NATIONAL ENGINEERING COLLEGE

(An Autonomous Institution – Affiliated to Anna University Chennai)

K.R.NAGAR, KOVILPATTI – 628 503

www.nec.edu.in

REGULATIONS - 2013

DEPARTMENT OF

MECHANICAL ENGINEERING

CURRICULUM AND SYLLABI OF

M.E. – ENERGY ENGINEERING

National Engineering College, K. R. Nagar, Kovilpatti-628503

(An Autonomous Institution Affiliated to Anna University Chennai)

Centre for Energy Studies

Programme Educational Objectives (PEOs)

- Produce researchers in the field of Renewable and Non-renewable Energy Technology.
- Prepare students to pursue research for emerging as a good academician in a leading Institution as well as acquire full-fledged knowledge in the technological advancements of a specific energy field to serve in an industry.
- Equip the students to understand and evaluate alternative modes of energy source and planning of energy source-demand chain.

Programme Outcomes (POs)

The students will attain the following outcomes:

a. an ability to apply knowledge of mathematics, science, and engineering to the field of study to pursue research and excel as professionals in the various fields of Energy Engineering
b. an ability to apply energy, momentum, continuity, state and constitutive equations to thermal, fluids and Energy systems in a logical and discerning manner.
c. an ability to create, select and apply appropriate techniques, resources, and modern engineering tools, including prediction and modeling, to complex energy engineering activities, with an understanding of the limitations.
d. an ability to design solutions for complex energy systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and ethical considerations.
e. an ability to understand energy and environmental problems and conduct investigations of various renewable energy technologies including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.
f. an ability to understand the potential in Solar Energy, the energy of future and to develop the technologies that make it economical for the production of energy.
g. an ability to communicate effectively on energy engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
h. an ability to function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.

REGULATIONS - 2013

M.E. ENERGY ENGINEERING

CURRICULUM I TO IV SEMESTERS (FULL TIME)

SEMESTER I

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	EEC11	Advanced Thermal Engineering	3	1	0	4
2	EEC12	Instrumentation and Control in Energy Systems	3	0	0	3
3	EEC13	Electrical Technology for Energy Engineers	3	0	0	3
4	EEC14	Energy Planning, Conservation and Management	3	0	0	3
5	EEC15	Renewable Energy Sources, Conversion and Technology	3	0	0	3
6	EEC16	Waste Management and Energy Recovery	3	0	0	3
PRACTICAL						
7	EEC17	Energy Lab – I	0	0	3	2
		TOTAL	**18**	**1**	**3**	**21**

SEMESTER II

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	EEC21	Solar Energy and Utilization	3	0	0	3
2	EEC22	Wind Energy Technology	3	0	0	3
3	EEC23	Bio Energy Engineering	3	0	0	3
4		Elective I	3	0	0	3
5		Elective II	3	0	0	3
6		Elective III	3	0	0	3
PRACTICAL						
7	EEC24	Energy Lab – II	0	0	3	2
8	EEC25	Mini Project*	0	0	3	1
		TOTAL	**18**	**0**	**6**	**21**

***Mini Project:** Studies to demonstrate simple basic concepts and aspects of various Energy Technologies have to be carried out by the students which will be evaluated by the Internal Examiner.

SEMESTER III

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
1		Elective IV	3	0	0	3
2		Elective V	3	0	0	3
3		Elective VI	3	0	0	3
PRACTICAL						
4	EEC31	Project work - Phase I#	0	0	12	6
		TOTAL	**9**	**0**	**12**	**15**

#Phase I: Review of Literature, Problem Identification, Methodology, Work Plan, theoretical modeling (if any), Presentation and Viva.

SEMESTER IV

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1	EEC41	Project work - Phase II**	0	0	24	12
		TOTAL	**0**	**0**	**24**	**12**

****Phase II**: Experimental and/or theoretical analysis, Results and discussions, Presentation and Viva

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE - 69

ELECTIVES FOR M.E ENERGY ENGINEERING (FULL TIME)

Semester – II						
S.NO	**COURSE CODE**	**COURSE TITLE**	**L**	**T**	**P**	**C**
1.	EEE2A	Hydro Power Technology	3	0	0	3
2.	EEE2B	Nuclear Engineering	3	0	0	3
3.	EEE2C	Industrial Energy Management	3	0	0	3
4.	EEE2D	Cogeneration and Waste Heat Recovery Systems	3	0	0	3
5.	EEE2E	Alternative Fuels	3	0	0	3
6.	EEE2F	Solar Architecture	3	0	0	3
7.	EEE2G	Fluidized Bed Systems	3	0	0	3
8.	EEE2H	Advanced Power Plant Engineering	3	0	0	3
9.	EEE2J	Materials Sciences and Engineering	3	0	0	3
10.	EEE2K	Advances in Metallurgical Engineering	3	0	0	3
11.	EEE2L	Design and Optimization of Energy Systems	3	0	0	3
12.	EEE2M	Coordination Chemistry	3	0	0	3
13.	EEE2N	Physical Organic Chemistry	3	0	0	3
Semester – III						
14.	EEE3A	Design of Heat Exchangers	3	0	0	3
15.	EEE3B	Advanced Thermal Storage Technologies	3	0	0	3
16.	EEE3C	Materials for Energy Applications	3	0	0	3
17.	EEE3D	Nanotechnology and Nano Electronics	3	0	0	3
18.	EEE3E	Solar Refrigeration and Air-Conditioning	3	0	0	3
19.	EEE3F	Fuel cells and Hydrogen Energy	3	0	0	3

20.	EEE3G	Concentrators and Solar Thermal Power Plants	3	0	0	3
21.	EEE3H	Solar Photovoltaic Power Plants: Planning, Design and Balance of Systems	3	0	0	3
22.	EEE3J	Solar Thermal Applications: Low and Medium Temperatures	3	0	0	3
23.	EEE3K	Spectroscopic Methods in Chemistry	3	0	0	3
24.	EEE3L	Analytical Chemistry	3	0	0	3

M.E. (ENERGY ENGINEERING)

CURRICULUM I TO VI SEMESTERS (PART TIME)

SEMESTER - I (Part time)

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	EEC11	Advanced Thermal Engineering	3	1	0	4
2	EEC12	Instrumentation and Control in Energy Systems	3	0	0	3
3	EEC13	Electrical Technology for Energy Engineers	3	0	0	3
PRACTICAL						
4	EEC17	Energy Lab – I	0	0	3	2
		TOTAL	**9**	**1**	**3**	**12**

SEMESTER - II (Part time)

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	EEC21	Solar Energy and Utilization	3	0	0	3
2	EEC22	Wind Energy Technology	3	0	0	3
3	EEC23	Bio Energy Engineering	3	0	0	3
PRACTICAL						
4	EEC24	Energy Lab – II	0	0	3	2
		TOTAL	**9**	**0**	**3**	**11**

SEMESTER - III (Part time)

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	EEC14	Energy Planning, Conservation and Management	3	0	0	3
2	EEC15	Renewable Energy Sources, Conversion and Technology	3	0	0	3
3	EEC16	Waste Management and Energy Recovery	3	0	0	3
		TOTAL	**9**	**0**	**0**	**9**

SEMESTER - IV (Part time)

SL.NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1		Elective I	3	0	0	3
2		Elective II	3	0	0	3
3		Elective III	3	0	0	3
PRACTICAL						
4	EEC25	Mini Project*	0	0	3	1
		TOTAL	**9**	**0**	**3**	**10**

***Mini Project:** Studies to demonstrate simple basic concepts and aspects of various Energy Technologies have to be carried out by the students which will be evaluated by the Internal Examiner.

SEMESTER - V (Part time)

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1		Elective IV	3	0	0	3
2		Elective V	3	0	0	3
3		Elective VI	3	0	0	3
PRACTICAL						
4	EEC31	Project work - Phase I#	0	0	12	6
		TOTAL	**9**	**0**	**12**	**15**

#Phase I: Review of Literature, Problem Identification, Methodology, Work Plan, theoretical modeling (if any), Presentation and Viva.

