of this course, the students will be able to
- CO 1: describe the physics of photo cells (K3)
- CO 2: compare various technologies along with their pros & cons (K4)
- CO 3: design & analyze on-grid and off-grid PV applications (K4)
- CO 4: realize cost benefit analysis of PV installations (K3)

UNIT I SOLAR CELL FUNDAMENTALS


UNIT II SOLAR CELL TECHNOLOGIES


UNIT III ON-GRID APPLICATIONS


UNIT IV OFF-GRID APPLICATIONS


UNIT V COMMERCIALS FOR SOLAR PV INSTALLATIONS


L: 45 TOTAL: 45 PERIODS

REFERENCES

6. www.pveducation.org
COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: realize the Basic Thermodynamic Modelling, Design Studies and Evaluation methods for Solar Cooling Systems. (K2, A1)
CO 2: familiarize with the economical use of the systems (K2, A1)

UNIT I   INTRODUCTION
Potential and scope of solar cooling. Types of solar cooling systems, solar collectors and storage systems for solar refrigeration and airconditioning.

UNIT II   VAPOUR ABSORPTION AND COMPRESSION REFRIGERATION SYSTEMS

UNIT III   THERMODYNAMIC MODELLING
Thermal modelling and computer simulation for continuous and intermittent solar refrigeration and airconditioning systems.

UNIT IV   SOLAR COOLING SYSTEMS

UNIT V   ECONOMICS
Solar thermoelectric refrigeration and airconditioning. Solar economics of cooling systems.

L: 45 TOTAL: 45 PERIODS

REFERENCES
5. IEEE Journals for “Power, Energy & Industry Applications”
15EN25E  SPECTROSCOPIC METHODS IN CHEMISTRY  
L T P C  
3 0 0 3

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: elucidate the electronic transition and the effect of conjugation present in the metal complex. (K2)
CO 2: identify the functional group and vibration of any metal complex. (K2)
CO 3: predict the splitting pattern and interpret integration of NMR spectra. (K3)
CO 4: predict the fragmentation pattern to find molecular mass and to identify the structure of a compound. (K3)
CO 5: interpret experiment spectra and analyzing the results to identify the geometry of the compound. (K2)

UNIT I  ULTRAVIOLET SPECTROSCOPY  
Electronic energy levels – Types of electronic excitations in UV-Vis spectroscopy – Change in position and intensity of absorption – Chromophores and auxochromes – Factors affecting the position of UV bands – Application of UV-Vis spectroscopy to transition metal complexes.

UNIT II  INFRARED SPECTROSCOPY  
Absorption of IR radiation and molecular vibrations – Spectral feature of major functional groups and interpretation of aromatic compounds – Characteristic IR absorption frequencies of important functional groups – Distinction between intermolecular and intramolecular hydrogen bonding – Applications of IR Spectroscopy.

UNIT III  NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY  
Principles of ¹H,¹³C NMR – Shielding mechanism – Chemical shift – Spin-Spin coupling – Coupling constants – Splitting of signals – Applications of NMR to organic compounds.

UNIT IV  MASS SPECTROMETRY  

UNIT V  ELECTRON SPIN RESONANCE (ESR) SPECTROSCOPY  

L: 45 TOTAL: 45 PERIODS

REFERENCES
COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO 1: reveal the various methods of waste management (K2, A1)
CO 2: familiarize with recent energy generation techniques and recent technologies of waste disposal (K2, A1)
CO 3: realize the importance of healthy environment (K2, A1)

UNIT I SOLID WASTE – CHARACTERISTICS AND PERSPECTIVES
Definition - types – sources – generation and estimation. Properties: physical, chemical and biological – regulation

UNIT II COLLECTION, TRANSPORTATION AND PROCESSING TECHNIQUES
Onsite handling, storage and processing – types of waste collection mechanisms - transfer Stations : types and location – manual component separation – volume reduction : mechanical, thermal – separation : mechanical, magnetic electro mechanical

UNIT III LIQUID WASTE MANAGEMENT

UNIT IV HAZARDOUS WASTE MANAGEMENT

UNIT V ULTIMATE DISPOSAL

REFERENCES