ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

REGULATIONS – 2015

CHOICE BASED CREDIT SYSTEM

M.E. SOLAR ENERGY

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

I. To prepare students to excel in research and to succeed in Solar Energy profession through global, rigorous post graduate education.

II. To provide students with a solid foundation in mathematical, scientific and engineering fundamentals required to solve Solar Energy problems.

III. To train students with good scientific and engineering knowledge so as to comprehend, analyze, design, and create novel products and solutions for the real time problems.

IV. To inculcate students in professional and ethical attitude, effective communication skills, teamwork skills, multidisciplinary approach, and an ability to relate Solar Energy issues to broader social context.

V. To provide students with an academic environment aware of excellence, leadership, written ethical codes and guidelines, and the life-long learning needed for a successful professional career.

PROGRAMME OUTCOMES (POs):

On successful completion of the programme,

1. Graduates will demonstrate knowledge of mathematics, science and engineering.
2. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
3. Graduates will demonstrate an ability to design and conduct experiments, analyze and interpret data.
4. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.
5. Graduates will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.
6. Graduates will demonstrate skills to use modern engineering tools, software and equipment to analyze problems.
7. Graduates will demonstrate knowledge of professional and ethical responsibilities.
8. Graduates will be able to communicate effectively in both verbal and written form.
9. Graduates will show the understanding of impact of engineering solutions on the society and also will be aware of contemporary issues.
10. Graduates will develop confidence for self education and ability for life-long learning.

Mapping of PEOs with POs

Programme Educational Objectives	Programme Outcomes									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
I			✓	✓	✓	✓			✓	
II	✓	✓							✓	
III			✓	✓		✓			✓	
IV							✓	✓		✓
V							✓			✓

			PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
YEAR 1	**SEM 1**	Advanced Numerical Methods	✓	✓				✓				
		Thermodynamic Analysis of Energy Systems	✓	✓		✓						
		Fluid Mechanics and Heat Transfer	✓	✓			✓	✓				
		Energy Resources and Conversion Techniques			✓	✓			✓		✓	
		Physics of Solar Engineering			✓	✓	✓	✓				
		Elective I										
		Solar Thermal Laboratory			✓	✓	✓	✓				
	SEM 2	Solar Photovoltaic Technologies			✓	✓	✓	✓				
		Solar Thermal Technologies			✓	✓	✓	✓				
		Energy Efficient Buildings Design				✓			✓		✓	
		Elective II										
		Elective III										
		Elective IV										
		Seminar							✓	✓		✓
		Solar Photovoltac Laboratory		✓	✓	✓	✓					
YEAR 2	**SEM 1**	Elective V										
		Elective VI										
		Elective VII										
		Project Work Phase I	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	SEM 2	Project Work Phase II	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

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UNIVERSITY DEPARTMENTS

REGULATIONS – 2015

CHOICE BASED CREDIT SYSTEM

CURRICULA AND SYLLABI

M.E. SOLAR ENERGY

SEMESTER I

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	EY7151	Energy Resources and Conversion Techniques	FC	3	3	0	0	3
2.	EY7152	Fluid Mechanics and Heat Transfer	FC	4	4	0	0	4
3.	EY7153	Thermodynamic Analysis of Energy Systems	FC	4	4	0	0	4
4.	MA7154	Advanced Numerical Methods	FC	4	4	0	0	4
5	SY7101	Physics of Solar Engineering	PC	3	3	0	0	3
6		Elective I	PE	3	3	0	0	3
PRACTICALS .								
7	SY7111	Solar Thermal Laboratory	PC	4	0	0	4	2
			TOTAL	**25**	**21**	**0**	**4**	**23**

SEMESTER II

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	EY7251	Energy Efficient Buildings Design	PC	3	3	0	0	3
2	SY7201	Solar Photovoltaic Technologies	PC	3	3	0	0	3
3	SY7202	Solar Thermal Technologies	PC	3	3	0	0	3
4		Elective II	PE	3	3	0	0	3
5		Elective III	PE	3	3	0	0	3
6		Elective IV	PE	3	3	0	0	3
PRACTICALS								
7	SY7211	Solar Photovoltaic Laboratory	PC	4	0	0	4	2
8	SY7212	Seminar	EEC	2	0	0	2	1
			TOTAL	**24**	**18**	**0**	**6**	**21**