SEMESTER VI (Part time)

SL. No	COURSE CODE	COURSE TITLE	L	T	P	C
PRACTICAL						
1	EEC41	Project work - Phase II**	0	0	24	12
		TOTAL	**0**	**0**	**24**	**12**

****Phase II**: Experimental and/or theoretical analysis, Results and discussions, Presentation and Viva

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE - 69

ELECTIVES FOR M.E ENERGY ENGINEERING (PART TIME)

S.NO	COURSE CODE	COURSE TITLE	L	T	P	C
Semester - IV						
1.	EEE2A	Hydro Power Technology	3	0	0	3
2.	EEE2B	Nuclear Engineering	3	0	0	3
3.	EEE2C	Industrial Energy Management	3	0	0	3
4.	EEE2D	Cogeneration and Waste Heat Recovery Systems	3	0	0	3
5.	EEE2E	Alternative Fuels	3	0	0	3
6.	EEE2F	Solar Architecture	3	0	0	3
7.	EEE2G	Fluidized Bed Systems	3	0	0	3
8.	EEE2H	Advanced Power Plant Engineering	3	0	0	3
9.	EEE2J	Materials Sciences and Engineering	3	0	0	3
10.	EEE2K	Advances in Metallurgical Engineering	3	0	0	3
11.	EEE2L	Design and Optimization of Energy Systems	3	0	0	3
12.	EEE2M	Coordination Chemistry	3	0	0	3
13.	EEE2N	Physical Organic Chemistry	3	0	0	3
Semester - V						
14.	EEE3A	Design of Heat Exchangers	3	0	0	3
15.	EEE3B	Advanced Thermal Storage Technologies	3	0	0	3
16.	EEE3C	Materials for Energy Applications	3	0	0	3
17.	EEE3D	Nanotechnology and Nano Electronics	3	0	0	3
18.	EEE3E	Solar Refrigeration and Air-Conditioning	3	0	0	3
19.	EEE3F	Fuel cells and Hydrogen Energy	3	0	0	3

20.	EEE3G	Concentrators and Solar Thermal Power Plants	3	0	0	3
21.	EEE3H	Solar Photovoltaic Power Plants: Planning, Design and Balance of Systems	3	0	0	3
22.	EEE3J	Solar Thermal Applications: Low and Medium Temperatures	3	0	0	3
23.	EEE3K	Spectroscopic Methods in Chemistry	3	0	0	3
24.	EEE3L	Analytical Chemistry	3	0	0	3

EEC11 - ADVANCED THERMAL ENGINEERING

L	T	P	C
3	1	0	4

COURSE OUTCOMES

1. Able to understand the basics of thermodynamics and various improvements possible in vapor power cycles and refrigeration cycles.
2. Ability to use the heat transfer concepts for various applications like finned systems & turbulence flows.
3. Capability to perform the thermal analysis and sizing of heat exchangers and to learn the heat transfer coefficient for compact heat exchanges.

UNIT I THERMODYNAMICS 10

Basic Concepts of Thermodynamics, Thermodynamics Laws, Entropy: Entropy as a property, Combined First and Second Law, Increase of Entropy Principle, Entropy Change of a Pure Substance, Liquid and solids, Efficiency of devices, second – law efficiency for a closed system and steady – state control volume.

UNIT II VAPOR POWER CYCLES 10

Properties of steam, phase change process, Rankine cycle, Deviation of Actual Vapor Power Cycles from Idealized Ones, Reheat cycle, Regenerative cycle, Second-Law Analysis of Vapor Power Cycles.

UNIT III REFRIGERATION 08

Refrigerators and Heat Pumps, The Reversed Carnot Cycle, The Ideal Vapor-Compression Refrigeration Cycle, Actual Vapor-Compression Refrigeration Cycle, Selecting the Right Refrigerant, Heat Pump Systems, Innovative Vapor-Compression Refrigeration Systems, Gas Refrigeration Cycles, Absorption Refrigeration Systems.

UNIT IV HEAT TRANSFER 10

Introduction to heat transfer processes, Heat transfer from finned surfaces; fin efficiency and effectiveness, two dimensional steady state heat conduction using analytical and numerical methods - Radiation from a black body & grey body - Quantitative analysis of heat transfer co-efficient for all the modes of heat transfer.

UNIT V HEAT EXCHANGERS 07

Different types of heat exchangers, arithmetic and logarithmic mean temperature differences, heat transfer coefficient for parallel, counter and cross flow type heat exchanger; effectiveness of heat exchanger, N.T.U. method, fouling factor. Constructional and manufacturing aspects of Heat Exchangers.

Tutorial: 15 Periods **Total: 60 Periods**

REFERENCES:

1. R. K. Rajput, "Thermal Engineering", Laxmi Publications, Ltd., 2010
2. A.Faghri, JHowell, Y Zhang, "Advanced Heat and Mass Transfer", Global Digital Press, 2010
3. P.K.Nag, "Engineering Thermodynamics" 4th Edition, Tata McGraw-Hill, 2008
4. Y.A Cengel, M.A.Boles, "Thermodynamics: An Engineering Approach" 6th edition Mcgraw-Hill Series 2007
5. Bejan,A., "Advanced Engineering Thermodynamics" 3rd Edition, John Wiley and Cons, 2006.
6. Arora.C.P, "Thermodynamics", Tata McGraw-Hill Education, 2001
7. Frank Kreith., "The CRC handbook of thermal engineering", Springer, 2000.
8. Hans Dieter Baehr, Karl Stephan," Heat and Mass Transfer", Springer, 2011.

EEC12 - INSTRUMENTATION AND CONTROL IN ENERGY SYSTEMS

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. To be familiar with the basic instruments for measurement of specific thermo physical properties
2. Able to understand the advanced measurement techniques
3. Able to develop fundamental knowledge of system control and process parameters

UNIT I MEASUREMENT CHARACTERISTICS 09

Instrument classification - characteristics of instruments – static and dynamic - experimental error analysis - systematic and random errors - statistical analysis – uncertainty - experimental planning and selection of measuring instruments - reliability of instruments

UNIT II MEASUREMENT OF PHYSICAL QUANTITIES 10

Measurement of thermo – physical properties, instruments for measuring temperature - pressure and flow

UNIT III ADVANCE MEASUREMENT TECHNIQUES 08

Shadow graph – Schileren – Interferometer - Laser doppler anemometer - Hot wire anemometer, Heat flux sensors - Telemetry in measurement.

UNIT IV CONTROL SYSTEMS 09

Introduction - controllability, observability, Continuous and discrete process Controllers – Control Mode – Two – Step mode – Proportional Mode – Derivative Mode – Integral Mode – PID Controllers – Programmable Logic Controllers - Microprocessor PC based control applications.

UNIT V DATA ACQUISITION AND PROCESSING 09

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.

TOTAL PERIODS: 45

REFERENCES:

1. Manabendra Bhuyan, "Intelligent Instrumentation", CRC Press, 2009
2. Morris A.S., "Principles of Measurements and Instrumentation", Butterworth-Heinemann, 2003
3. Ernest Doebelin, "Measurement Systems", McGraw-Hill, 2003
4. Singh. S. K., "Industrial Instrumentation and Control", Tata McGraw-Hill, 2003
5. Holman J.P. "Experimental methods for Engineers, 7th Edition", McGraw – Hill, 2001
6. Rangan., "Instrumentation Devices and Systems", Tata McGraw-Hill Education, 2001
7. John G. Webster., "The Measurement, Instrumentation, and Sensors Handbook", Springer, 1999

EEC13 - ELECTRICAL TECHNOLOGY FOR ENERGY ENGINEERS

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. Able to understand the basic working principles of Electrical & Electronic devices
2. Able to understand various types of Transformers & Motors with energy efficiency perspective
3. Capable of analyzing and understanding storage concepts of electricity
4. To be familiar with the concepts of Electricity Transmission & Distribution
5. Able to understand the concepts of Wheeling and Power Evacuation of Wind & Solar Power

UNIT I INTRODUCTION 12

Introduction to Motors, Generators – Classification of Motors & Generators - Induction - Synchronous – Applications - Electronic Converter – Types - Rectifier - Dc – Dc Converter - Inverter – Transformer – Working Principle

UNIT II ELECTRICAL ENERGY STORAGE 07

Introduction for Electrical Energy storage - Types of storage – Electrical Storage – Batteries – Types – Selection of Batteries - Electrochemical Storage – Electro- magnetic Storage - Capacitor – Super capacitors

UNIT III ELECTRICITY TRANSMISSION & DISTRIBUTION 10

Introduction to Transmission – Sub transmission – Types of transmission – Losses in transmission – Control strategies - Grid – Types of grid – Distribution – Types of Distribution – Metering - Measuring Instruments

UNIT IV ELECTRICAL SYSTEM FOR WIND ENERGY SYSTEMS 08

Generators for wind energy applications – Types of generators - Grid Connected and self excited Induction Generator – Speed control - Constant Voltage - Constant Frequency Operation – Reactive Power Compensation – Power evacuation

UNIT V ELECTRICAL SYSTEM FOR SOLAR ENERGY SYSTEMS 08

Introduction – Balance of System – Tracking – Types of tracking - Inverter – Charge controller – Standalone System – Grid-Tied System – Efficiency – Frequency variation – Data monitoring – Types - Remote – On-site monitoring

TOTAL PERIODS: 45

REFERENCES:

1. B.L.Thereja "A Textbook of Electrical Technology", 25th Edition S Chand Publishers, 2008
2. S.N.Bhadra, D.Kastha and S. Banerjee, " Wind electrical systems", Oxford University Press, 2005
3. C.L. Wadhwa "Generation Distribution and Utilization of Electrical Energy" Revised Edition New Age International 2005.
4. H.A. Kiehne "Battery Technology Handbook" Second Edition, Taylor & Francis

EEC14 - ENERGY PLANNING, CONSERVATION AND MANAGEMENT

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. The present energy scenario and the need for energy conservation and various energy conservation measures would be learnt
2. Talented to understand the concepts of Energy Planning and forecasting techniques for performing energy analysis
3. Be aware of the methods of pollution controls produced during energy generation
4. To be familiar with various energy policies (National and International) & standards

UNIT I INTRODUCTION 09

Energy Scenario - world and India. Energy Resources- Availability in India. Energy consumption pattern. Energy conservation potential - Industries and commercial establishments. Energy intensive industries - overview. Energy conservation and energy efficiency – needs and advantages.

UNIT II ENERGY FORECASTING TECHNIQUES 09

Energy demand – supply balancing, Energy models, Software for energy planning, Simulation and forecasting of future energy demand consistent with macroeconomic parameters in India. Basic concept of Econometrics (OLS) and statistical analysis (Multiple Regression), Econometrics techniques used for energy analysis and forecasting with case studies from India

UNIT III POLLUTION FROM ENERGY GENERATION 09

Coal and Nuclear based Power Plants – Fly Ash generation and environment impact, Fly ash utilization and disposal, nuclear fuel cycle, radioactive wastes – treatment and disposal- Environmental pollution limits guidelines for thermal power plant pollution control- Environmental emissions from extraction, conversion, transport and utilization of fossil fuels- Green house effect- Global warming

UNIT IV ENERGY POLICIES 09

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 V ENERGY CONSERVATION AND AUDITING 09

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 audit instruments; Energy Conservation Act; Duties and responsibilities of energy managers and auditors.

TOTAL PERIODS: 45

REFERENCES:

1. Steve Doty, Wayne C. Turner "Energy management handbook", 7th Edition, the Fairmont Press, Inc., 2009.
2. Michael Wickens "Macroeconomic Theory: A Dynamic General Equilibrium Approach", Princeton University Press, 2009
3. F Kreith , D. Y Goswami, "Energy management and conservation handbook", CRC Press, 2008
4. YP Abbi and Shashank Jain. "Handbook on Energy Audit and Environment Management", TERI Publications, 2006
5. R Loulou, P R Shukla and A Kanudia, "Energy and Environment Policies for a sustainable Future", Allied Publishers Ltd, New Delhi, 1997

EEC15 - RENEWABLE ENERGY SOURCES, CONVERSION AND TECHNOLOGY

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. Able to understand the basic principles of concept of various forms of renewable energy
2. Be familiar with the concept of Solar radiation and Energy conversion
3. Able to understand the concepts of extraction of Wind Energy
4. Able to understand the concepts of various Bio-Energy Conversion techniques
5. Be familiar with the concepts of Hydrogen Energy and other forms of Renewable Energy

UNIT I SOLAR ENERGY 09

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 09

Atmospheric circulations – classification - factors influencing wind - wind shear – turbulence - wind speed monitoring - Betz limit - Aerodynamics of wind turbine rotor- site selection - wind resource assessment - wind energy conversion devices - classification, characteristics and applications. Hybrid systems - safety and environmental aspects.

UNIT III BIO-ENERGY 09

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 09

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 09

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.

TOTAL PERIODS: 45

REFERENCES:

1. Sukhatme S.P., "Solar Energy", Tata McGraw Hill, 2008**.**
2. Mukund R. Patel, "Wind and Solar Power Systems", CRC Press, 1999.
3. Hart, A.B., and Womack, G. J.,"Fuel Cells: Theory & Applications", Prentice Hall, 1997.
4. Godfrey Boyle, "Renewable Energy, Power for a Sustainable Future", Oxford University Press, U.K, 1996.
5. Veziroglu, T.N., "Alternative Energy Sources", Vol 5 and 6, McGraw-Hill, 1990
6. Twidell, J.W. and Weir, A., "Renewable Energy Sources", EFN Spon Ltd., 1986.
7. Khandelwal K.C, Mahdi S.S., "Biogas Technology" - A Practical Handbook, Tata McGraw Hill, 1986.
8. Kreith, F and Kreider, J. F.," Principles of Solar Engineering", McGraw-Hill, 1978.

EEC16 - WASTE MANAGEMENT AND ENERGY RECOVERY

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. Provision of information on various methods of waste management
2. Familiarization of the students with recent energy generation techniques
3. Knowledge on recent technologies of waste disposal
4. Importance of healthy environment will be realized.

UNIT I SOLID WASTE – CHARACTERISTICS AND PERSPECTIVES 06

Definition - types – sources – generation and estimation. Properties: physical, chemical and biological – regulation

UNIT II COLLECTION, TRANSPORTATION AND PROCESSING TECHNIQUES 08

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 16

Basics, types, working and typical conversion efficiencies of composting – anaerobic digestion – RDF – combustion – incineration – gasification – pyrolysis

UNIT IV HAZARDOUS WASTE MANAGEMENT 08

Hazardous waste – definition - potential sources - waste sources by industry – impacts – waste control methods – transportation regulations - risk assessment - remediation technologies – Private public paternership – Government initiatives.

UNIT V ULTIMATE DISPOSAL 07

Landfill – classification – site selection parameters – design aspects – Leachate control – environmental monitoring system for Land Fill Gases.

TOTAL: 45 PERIODS

REFERENCES

1. Michael D. Lagrega., et al., "Hazardous Waste Management", Waveland Pr Inc, 2010
2. Paul T. Williams, "Waste treatment and disposal", 2nd Edition, John Wiley and Sons, 2005
3. Velma I. Grover, "Recovering Energy" Science Publishers, 2002
4. Tchobanoglous, Theisen and Vigil, "Integrated Solid Waste Management", 2nd Edition McGraw-Hill, New York, 1993
5. Stanley E. Manahan. "Hazardous Waste Chemistry, Toxicology and Treatment", Lewis Publishers, Chelsea, Michigan, 1990

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EEC17 - ENERGY LAB – I

L	T	P	C
0	0	3	2

RENEWABLE ENERGY 27

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 12

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 06

1. Thermal Storage Systems

TOTAL: 45 PERIODS

EEC21 - SOLAR ENERGY AND UTILIZATION

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. Knowledge on radiation principles with respective solar energy estimation
2. Be familiar with various collecting techniques of solar energy and storage
3. PV technology principles and techniques of various solar cells / materials for energy conversion will be learnt
4. Economical and environmental merits of solar energy for variety of applications will be understood

UNIT - I SOLAR RADIATION **09**

Source of radiation – Sun earth relationship- extra terrestrial radiation.– Atmospheric attenuation – Terrestrial radiation-radiation on a horizontal surfaces and inclined planes - relations between monthly, daily and hourly radiation and components of the radiations– solar charts – Critical radiation-Measurement of global, direct and diffuse solar radiation - pyroheliometer, pyranometer, pyrogeometer, sunshine recorder – an overview of solar radiation data in India.

UNIT II SOLAR COLLECTORS **09**

Design considerations – classification- Flat plate collectors- air heating collectors liquid heating – Temperature distributions- Heat removal rate- Useful energy gain – Losses in the collectors-for efficiency of flat plate collectors – selective surfaces – tubular solar energy collectors analysis of concentric tube collector – testing of flat plate collectors. Concentric collectors - Limits to concentration – concentrator mounting – tracking mechanism - performance analysis focusing solar concentrators: Heliostats.

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UNIT III PHOTOVOLTAIC SYSTEMS **09**

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 **09**

Sensible Heat Storage – Liquid media storage – Solid media storage – Latent heat storage - Phase change materials – Chemical storage

UNIT V INDUSTRIAL APPLICATIONS OF SOLAR HEAT **09**

Solar Thermal Power Plant, Solar Desalination, Solar Water Heating, Solar Air Heating, Solar Drying, Solar Cooking, Solar Greenhouse technology: Fundamentals, design, modeling and applications

Total: 45 Periods

REFERENCES

1. L D. Partain, L M. Fraas, "Solar Cells and Their Applications",2nd Edition, John Wiley and Sons, 2010
2. Soteris Kalogirou, "Solar Energy Engineering", Academic Press, 2009
3. Sukhatme S P, "Solar Energy, 3rd Edition", Tata McGraw-Hill Education, 2008
4. Duffie, J. A. and Beckman, W. A., "Solar Engineering of Thermal Processes",3rd Edition, Wiley, 2006
5. A Luque, S Hegedus, "Handbook of Photovoltaic Science and Engineering", John Wiley and Sons, 2003
6. G. N. Tiwari, "Solar Energy Fundamentals, Design, Modelling and Applications", Narosa Publishing House Pvt. Ltd., 2002
7. H.P. Garg and J. Prakash, "Solar Energy- Fundamentals & Applications", Tata McGraw-Hill, 2000.