SEMESTER III

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1		Elective V	PE	3	3	0	0	3
2		Elective VI	PE	3	3	0	0	3
3		Elective VII	PE	3	3	0	0	3
PRACTICALS								
4	SY7311	Project Work Phase I	EEC	12	0	0	12	6
			TOTAL	**21**	**9**	**0**	**12**	**15**

SEMESTER IV

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICALS								
1.	SY7411	Project Work Phase II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

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

FOUNDATION COURSES (FC)

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	MA	Advanced Numerical Methods	FC	4	4	0	0	4
2.	EY	Thermodynamic Analysis of Energy Systems	FC	4	4	0	0	4
3.	EY	Fluid Mechanics and Heat Transfer	FC	4	4	0	0	4
4.	EY	Energy Resources and Conversion Techniques	FC	3	3	0	0	3

PROFESSIONAL CORE (PC)

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	SY	Physics of Solar Engineering	PC	3	3	0	0	3
2.	SY	Solar Photovoltaic Technologies	PC	3	3	0	0	3

3.	EY	Energy Efficient Buildings Design	PC	3	3	0	0	3
4.	SY	Solar Thermal Technologies	PC	3	3	0	0	3
5.	SY	Solar Thermal Laboratory	PC	4	0	0	4	2
6.	SY	Solar Photovoltaic Laboratory	PC	4	0	0	4	2

PROFESSIONAL ELECTIVES (PE)

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	EY7071	Advanced Energy Storage Technologies	PE	3	3	0	0	3
2.	EY7073	Electrical Drives and Controls	PE	3	3	0	0	3
3.	EY7074	Energy Forecasting, Modeling and Project Management	PE	3	3	0	0	3
4.	EY7075	Environmental Engineering and Pollution Control	PE	3	3	0	0	3
5.	EY7076	Power Electronics for Renewable Energy Systems	PE	3	3	0	0	3
6.	EY7077	Power Generation, Transmission and Distribution	PE	3	3	0	0	3
7.	IC7071	Computational Fluid Dynamics	PE	3	3	0	0	3
8.	IC7251	Instrumentation For Thermal Systems	PE	3	3	0	0	3
9.	RA7071	Fuzzy Logic and Neural Networks	PE	3	3	0	0	3
10.	SY7001	Embedded Systems	PE	3	3	0	0	3
11.	SY7002	Materials for Solar Devices	PE	3	3	0	0	3
12.	SY7003	Solar Energy Appliances	PE	3	3	0	0	3
13.	SY7004	Solar Energy for Industrial Process Heating	PE	3	3	0	0	3
14.	SY7005	Solar Energy Utilization	PE	3	3	0	0	3
15.	SY7006	Solar Passive Architecture	PE	3	3	0	0	3
16.	SY7007	Solar Power Generation	PE	3	3	0	0	3

		Technologies and Policies						
17.	SY7008	Solar Power Plants	PE	3	3	0	0	3
18.	SY7009	Solar Systems for Building Techniques	PE	3	3	0	0	3
19.	SY7071	Solar Refrigeration and Air Conditioning	PE	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	SY	Seminar	EEC	2	0	0	2	1
2.	SY	Project Work Phase I	EEC	12	0	0	12	6
3.	SY	Project Work Phase II	EEC	24	0	0	24	12

EY7151 ENERGY RESOURCES AND CONVERSION TECHNIQUES **L T P C**
3 0 0 3

OBJECTIVES:

- To explain the concept of various forms of renewable energy
- To outline division aspects and utilization of renewable energy sources for both domestics and industrial applications
- To understand the various energy conversion techniques and their relative merits and demerits.

UNIT I SOLAR ENERGY **9**

Present energy scenario in India - Solar radiation at the earth's surface – solar radiation measurements – estimation of average solar radiation - solar thermal flat plate collectors - concentrating collectors – solar thermal applications - heating, cooling, desalination, drying, cooking, etc – solar thermal electric power plant - principle of photovoltaic conversion of solar energy, types of solar cells - Photovoltaic applications: battery charger, domestic water pumping etc - lighting, street lighting, solar PV power plant – Net metering concept.

UNIT II WIND ENERGY **9**

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

UNIT III BIO-ENERGY **9**

Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - direct combustion – biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - types of biogas Plants - applications - alcohol production from biomass – bio diesel production – Urban waste to energy conversion - Biomass energy programme in India.

UNIT IV OTHER TYPES OF ENERGY **9**

Ocean energy resources - principle of ocean thermal energy conversion (OTEC) - ocean thermal power plants - ocean wave energy conversion - tidal energy conversion – small hydro - geothermal energy - geothermal power plants – hydrogen production and storage - Fuel cell – principle of working - various types - construction and applications.

UNIT V DIRECT CONVERSION OF THERMAL TO ELECTRICAL ENERGY **9**

Conventional energy conversion cycles **-** Reversible and irreversible cycles – Thermodynamics analysis of Carnot – Stirling – Ericsson – Otto – Diesel – Dual – Lenoir – Atkinson – Brayton - Rankine. Thermoelectric Converters –Thermionic converters – MHD – Ferro electric converter – Nernst effect generator

TOTAL: 45 PERIODS

OUTCOMES:

- Knowledge in working principle of various renewable energy systems
- Capability to do basic design of renewable energy systems
- Awareness on various energy conversion principles

REFERENCES:

1. Sukhatme, S.P., Solar Energy, Tata McGraw Hill, 1984.
2. Twidell, J.W. and Weir, A., Renewable Energy Sources, EFN Spon Ltd., 1986.
3. Kishore VVN, Renewable Energy Engineering and Technology, Teri Press, New Delhi, 2012.
4. Peter Gevorkian, Sustainable Energy Systems Engineering, McGraw Hill, 2007**.**
5. Kreith, F and Kreider, J. F., Principles of Solar Engineering, McGraw-Hill, 1978.
6. Godfrey Boyle, Renewable Energy, Power for a Sustainable Future, Oxford University Press, U.K, 1996.
7. Veziroglu, T.N., Alternative Energy Sources, Vol 5 and 6, McGraw-Hill, 1990.
8. Anthony San Pietro, Biochemical and Photosynthetic aspects of Energy Production, Academic Press, 1980.
9. Bridgurater, A.V., Thermochemical processing of Biomass, Academic Press, 1981.
10. Bent Sorensen, Renewable Energy, Elsevier, Academic Press, 2011.

EY7152 FLUID MECHANICS AND HEAT TRANSFER L T P C
4 0 0 4

OBJECTIVES:

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

UNIT I BASIC EQUATION, POTENTIAL FLOW THEORY AND BOUNDARY LAYER CONCEPT 12

Three dimensional continuity equation – differential and integral forms – equations of mass, momentum and Energy and their engineering applications. Rotational and irrotational flows – circulation – vorticity – stream and potential functions. Boundary Layer - displacement and momentum thickness – laminar and turbulent boundary layers in flat plates – circular pipes.

UNIT II INCOMPRESSIBLE AND COMPRESSIBLE FLOWS 12

Laminar and turbulent flow between parallel plates – flow through circular pipe – friction factor – smooth and rough pipes – Moody diagram – losses during flow through pipes. Pipes in series and parallel – transmission of power through pipes. One dimensional compressible fluid flow – flow through variable area passage – nozzles and diffusers.

UNIT III CONDUCTION AND RADIATION HEAT TRANSFER 15

Governing Equation and Boundary conditions, Extended surface Heat Transfer, Transient conduction – Use of Heisler's charts, Conduction with moving boundaries, Radiation Heat Transfer, Gas Radiation

UNIT IV TURBULENT FORCED CONVECTIVE HEAT TRANSFER 11

Turbulence theory – mixing length concept – turbulence model – k Є model – analogy between heat and momentum transfer – Reynolds, Colburn, Prandtl turbulent flow in a tube – high speed flows.