EEC22 - WIND ENERGY TECHNOLOGY

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. The fundamentals of wind energy and its conversion system will be comprehended
2. To be familiar with the wind measurement techniques
3. Be aware of the concepts of aerodynamics, wind farms and cycles

UNIT I WIND CHARACTERISTICS AND RESOURCES 09

Characteristics of the Wind Resource- Characteristics of the Atmospheric Boundary Layer-Wind Data Analysis and Resource Estimation-Wind Turbine Energy Production Estimates Using Statistical Techniques-Regional Wind Resource Assessment-Wind Prediction and Forecasting-Wind Measurement and Instrumentation.

UNIT II AERODYNAMICS OF WIND TURBINES 09

One-dimensional Momentum Theory and the Betz Limit-Ideal Horizontal Axis Wind Turbine with Wake Rotation-Airfoils and General Concepts of Aerodynamics-Blade Design for Modern Wind Turbines-Momentum Theory and Blade Element Theory-Blade Shape for Ideal Rotor without Wake Rotation-General Rotor Blade Shape Performance Prediction-Blade Shape for Optimum Rotor with Wake Rotation-Generalized Rotor Design Procedure-Simplified HAWT Rotor Performance Calculation Procedure-Effect of Drag and Blade Number on Optimum Performance-Computational and Aerodynamic Issues in Aerodynamic Design-Aerodynamics of Vertical Axis Wind Turbines

UNIT III MODERN WIND TURBINE CONTROL & MONITORING SYSTEM 09

Details of Pitch and Yaw Systems & Control Algorithms, Protections used & Safety Consideration in Wind turbines, Wind Turbine Monitoring with Error codes, SCADA & Databases: Remote Monitoring and Generation Reports, Operation & Maintenance for Product Life Cycle, Balancing technique (Rotor & Blade), FACTS control & LVRT & New trends for new Grid Codes

UNIT IV CONCEPT OF WIND FARMS 09

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 09

Economic Assessment of Wind Energy Systems- Capital Costs of Wind Energy Systems- Operation and Maintenance Costs- Value of Wind Energy- Economic Analysis Methods- Wind Energy Market Considerations

TOTAL: 45 PERIODS

REFERENCES:

1. T Burton, et.al, "Wind Energy Handbook",2nd Edition, John Wiley and Sons, 2011
2. J.F. Manwell, et.al, "Wind Energy Explained",2nd Edition, John Wiley and Sons, 2009
3. D. A. Spera, "Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering", 2nd Edition, ASME Press, 2009
4. William W. Peng, "Fundamentals of turbomachinery", John Wiley and Sons, 2008
5. Mukund. R. Patel, "Wind and solar power systems" 2nd Edition, Taylor & Francis, 2006

EEC23 - BIO ENERGY ENGINEERING

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. Knowledge on the types of biomass, its surplus availability and characteristics.
2. Capability to analyze the technologies available for conversion of biomass to energy in terms of its technical competence and economic implications.

UNIT I INTRODUCTION **08**

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

UNIT II BIO - METHANATION **08**

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 **10**

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 pre-processing – advantages – drawbacks

UNIT IV GASIFICATION **10**

Types – comparison – application – performance evaluation – economics – dual fuel engines – 100 % Gas Engines – engine characteristics on gas mode – gas cooling and cleaning train.

UNIT V PYROLYSIS AND CARBONIZATION **09**

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.

TOTAL: 45 PERIODS

REFERENCES

1. A.A. Vertès, N Qureshi, H Yukawa, "Biomass to biofuels: strategies for global industries", John Wiley and Sons, 2009
2. J D. Wall, C S. Harwood, A L. Demain ," Bioenergy", ASM Press, 2008
3. D.M. Mousdale, "Biofuels", CRC Press, 2008
4. Nijaguna, B.T.," Biogas Technology", New Age International publishers (P) Ltd.,2006
5. Rezaiyan. J and N. P. Cheremisinoff, "Gasification Technologies, A Primer for Engineers and Scientists", Taylor & Francis, 2005
6. IEEE Journals for "Power, Energy, & Industry Applications"

EEC24 - ENERGY LAB – II

L	T	P	C
0	0	3	2

I Cycle (using ANSYS) **24** Periods

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) **21** Periods

Performance analysis of Solar PV panel
Performance analysis of Flat Plate Collecting System
Performance analysis of Evacuated Tube Collecting System
Performance analysis of Concentrated Solar Thermal Collecting System
Simulation of Solar Water Heating System
Cooling tower Analysis

TOTAL: 45 PERIODS

ELECTIVE SUBJECTS

EEE2A - HYDRO POWER TECHNOLOGY

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. Able to understand the basic concepts of aerodynamics, horizontal and vertical axis wind turbines, small hydro system components and design
2. Ability to develop prototype systems
3. Ability to select and analyze the particular turbine for specific need

UNIT I HYDROLOGY 09

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 PROTO TYPE SYSTEMS 12

Advances in Planning, Design and Construction of Hydroelectric Power Stations-Trends in Development of Generating Plant and Machinery-Plant Equipment for pumped Storage Schemes-Some aspects of Management and Operations-Updating and Refurbishing of Turbines-Case Studies

UNIT III SELECTION AND ANALYSIS OF TURBINES 07

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 10

Governing of Power Turbines - Functions of Turbine Governor - Condition for Governor Stability - Surge Tank Oscillation and Speed Regulative Problem of Turbine Governing in Future Planning, Design and Construction of Hydroelectric Power Stations-Remaining Lifecycle Analysis.

UNIT V SMALL, MINI AND MICRO HYDRO POWER PLANTS TURBINES 09

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.)

Total: 45 PERIODS

REFERENCES:

1. P.K Nag ,"Power plant Engineering", Tata McGraw-Hill Education, 2008
2. A.K.Raja , Amit Prakash Srivastava, "Power Plant Engineering", New Age International, 2007
3. Finn R. Førsund , "Hydropower economics", Springer, 2007
4. Scott Davis," Microhydro: clean power from water", New Society Publishers, 2004.

EEE2B - NUCLEAR ENGINEERING

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. Knowledge on fundamentals of nuclear reactions
2. Be able to learn nuclear fuels cycles, characteristics, fundamental principles governing nuclear fission chain reaction and fusion
3. Awareness on future nuclear reactor systems with respect to generation of energy, fuel breeding, incineration of nuclear material and safety.

UNIT I NUCLEAR REACTIONS 09

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 09

Nuclear Fuel Cycles - characteristics of nuclear fuels - Uranium - production and purification of Uranium - conversion to UF4 and UF6 - other fuels like Zirconium, Thorium - Berylium.

UNIT III REPROCESSING 09

Nuclear fuel cycles - spent fuel characteristics - role of solvent extraction in reprocessing - solvent extraction equipment.

UNIT IV SEPARATION OF REACTOR PRODUCTS 09

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 - refinng - Isotopes - principles of Isotope separation.

UNIT V WASTE DISPOSAL AND RADIATION PROTECTION 09

Types of nuclear wastes - safety control and pollution control and abatement - international convention on safety aspects - radiation hazards prevention.

TOTAL: 45 PERIODS

REFERENCES:

1. Raymond LeRoy Murray, "Nuclear energy: an introduction to the concepts, systems, and applications of nuclear processes",6th Edition, Butterworth-Heinemann, 2009
2. John R. Lamarsh, "Introduction to nuclear reactor theory", American Nuclear Society, 2002
3. Glasstone, S. and Sesonske, A, "Nuclear Reactor Engineering", 4th Edition, Springer, 1994.
4. Winterton, R.H.S., "Thermal Design of Nuclear Reactors", Pergamon Press, 1981.

EEE2C - INDUSTRIAL ENERGY MANAGEMENT

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. Be aware of present energy scenario and the need for energy conservation and various energy conservation measures
2. Concepts of basic measurement, instruments for measuring various parameters in energy systems, energy auditing, digital data processing, computer data processing, etc. will be familiarized

UNIT I INTRODUCTION **09**

Energy Scenario - world and India. Energy Resources Availability in India - Energy consumption pattern, Energy conservation potential in various Industries and commercial establishments - Energy intensive industries - an overview. Energy conservation and energy efficiency – needs and advantages, Energy auditing - types, methodologies, barriers - Role of energy manager – Energy audit questionnaire - Energy Conservation Act 2003.

UNIT II INSTRUMENTS FOR ENERGY AUDITING **09**

Instrument characteristics – sensitivity, readability, accuracy, precision, hysteresis, Error and calibration. Measurement of flow, velocity, pressure, temperature, speed, Lux, power and humidity. Analysis of stack, water quality, power and fuel quality.