UNIT V PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGER 10

Condensation on bank of tubes – boiling – pool and flow boiling, Heat exchanger – Є – NTU approach and design procedure – compact heat exchanger.

TOTAL: 60 PERIODS

OUTCOME

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

TEXT BOOKS

1. Anderson, J.D., Fundamentals of Aerodynamics, McGraw Hill, Boston, 2001.
2. Ozisik. M.N., Heat Transfer – A Basic Approach, McGraw Hill Co., 1985.
3. Streeter, V.L., Wylie, E.B., and Bedford, K.W., Fluid Mechanics, WCB McGraw Hill, Boston, 1998.
4. Bansal,R.K., Fluid Mechanics, Saurabh and Co., New Delhi, 1985.
5. Holman.J.P., Heat Transfer, Tata McGraw Hill, 2002.
6. Ghoshdastidar.P.S., Heat Transfer, Oxford University Press, 2004

EY7153 THERMODYNAMIC ANALYSIS OF ENERGY SYSTEMS **L T P C**
4 0 0 4

OBJECTIVES

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

UNIT I AVAILABILITY ANALYSIS AND THERMODYNAMIC PROPERTY RELATIONS 14

Reversible work - availability – irreversibility. Second law efficiency for a closed system and steady – state control volume. Availability analysis of simple cycles. Thermodynamic potentials. Maxwell relations. Generalized relations for changes in entropy - internal energy and enthalpy - C_p and $C_{V.}$ Clausius Clayperon equation, Joule – Thomson coefficient. Bridgeman tables for thermodynamic relations.

UNIT II REAL GAS BEHAVIOUR AND MULTI – COMPONENT SYSTEMS 12

Different equations of state – fugacity – compressibility. Principle of corresponding States - Use of generalized charts for enthalpy and entropy departure. Fugacity coefficient, Lee – Kesler generalized three parameter tables. Fundamental property relations for systems of variable composition. Partial molar properties. Ideal and real gas mixtures. Equilibrium in multi phase systems.

UNIT III CHEMICAL THERMODYNAMICS AND EQUILIBRIUM 12

First and second law analysis of reacting systems - Adiabatic flame temperature - entropy change of reacting systems. Criterion for reaction equilibrium. Equilibrium constant for gaseous mixtures and evaluation of equilibrium composition.

UNIT IV COMBUSTION CHEMISTRY 12

Combustion of Hydrocarbon Fuels. Heat of reaction, combustion and formation. Stoichiometric, fuel rich and oxygen rich reactions. Heating value of fuels. Application of energy equation to the combustion process. Explosion limits, flames and flammability limits. Diffusion and premixed flames.

UNIT V COMBUSTION PROCESS AND COMBUSTION CHAMBERS 10

Combustion in IC Engines and Gas turbines. Knocking and Detonation and control. Design principles of combustion chambers for IC Engines and Gas turbine. Arrangements of gas turbine combustion chambers for power and comparative analysis.

TOTAL = 60 PERIODS

OUTCOMES
Students will able to

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

TEXT BOOKS

1. Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Cons, 1988.
2. Kuo, K.K., Principles of Combustion, John Wiley and Sons, 2005.
3. Winterbone D E, Advanced Thermodynamics for Engineers, Arnold, 1997.
4. Ganesan, V., Gas Turbines, Tata McGrawHill, 2011.
5. Ganesan,V., Internal Combustion Engines, Tata McGrawHill, 2006.
6. Kuo, K.K., Principles of Combustion, John Wiley and Sons, 2005.
7. Khajuria P.R and Dubey S.P., Gas Turbines and Propulsive Systems, Dhanpat Rai Publications, 2003.
8. Cohen, H., Rogers, G F C and Saravanmotto, H I H, Gas Turbine Theory, John Wiely, 5th Edition 2001.

MA7154	ADVANCED NUMERICAL METHODS	L T P C
		4 0 0 4

OBJECTIVE

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

UNIT I ALGEBRAIC EQUATIONS 12

Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm for tridiagonal system – Jacobi, Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Method, Eigenvalue problems: power method, inverse power method, Faddeev – Leverrier Method.

UNIT II ORDINARY DIFFERENTIAL EQUATIONS 12

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

UNIT III FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATION12 12

Parabolic equations: explicit and implicit finite difference methods, weighted average approximation - Dirichlet and Neumann conditions – Two dimensional parabolic equations – ADI method; First order hyperbolic equations – method of characteristics, different explicit and implicit methods; numerical stability analysis, method of lines – Wave equation: Explicit scheme- Stability of above schemes.

UNIT IV FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS 12

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

UNIT V FINITE ELEMENT METHOD 12

Partial differential equations – Finite element method - orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method.

TOTAL: 60 PERIODS

OUTCOME

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

REFERENCES

1. Saumyen Guha and Rajesh Srivastava, "Numerical methods for Engineering and Science", Oxford Higher Education, New Delhi, 2010.
2. Gupta S.K., "Numerical Methods for Engineers", New Age Publishers, 1995
3. Burden, R.L., and Faires, J.D., "Numerical Analysis – Theory and Applications", Cengage Learning, India Edition, New Delhi, 2009
4. Jain M. K., Iyengar S. R., Kanchi M. B., Jain, "Computational Methods for Partial Differential Equations", New Age Publishers, 1993.
5. Morton K.W. and Mayers D.F., "Numerical solution of partial differential equations", Cambridge University press, Cambridge, 2002.

SY7101 PHYSICS OF SOLAR ENGINEERING L T P C
3 0 0 3

OBJECTIVES:

- To explain the concept of various laws related to solar engineering.
- To outline the basic idea of solar energy collecting as well as energy storage devices.

UNIT I INTRODUCTION 9

Basics of solar energy - Brief History of solar energy utilization - Various approaches of utilizing solar energy - Blackbody radiation- Relation between radiation field energy density and radiation spectrum - Planck's formula in energy unit - Maximum spectral density - Planck's formula in wavelength unit - Wien displacement law - Stefan - Boltzmann law - Photoelectric effect - Einstein's theory of photons - Einstein's derivation of the black-body formula.

UNIT II ORIGIN OF SOLAR ENERGY, TRACKING SUNLIGHT & ATMOSPHERIC INTERACTION 12

Basic parameters of the Sun - Measurement of the solar constant - The structure of the Sun - The origin of solar energy - Rotation and orbital motion of the Earth around the Sun - Solar time, sidereal time, universal standard time, local standard time - Equation of time - Intensity of sunlight on an arbitrary surface at any time - Interaction with the atmosphere - Absorption of the molecules - Air mass - Rayleigh scattering - Direct and scattered sunlight.

UNIT III SOLAR CELLS 10

Formation of a pn – junction - Space charge and internal field - Quasi - Fermi levels - The Shockley diode equation - Structure of a solar cell - The solar cell equation - Fill factor and maximum power - Various electron - hole-pair recombination mechanisms - Crystalline silicon solar cells - Thin film solar cells: CIGS, Cite and a – silicon - Tandem solar cells - Dye - sensitized solar cells - Organic solar cells

UNIT IV CONCENTRATION OF SOLAR ENERGY 8

Three types of imaging optics: trough or linear collectors, central receiver with heliostats, and parabolic dish concentrator with on - axis tracking- Solar thermal electricity using Stirling engine or Ranking engine - Solar photovoltaic's with concentration.

UNIT V ENERGY STORAGE 6

Necessity of storage for solar energy- Chemical energy storage - Thermal energy storage - Thermal Flywheels - Compressed air- Rechargeable batteries*.*

TOTAL:45 PERIODS

OUTCOMES:

- The concept of various laws related to solar engineering were studied in detail.
- The basic physics behind radiation and the solar energy collecting devices were learnt in detail.