UNIT III STEAM SYSTEMS **09**

Properties of steam - Steam distribution - Assessment of steam distribution losses Steam leakages, Steam trapping - Condensate recovery and flash steam utilisation system, Identifying opportunities for energy savings -Thermal Insulation. Boiler –efficiency testing, excess air control

UNIT IV WASTE HEAT RECOVERY **09**

Recuperators, regenerators, heat pipes, heat pumps. Cogeneration - concept, options (steam/gas turbines/diesel engine based), selection criteria, control strategy. Heat exchanger networking - concept of pinch, target setting, problem table approach, composite curves. Demand side management.

UNIT V ELECTRICAL SYSTEMS **09**

Demand control, power factor correction, load scheduling/shifting, Motor drives- motor efficiency testing, energy efficient motors, motor speed control. Lighting- lighting levels, efficient options, fixtures, day lighting, timers, Energy efficient windows. Energy conservation in Pumps, Fans (flow control), Compressed Air Systems, Refrigeration & air conditioning systems.

TOTAL: 45 PERIODS

REFERENCES:

1. "Industrial Energy Conservation Manuals", MIT Press, Mass, 2007.
2. I.G.C.Dryden, Butterworths, "the Efficient Use of Energy", London, 2001
3. W.C.Turner, Wiley, "Energy Management Handbook", New York, 2010.
4. "Technology Menu for Efficient energy use- Motor drive systems", Prepared by National Productivity Council and Center for & Environmental Studies- Princeton Univ 1993.
5. Guide book for "National Certification Examination for Energy Managers and Energy Auditors" (Could be downloaded from www.energymanagertraining.com)

EEE2D - COGENERATION AND WASTE HEAT RECOVERY SYSTEMS

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. Importance of cogeneration in improving the overall efficiency, thus reducing fuel consumption, improving economy and limiting global warming will be brought out
2. Capability to analyze the basic energy generation cycles
3. Detailed knowledge of concepts of cogeneration, its types and probable areas of applications
4. To study the significance of waste heat recovery systems and carry out its economic analysis

UNIT I INTRODUCTION 09

Introduction - principles of thermodynamics – cycles - topping - bottoming – combined cycle - organic rankine cycles – performance indices of cogeneration systems – waste heat recovery – sources and types – concept of tri generation.

UNIT II COGENERATION TECHNOLOGIES 09

Configuration and thermodynamic performance – steam turbine cogeneration systems – gas turbine cogeneration systems – reciprocating IC engines cogeneration systems – combined cycles cogeneration systems – advanced cogeneration systems: fuel cell, Stirling engines etc.,

UNIT III ISSUES AND APPLICATIONS OF COGENERATION TECHNOLOGIES 09

Cogeneration plants electrical interconnection issues – utility and cogeneration plant interconnection issues – applications of cogeneration in utility sector – industrial sector – building sector – rural sector – impacts of cogeneration plants – fuel, electricity and environment

UNIT IV WASTE HEAT RECOVERY SYSTEMS 09

Election criteria for waste heat recovery technologies - recuperators - Regenerators - Economizers - plate heat exchangers - thermic fluid heaters - Waste heat boilers classification, location, service conditions, design Considerations - fluidized bed heat exchangers - heat pipe exchangers - heat pumps – sorption systems.

UNIT V ECONOMIC ANALYSIS 09

Investment cost – economic concepts – measures of economic performance – procedure for economic analysis – examples – procedure for optimized system selection and design – load curves - sensitivity analysis – regulatory and financial frame work for cogeneration and waste heat recovery systems.

TOTAL: 45 PERIODS

REFERENCES

1. R.Kehlhofer, B. Rukes, F. Hannemann, F. Stirnimann, "Combined-cycle gas & steam turbine power plants,3rd Edition", PennWell Books, 2009.
2. Steve Doty, Wayne C. Turner, "Energy management handbook",7th Edition, The Fairmont Press, Inc., 2009
3. A.Thumann, D. Paul Mehta, "Handbook of energy engineering", 6th Edition, The Fairmont Press, Inc., 2008
4. B.F.Kolanowski, "Small-scale cogeneration handbook", 2nd Edition, Fairmont Press, 2003
5. M.P. Boyce, "Handbook for cogeneration and combined cycle power plants", ASME Press, 2002
6. EDUCOGEN – "The European Educational tool for cogeneration", Second Edition, 2001

EEE2E - ALTERNATIVE FUELS

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. Able to get an insight into the availability of petroleum based fuels, their progress and its influence on environment.
2. Able to get an exposure to 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

UNIT I OVERVIEW 09

Introduction – Alternative fuels – Potential solid - liquid - and gaseous fuels. – Alcohols – ethanol, methanol, M85, E85 and gashol – properties – SI engine combustion performance and emission characteristics. Alcohols for CI engine – Alcohol fumigation – Dual fuel injection – Surface ignition and spark ignition- storage, dispensing and safety – material compatibility.

UNIT II VEGETABLE OILS AND OTHER SIMILAR FUELS DERIVED 09

Vegetable oils- properties – advantages and disadvantages – Biodiesel – trans-esterification -Factors affecting the process – Properties- Biodiesel blends – engine combustion, performance and emission characteristics- material compatibility , other alternative liquid fuels – benzol – acetone – diethyl ether.

UNIT III NATUARAL GAS AND LPG 09

Alternative gaseous fuels – natural gas and LPG – production – properties of natural gas and LPG – CNG conversion kits – Advantages and disadvantages of NG and LPG – comparison of gasoline and LPG – CNG and LPG fuel feed system – LPG & CNG for CI engine – methods of fuel induction engine combustion, performance and emission characteristics.

UNIT IV HYDROGEN AS ALTERNATIVE FUEL 09

Hydrogen energy – properties , production , thermo- chemical methods – Hydrogen storage – Delivery – conversion – safety – Hydrogen engines, methods of usage in SI and CI engine – Hydrogen injection system – Hydrogen induction in SI engine.

UNIT V BIOGAS FOR IC ENGINES 09

Biogas – properties – Biogas for running IC engine – Biogas as vehicle fuel – biogas consumption – engine performance and emission- Biomass gasification – producer gas – consumption – dual fuel operation – engine performance and emission.

TOTAL: 45 PERIODS

REFERENCES

1. D Tomes, P Lakshmanan., Biofuels: "Global Impact on Renewable Energy, Production Agriculture, and Technological Advancements", Springer, 2010
2. Ram B. Gupta, "Hydrogen fuel: production, transport, and storage", CRC Press, 2009
3. Ganesan.V, - "Internal Combustion Engines", Tata McGraw-Hill Education, 2008
4. M.F. Hordeski, "Alternative fuels: the future of hydrogen",2nd Edition, The Fairmont Press, Inc., 2008
5. Sunggyu Lee, J.G.Speight, S.K.Loyalka, "Handbook of alternative fuel technologies", CRC Press, 2007.
6. B. T. Nijaguna, "Biogas Technology", New Age International, 2006
7. IEEE Journals for "Power, Energy, & Industry Applications"

EEE2F - SOLAR ARCHITECTURE

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. Ability to elaborate the current trends in solar architecture and following key concepts: Solar Passive Architecture and heat transfer in buildings
2. Able to understand the Natural Heating/Cooling concepts for Building, Earth to Air Heat Exchanger, Thermal Comfort Requirements
3. Knowledge on Energy Conservation , Concept of Zero Energy Buildings

UNIT I INTRODUCTION 09

Bio-climatic classification of India, Passive Solar Passive Building and Green Building Concepts, National Building Code, Energy Star Rating , Policies on Energy Efficient and Green buildings

UNIT II PASSIVE HEATING & COOLING CONCEPTS 09

Passive heating concepts: Direct heat gain, indirect heat gain, isolated gain and sunspaces, Solar Green Houses, Solar Wall, Solar Trombe wall 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 systems for cooling

UNIT III THERMAL ANALYSIS AND DESIGN FOR HUMAN COMFORT 09

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 09

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 09

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

TOTAL: 45 PERIODS

REFERENCES

1. David Findley, "Solar Power for Your Home", McGraw-Hill Professional, 2010
2. Jan F. Kreider, P Curtiss, Ari Rabl, "Heating and cooling of buildings: design for efficiency", 2nd Edition, CRC Press, 2010.
3. Sue Reed, "Energy-Wise Landscape Design", New Society Publishers, 2010
4. S Roaf, M Fuentes, S Thomas, "Ecohouse: a design guide",3rd Edition, Architectural Press, 2007
5. DS Lal "Climatology", Sharda Pustak Bhawan, Allahabad, 2003
6. Christian Schittich, "Solar architecture: strategies, visions, concepts", Edition Detail, 2003
7. Daniel D. Chiras, "The solar house: passive heating and cooling", Chelsea Green Publishing, 2002
8. IEEE Journals for "Power, Energy, & Industry Applications"

EEE2G - FLUIDIZED BED SYSTEMS

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. Understand the concepts of fluidization and heat transfer in fluidized beds.
2. Able 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 06

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 06

Fluidized bed combustion and gasification – stages of combustion of particles – performance - start-up methods. Pressurized fluidized beds.

UNIT IV DESIGN CONSIDERATIONS 09

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

REFERENCES:

1. Prabir Basu., "Combustion and gasification in fluidized beds", CRC/Taylor & Francis, 2006
2. Simeon Oka, E. J. Anthony, "Fluidized bed combustion", M. Dekker, 2004
3. Wen-ching Yang, "Handbook of fluidization and fluid-particle systems", Marcel Dekker, 2003
4. C. K. Gupta, D. Sathiyamoorthy ,"Fluid bed technology in materials processing", CRC Press, 1999
5. Otto Molerus, Karl-Ernst Wirth, "Heat transfer in fluidized beds", Springer, 1997

EEE2H - ADVANCED POWER PLANT ENGINEERING

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. Able to understand the energy scenario and the environmental issues related to the power plants.
2. Familiarized with various improvements possible in steam cycles, gas power cycles.
3. Be aware of the advances in nuclear and MHD power plants.
4. Able to study the economic feasibility of various power plants.

UNIT I ANALYSIS OF STEAM POWER PLANTS (SPP): 09

Components of steam power plants, typical layout, Rankine Cycle – performance - energy analysis of Rankine cycle - cycle improvements – Ideal reheat Rankine cycle - The Ideal Regenerative Rankine Cycle - Open Feedwater Heaters - Closed Feedwater Heaters

UNIT II ANALYSIS OF HYDROELECTRIC POWER PLANTS (HEPP): 09

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: 09

Gas turbine cycles – optimization – thermodynamic analysis of cycles – cycle improvements - Intercoolers, reheaters, regenerators - operation and performance – layouts. - comparison with other types of power plants.

UNIT IV NUCLEAR AND MHD POWER PLANTS 09

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: 09

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

TOTAL: 45 PERIODS

REFERENCES:

1. Nag, P.K., "Power Plant Engineering, 3rd Edition", Tata McGraw-Hill Education, 2008.
2. Arora and Domkundwar, "A course in Power Plant Engineering", Dhanpat Rai and CO, 2004.
3. Philip Kiameh., "Power generation handbook", Tata McGraw-Hill, 2004
4. Stan Kaplan, "Power Plant Characteristics and Costs", Nova Science Publishers, Inc., 2010
5. R.K. Rajput , "A Textbook of Power Plant Engineering" , Laxmi Publications, 2005

EEE2J - MATERIALS SCIENCES AND ENGINEERING

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. Knowledge in advanced materials to make him aware of the vast selection of engineering materials.
2. Able to analyze the crystal structure by knowing the bonding of materials.
3. Student will be well-versed with the magnetic, electrical and thermal properties of materials.

UNIT I ADVANCED MATERIALS 06

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, Al_2O_3, SiC, Si_3N_4, and diamond –properties, processing and applications - Future trends in materials usage

UNIT II ATOMIC STRUCTURE AND BONDING 08

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 10

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 09

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 12

Magnetic Properties - Definition of Magnetic Properties, Types of magnetic bodies, 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.

TOTAL PERIODS: 45

REFERENCES:

1. W.D.Callister, Jr., "Materials Science and engineering", Wiley India (P) LTD., 2007
2. G.E.Dieter, "Mechanical Metallurgy", McGraw Hill book Company (UK) LTD., London, 1988
3. R.E.Reed-Hill; "Physical Metallurgy Principles" 4th Edition, Cengage Learning, 2003
4. Willam F. Smith, "Foundations of Materials Science and Engineering", McGraw-Hill series in materials science, third edition, 2003
5. Buschow K.H.J. (Ed.), "Handbook of Magnetic Materials", Amsterdam : Elsevier

EEE2K - ADVANCES IN METALLURGICAL ENGINEERING

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. Able to apply their knowledge of the fundamental 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.
2. Able to characterize the synthesized materials.
3. Students will gain fundamental understanding of electrical conduction (transport) in solids, major properties of bulk and nanostructured superconductors.
4. Able to create a scientific basis to ensure the safe and responsible development of engineered nanoparticles and nanotechnology-based materials and products

UNIT I ADVANCED MATERIALS AND TOOLS 09

Smart materials, exhibiting ferroelectric, piezoelectric, optoelectric, semiconducting behaviour, lasers and optical fibres, photoconductivity and superconductivity, nanomaterials, synthesis, properties and applications.

UNIT II PHYSICAL METHODS FOR CHARACTERIZATION 09

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, Thermo gravimetric analysis, Differential scanning calorimery)

UNIT III ELECTRONIC MATERIALS 09

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 09

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 & NANOTECHNOLOGY 09

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.

TOTAL PERIODS: 45

REFERENCES:

1. William F. Smith – "Foundation of Materials Science and Engineering", Mc Graw- Hill International Edition, 2nd Edition, 1993.
2. S. O. Kasap – "Principles of Electronic Materials and Devices", Tata Mc Graw-Hill Publication, 2nd Edition, 2002.
3. B.D. Cullity, "Elements of X-ray Diffraction (For X-rays) ", 3rd edition, Prentice-Hall, Upper Saddle River 2001
4. C.N. Banwell, "Fundamentals of Molecular Spectroscopy", 4th edition, Tata McGraw-Hill Education, 1994.
5. Paul Gabbott, "Principles and Applications of Thermal Analysis", Publisher Wiley-Blackwell, 2007.
6. A.V. Narlikar, "Frontiers in Superconducting Materials", Editor, A.V. Narlikar, Publisher Springer, ISBN 978-3-540-27294-6.

7. Dieter Vollath, Nanomaterials: "An introduction to synthesis, properties and applications", Wiley- CVH.
8. Kenneth J. Klabunde, Nanoscale "Materials in Chemistry", Publisher- Wiley- Interscience.

EEE2L - DESIGN AND OPTIMIZATION OF ENERGY SYSTEMS

L T P C
3 0 0 3

COURSE OUTCOMES

After the completion of course the student will be able to
1. Perform the Simulation and Modeling of typical energy system
2. Analyse the effect of constraints on the performance of energy systems
3. Design energy systems and perform Energy-Economic Analysis for typical Applications.

UNIT I INTRODUCTION 09

Engineering Design- Design as Part of Engineering Enterprise- Thermal Systems

UNIT II BASIC CONSIDERATIONS IN DESIGN 09

Formulation of the Design Problem- Conceptual Design- Steps in the Design Process- Computer-Aided Design of Thermal Systems- Material Selection

UNIT III MODELING OF THERMAL SYSTEMS 09

Types of Models- Mathematical Modeling- Physical Modeling and Dimensional Analysis- Curve Fitting

UNIT IV ECONOMIC CONSIDERATIONS 09

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

UNIT V OPTIMIZATION 09

Basic Concepts- Optimization Methods- Optimization of Thermal Systems- Practical Aspects in Optimal Design

TOTAL: 45 PERIODS

REFERENCES

1. Jasbir Arora, Introduction to Optimum Design, 3rd Edition, Elsevier Science & Technology, 2011.
2. Stoecker W.F., Design of Thermal Systems, McGraw Hill, 2011.
3. C. Balaji, Essentials of Thermal System Design and Optimization, Aue Books, 2011.
4. William S. Janna, Design of Fluid Thermal Systems, 3rd Edition, Cengage Learning, 2010.
5. Yogesh Jaluria, Design and Optimization of Thermal systems, 2nd Edition, CRC Press, 2007.
6. Kalyanmoy Deb, Optimization for Engineering design: Algorithms and examples, PHI Learning Pvt. Ltd., 2004.
7. IEEE Journals for Power, Energy, & Industry Applications

EEE2M - COORDINATION CHEMISTRY

L T P C
3 0 0 3

COURSE OUTCOMES

After the completion of course the student will be able to

- elucidate the structure of the coordination compounds.
- apply the theories and identify the nature of hybridization .
- assign term symbols for any transition metal complexes.
- identify the reaction mechanism of metal complexes.
- describe the keyways by which the biological important metal ion catalysis.

UNIT I NOMENCLATURE OF METAL COMPLEXES 09

Coordination compounds – Nomenclature – Characteristics– Structural isomerism – Stereoisomerism – Optical isomerism – Stability of complexes – Geometry of complexes.

UNIT II THEORIES OF COORDINATION COMPOUNDS 09

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 09

Russell-Saunders state – Quantum numbers – Spin-spin coupling, orbit-orbit coupling and spin-orbit coupling – Orgel diagrams – Tanabe-sugano diagram for d^3 complex – Electronic spectra of $d^{2,}$ d^3, d^4, d^5, d^6, d^7, d^8 and d^9 complexes – Charge transfer spectra.

UNIT IV REACTIONS OF METAL COMPLEXES 09

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 09

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.

TOTAL: 45 PERIODS

REFERENCES

1. F.A. Cotton, G. Wilkinson, C.A. Murillo, M. Bochmann, Advanced Inorganic Chemistry, John Wiley and Sons, 6th Edition, 2009.
2. Concise Coordination chemistry. R. Gopalan and V. Ramalingam. Vikas publishing house private Limited, 2001.

EEE2N - PHYSICAL ORGANIC CHEMISTRY

L T P C
3 0 0 3

COURSE OUTCOMES

After the completion of course the student will be able to

1. draw mechanism, knowledge, reactivity and their structure in various molecular rearrangement.
2. recall reagents and predict products for a defined set of organic reactions and to propose mechanism.
3. determine the electronic structure of solids and crystal / (dis) order and defects.
4. outline the mechanistic aspect for the important photochemical reaction .
5. evaluate and choose appropriate reagent for selective functional group transformations and to discuss the mechanism of important organic transformations.

UNIT I MOLECULAR REARRANGEMENTS 09

Types of rearrangements, Nucleophilic, electrophilic and free radical reactions – Wagner-Meerwein – Pinacol-Pinacolone – Benzil-Benzilic acid – Demjanov – Baeyer Villiger and Curtius rearrangements.

UNIT II NAME REACTIONS 09

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 09

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 09

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 09

Reagents for organic synthesis and functional group transformations: Lithium aluminum hydride – Gilman's reagent – Sodiumborohydride – LDA – DCC – Von Rudloff reagent – Lemieux-Johnson reagent – Vaskas catalyst – Wilkinson's catalyst – Ziegler-Natta catalyst.

TOTAL: 45 PERIODS

REFERENCES

1. Carey, F.A. & Sundberg, R. J. Advanced Organic Chemistry, Parts A & B, Plenum: U.S, 2004.
2. A.R. West, Solid State Chemistry and its Applications, 2nd Edition, John Wiley & sons, 2014.

EEE3A - DESIGN OF HEAT EXCHANGERS

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. Able to understand the basic principles of Heat transfer & Heat Exchangers and applications
2. Able to understand various types of flows and disturbances
3. Able to design Shell& Tube and Double-Pipe Heat Exchanger
4. Able to design Compact and Plate Heat Exchanger
5. Able to design Condenser and performance analysis of Cooling Towers

UNIT I FUNDAMENTALS OF HEAT EXCHANGER 09

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 09

Flow – types – Disturbances in flow - Effect of turbulence – friction factor – Pressure loss – stress in tubes – Fouling – Process – types of fouling – control strategies - thermal stresses – types - shear stresses

UNITIII DOUBLE PIPE AND SHELL & TUBE HEAT EXCHANGER 09

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 EXCHANGER 09

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 09

Condensers – Types – Shell & tube – Plate condenser - Design - Cooling tower – types – Natural draft – Mechanical draft - performance characteristics – Range and approach of a cooling tower

TOTAL: 45 PERIODS

REFERENCES:

1. R.W.Serth, "Process Heat Transfer: Principles and Applications", Academic Press, 2007
2. R. K. Shah, D P. Sekulić, "Fundamentals of Heat Exchanger Design", John Wiley and Sons, 2003
3. Sadik Kakac and Hongtan Liu, "Heat Exchangers Selection, Rating and Thermal Design", CRC Press, 2002
4. T. Kuppan, "Heat exchanger design handbook", Marcel Dekker, 2000
5. IEEE Journals for "Power, Energy, & Industry Applications"

L T P C

EEE3B - ADVANCED THERMAL STORAGE TECHNOLOGIES 3 0 0 3

COURSE OUTCOMES

1. Familiar with the various types of thermal storage systems and the storage materials
2. Ability to develop the model and analyze the sensible and latent heat storage units
3. Be aware of various applications of thermal storage systems

UNIT I INTRODUCTION 08

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 09

Basic concepts and modelling of heat storage units - modelling of simple water and rock bed storage system – pressurized water storage system for power plant applications – packed beds.

UNIT III REGENERATORS 10

Parallel flow and counter flow regenerators – finite conductivity model – non – linear model – transient performance – step changes in inlet gas temperature – step changes in gas flow rate – parameterization of transient response – heat storage exchangers.

UNIT IV LATENT HEAT STORAGE SYSTEMS 09

Modeling of phase change problems – temperature based model - enthalpy model - porous medium approach - conduction dominated phase change – convection dominated phase change.

UNIT V APPLICATIONS 09

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.

TOTAL: 45 PERIODS

REFERENCES

1. Ibrahim Dincer and Mark A. Rosen, "Thermal Energy Storage Systems and Applications", John Wiley & Sons 2010.
2. A Thumann, D. Paul Mehta, "Handbook of energy engineering", 6th Edition, The Fairmont Press, Inc., 2008
3. Halime Ö Paksoy, "Thermal energy storage for sustainable energy consumption", Springer, 2007
4. IEEE Journals for "Power, Energy, & Industry Applications"

EEE3C - MATERIALS FOR ENERGY APPLICATIONS

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. Able to understand the properties and characteristics of materials used in energy applications
2. Basic design concepts and technologies for manufacturing the solar cells will be acquired
3. Be familiar about various heat storage media viz., rock-bed, earth, Aquifers etc.,

UNIT I MATERIALS 09

Glazing materials, Properties and Characteristics of Materials, Reflection from surfaces, Selective Surfaces: Ideal coating characteristics, Types and applications, Anti-reflective coating, Preparation and characterization, Reflecting Surfaces and transparent materials, Types of Insulation and properties

UNIT II PHYSICS OF SOLAR CELLS 09

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 09

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 a complete silicon, GaAs, InP solar cell

UNIT IV SENSIBLE HEAT STORAGE MATERIALS 09

Stratified storage systems, Rock-bed storage systems, Thermal storage in buildings, Earth storage, Energy storage in aquifers, Heat storage in SHS systems, Aquifers storage

UNIT V PHASE CHANGE MATERIALS, PIEZOELECTRICITY AND FERRO ELECTRICITY 09

Selection criteria of Phase change, Materials use in Solar heating or cooling, Research Status Optical properties, Interaction of solids with radiation, Luminescence, Photoconductivity

TOTAL: 45 PERIODS

REFERENCES

1. İbrahim Dinçer, Marc Rosen "Thermal Energy Storage", 2nd Edition, John Wiley and Sons, 2010
2. WD Callister, Jr, "Materials Science and Engineering: An Introduction", John Wiley, New York, 2010
3. Robert A. Huggins, "Energy Storage", Springer, 2010
4. Srinivasan, "Engg Materials And Mettalurgy", 2nd Edition, Tata McGraw-Hill Education, 2010
5. A Ter-Gazarian, "Energy Storage for Power Systems", Peter Peregrinus Ltd London, 1994
6. R Narayan, B Viswanathan, "Chemical and Electrochemical Energy System", Universities Press, 1998
7. IEEE Journals for "Power, Energy, & Industry Applications"

EEE3D - NANOTECHNOLOGY AND NANO ELECTRONICS

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. A scientific basis to ensure the safe and responsible development of engineered nanoparticles and nanotechnology-based materials and products.
2. Better knowledge of the risks of nanomaterials for health and the environment will form a solid basis to avoid unnecessary damage and loss of investments; and allow for a sustainable development of the nanotechnology industries and markets.
3. Student will be able to explore, develop, characterize and evaluate unique nanoscale packaging materials for thin film passive components.
4. Familiarize students with semiconductors and devices including the P-N junction, and the transistors.

UNIT I FUNDAMENTALS OF SOLID STATE ENGINEERING: 09

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: 09

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: 09

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: 09

Basic compound semiconductors, Bulk single crystal growth techniques, Epitaxial growth techniques, Physical vapour deposition and sputtering, Thermodynamics and kinetics of growths, Nan scale growth modes

UNIT V CHARACTERIZATION TECHNIQUES: 09

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.

TOTAL PERIODS: 45

REFERENCES:

1. M. Razeghi, "Fundamentals of Solid State Engineering", 2nd Edition Springer, 2006
2. W. R. Fahrner, "Nanotechnology and Nan electronics: Materials, Devices, Measurement Techniques" Springer-Verlag Berlin Heidelberg, 2005
3. R. W. Kelsall, I. W. Hamley, and M. Geoghegan, "Nanoscale Science and Technology" John Wiley & Sons Ltd, England, 2005
4. B.D. Cullity, "Elements of X-ray Diffraction (For X-rays), 3rd edition"., Prentice-Hall, Upper Saddle River, 2001

EEE3E - SOLAR REFRIGERATION AND AIR-CONDITIONING

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. Able to understand the Basic Thermodynamic Modeling, Design Studies and Evaluation Methods for Solar Cooling Systems.
2. Familiar with the economical use of the systems

UNIT I INTRODUCTION 09

Potential and scope of solar cooling, Types of solar cooling systems, solar collectors and storage systems for solar refrigeration and air conditioning.

UNIT II VAPOUR ABSORPTION AND COMPRESSION REFRIGERATION SYSTEMS 09

Solar operation of vapour absorption – Lithium Bromide –Water Absorption system – Aqua Ammonia Absorption system - Intermittent Absorption Refrigeration system – Vapour compression refrigeration cycles and their assessment.

UNIT III THERMODYNAMIC MODELLING 09

Thermal modelling and computer simulation for continuous and intermittent solar refrigeration and air conditioning systems.

UNIT IV SOLAR COOLING SYSTEMS 09

Solar desiccant cooling systems. Open cycle absorption/ desorption solar cooling alternatives. Advanced solar cooling systems, Refrigerant storage for solar absorption cooling systems.

UNIT V ECONOMICS 09

Solar thermoelectric refrigeration and air conditioning - solar economics of cooling systems.

TOTAL PERIODS: 45

REFERENCES:

1. Ursula Eicker, "Low Energy Cooling for Sustainable Buildings", John Wiley and Sons, 2009
2. Hans-Martin Henning, "Solar-assisted air conditioning in buildings: a handbook for planners", Springer, 2007
3. M. Santamouris, D. Asimakopoulos, "Passive cooling of buildings", Earthscan, 1996
4. A. A. M. Sayigh, J. C. McVeigh, "Solar air conditioning and refrigeration", Pergamon Press, 1992
5. IEEE Journals for "Power, Energy, & Industry Applications"

EEE3F - FUEL CELLS AND HYDROGEN ENERGY

L	T	P	C
3	0	0	3

COURSE OUTCOMES

1. Knowledge on the hydrogen production methodologies, possible applications and various storage options
2. Ability to converse about the working of a typical fuel cell, its types and to elaborate on its thermodynamics and kinetics
3. Able to analyze the cost effectiveness and eco-friendliness of Fuel Cells

UNIT I FUEL CELL BASICS 09

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 09

Classification by operating temperature/electrolyte type, Fuel Cell Performance, Activation, Ohmic and Concentration over potential

UNIT III FUEL CELL DESIGN AND COMPONENTS 09

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 09

Production of hydrogen from fossil fuels, electrolysis, thermal decomposition, photochemical and photo-catalytic methods.

UNIT V HYDROGEN STORAGE METHODS 09

Metal hydrides, metallic alloy hydrides, carbon nano-tubes, sea as source of deuterium.

TOTAL PERIODS: 45

REFERENCES

1. A Faghri & Y Zhang, “Transport Phenomena in Multiphase Systems”, Elsevier 2006
2. S Srinivasan, “Fuel Cells: From Fundamentals to Applications”, Springer 2006
3. O’Hayre, SW Cha, W Colella and FB Prinz, “Fuel Cell Fundamentals”, Wiley, 2005
4. Xianguo Li, “Principles of Fuel Cells”, Taylor and Francis, 2005
5. J Larminie and A Dicks, “Fuel Cell Systems Explained, 2nd Edition”, Wiley,2003
6. IEEE Journals for “Power, Energy, & Industry Applications”

EEE3H - SOLAR PHOTOVOLTAIC POWER PLANTS: PLANNING, DESIGN AND BALANCE OF SYSTEMS

L	T	P	C
3	0	0	3

COURSE OUTCOMES

On completion of the course, the student will be

1. capable of understanding the physics of photo cells
2. proficient to differentiate various technologies along with their pros & cons
3. competent to design & analyze on-grid PV applications
4. skilled to design & analyze off-grid PV applications
5. able to realize cost benefit analysis of PV installations

UNIT I SOLAR CELL FUNDAMENTALS 09

Contribution of Solar PV in Global Energy Scenario – Fundamentals of Semiconductors and Solar cells, Energy band, Charge carriers – Motion, PN Junction diode, Solar cells – Design characteristics, Solar radiation.

UNIT II SOLAR CELL TECHNOLOGIES 09

Silicon cell – Mono crystalline & Multi crystalline – Production, Silicon – Wafer based Solar cell, Thin film solar cells – A-Si, Cd-Te & CIGS, Concentrated PV cells, Emerging technologies – Organic cells, Dye sensitized cells.

UNIT III ON-GRID APPLICATIONS 09

Solar cells to solar array – On-Grid PV system – With & Without storage – Balance of system – DC-DC converters – Inverters – Net Metering – Design & analysis – Performance evaluation & monitoring – Field visit – Grid tied PV power plant.

UNIT IV OFF-GRID APPLICATIONS 09

Off-Grid stand alone PV system – System sizing – Module & Battery – Storage – Batteries for PV systems – Sun Tracking mechanism – Types of tracking – One-axis, Two-axis – Maximum power point tracking – Design & analysis – Performance evaluation & monitoring – Field visit – Off-grid PV system.

UNIT V COMMERCIALS FOR SOLAR PV INSTALLATIONS 09

Cost and manufacturability – Cost modeling – Manufacturing economics – scaling – Pricing – Trends in retail pricing – energy economics – grid tied –stand alone applications

TOTAL PERIODS: 45

REFERENCES

1. Chetan Singh Solanki "Solar Photovoltaics Fundamentals, Technologies and Applications", Second Edition, Prentice Hall of India, 2011
2. Robert Foster Majid Ghassemi, Alma Cota "Solar Energy – Renewable Energy and the Environment", CRC Press, 2010
3. James P. Dunlop "Photovoltaic Systems", Second Edition by American Technical Publishers, 2009
4. Eduardo Lorenzo "Solar Electricity: Engineering of Photovoltaic Systems" by PROGENSA, 1994
5. www.pveducation.org

EEE3K - SPECTROSCOPIC METHODS IN CHEMISTRY

L T P C
3 0 0 3

COURSE OUTCOMES

After the completion of course the student will be able to

1. elucidate the electronic transition and the effect of conjugation present in the metal complex.
2. identify the functional group and vibration of any metal complex.
3. predict the splitting pattern and interpret integration of NMR spectra.
4. predict the fragmentation pattern to find molecular mass and to identify the structure of a compound.
5. interpret experiment spectra and analyzing the results to identify the geometry of the compound.

UNIT I ULTRAVIOLET SPECTROSCOPY 09

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 09

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 09

Principles of ^{1}H,^{13}C NMR – Shielding mechanism – Chemical shift – Spin-Spin coupling – Coupling constants – Splitting of signals – Applications of NMR to organic compounds.

UNIT IV MASS SPECTROMETRY 09

Principle of mass spectrometry – Molecular peak, base peak, isotopic peak, metastable peak and their uses – Mass spectrum of organic compounds – identification – alcohols, aldehydes and aromatic hydrocarbons.

UNIT V ELECTRON SPIN RESONANCE (ESR) SPECTROSCOPY 09

Principle of ESR – Spin-spin relaxation – Hyperfine splitting – Zeeman splitting – g-values – Factors affecting g-value – Determination of g value – Zero field splitting – Application of ESR measurements.

TOTAL: 45 PERIODS

REFERENCES

1. Skoog D A, West D M, Fundamentals of Analytical Chemistry, Thomson Asia Private Limited. 8th Edition, 2004.
2. Jag Mohan, Organic spectroscopy. Narosa publishing House, New Delhi, 2011.

EEE3L - ANALYTICAL CHEMISTRY

L T P C
3 0 0 3

COURSE OUTCOMES

After the completion of course the student will be able to

- select a proper chromatographic technique to isolate the compound.
- apply the knowledge in solving problems / tasks in the field of electro analytical chemistry.
- interpret the data and qualitative estimation by wet chemical analysis.
- evaluate and access chemical reaction and kinetic properties between 0-1600°C for compound.
- expand the knowledge of radiochemical analytical technique.

UNIT I CHROMATOGRAPHIC METHODS 09

Principle – Classification of chromatographic techniques – Technique and applications of paper chromatography – Thin-layer chromatography – HPTLC – Column chromatography – HPLC, GC-MS and its applications.

UNIT II ELECTRO ANALYTICAL TECHNIQUES 09

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 09

Principle of volumetric analysis – Neutralization, Complexometric titrations – Precipitation titrations – Redox titrations – Theoretical aspects of titration curves and end point evaluation – Gravimetric analysis.

UNIT IV THERMAL METHODS 09

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

UNIT V RADIOCHEMICAL METHODS 09

General theoretical considerations – Special precautions for radiochemical studies – Equipment for measuring radio activity – G.M. Counter– Determination of characteristics of GM counter – Determination of the absorption curve for ^{234}Th – ^{234}Pa sample.

TOTAL: 45 PERIODS

REFERENCES

1. B. Sivasankar, Instrumental Methods of Analysis (Oxford Higher Education), 2012.
2. F. Settle – Handbook of Instrumental Techniques for Analytical Chemistry, Pearson Education, Singapore, 2004.