REFERENCES

1. Duffie, J.A., and Beckman, W.A. Solar Energy Thermal Process, John Wiley and Sons, New York, Jui Sheng Hsieh, Solar Energy Engineering, Prentice-Hall, 2007.
2. M. Stix, The Sun, An Introduction, Second Edition, Springer 2002.
3. Nelson, The Physics of Solar Cells. Imperial College Press, 2003.
4. Rai, G.D., Solar Energy Utilization, Khanna Publishers, N. Delhi, 2010.
5. Sukhatme S.P., Solar Energy, Tata McGraw Hills P Co., 3rd Edition, 2008.
6. B.G. Streetman and S. Banerjee, Solid State Electronic Devices, Sixth Edition, Prentice Hall, 2006.

SY7111	SOLAR THERMAL LABORATORY	L T P C
		0 0 4 2

OBJECTIVE

- To produce an ultimate practical knowledge on various gadgets of solar systems and trying with assorted parameters
- To analyze of analyzing the numerical results from experimentation
- To generate consciousness on routine usages of solar energy gadgets/ industrial utilities

EXPERIMENTS

1. Solar Radiation Measurements
2. Flat Plate Solar Water Heater
3. Flat Plate Solar Air Heater
4. Flat Plate Collector with Reflector
5. Parabolic Trough Collector
6. Evacuated Tube Collector
7. Solar Cookers
8. Thermal Storage System

TOTAL :60 PERIODS

OUTCOME

The student will be able to understand

- The working principle behind the existing collector systems practically.
- The domestic and industrial purposes and usages of solar gadgets available.
- The various radiation measuring instruments and storages related to solar thermal studies.

EQUIPMENTS REQUIRED

1. Solar water heater – 100 LPD
2. Solar cooker
3. Pyrheliometer
4. Pyranometer
5. Solar Radiation Meters
6. Thermocouple
7. Manometer
8. Anemometer
9. PCM based energy storage system

EY7251 ENERGY EFFICIENT BUILDINGS DESIGN

L	T	P	C
3	0	0	3

OBJECTIVES

- To learn the green buildings concepts applicable to modern buildings
- Acquaint students with the principle theories, materials, construction techniques and to create energy efficient buildings

UNIT I INTRODUCTION 9

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

UNIT II LANDSCAPE AND BUILDING ENVELOPES 9

Energy efficient Landscape design - Micro-climates – various methods – Shading, water bodies- Building envelope: Building materials, Envelope heat loss and heat gain and its evaluation, paints, Insulation, Design methods and tools.

UNIT III HEATING, VENTILATION AND AIR-CONDITIONING 9

Natural Ventilation, Passive cooling and heating - Application of wind, water and earth for cooling, evaporative cooling, radiant cooling – Hybrid Methods – Energy Conservation measures, Thermal Storage integration in buildings

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. Design of daylighting; Estimation of building loads: Steady state method, network method, numerical method, correlations; Computer packages for carrying out thermal design of buildings and predicting performance.

UNIT V PASSIVE COOLING & RENEWABLE ENERGY IN BUILDINGS 9

Passive cooling concepts: Evaporative cooling, radiative cooling; Application of wind, water and earth for cooling; Shading, paints and cavity walls for cooling; Roof radiation traps; Earth air-tunnel. Introduction of renewable sources in buildings, Solar water heating, small wind turbines, stand-alone PV systems, Hybrid system – Economics.

TOTAL: 45 PERIODS

OUTCOME

Student will be able to

(a) Perform energy audits in any type of building and suggest the conservation measures.

(b) Acquaint students with the principle theories materials, construction techniques and to create energy efficient buildings
(b) Integrate the renewable energy systems in the buildings and passive cooling in buildings

REFERENCES

1. Krieder, J and Rabi, A., Heating and Cooling of buildings : Design for Efficiency, McGraw Hill, 1994.
2. Ursala Eicker, “Solar Technologies for buildings”, Wiley publications, 2003.
3. Guide book for National Certification Examination for Energy Managers and Energy Auditors (Could be downloaded from www.energymanagertraining.com)

SY7201 SOLAR PHOTOVOLTAIC TECHNOLOGIES L T P C
3 0 0 3

OBJECTIVES:

- To explain basics of solar photovoltaic systems.
- To know in depth of its types and design of various PV-interconnected systems

UNIT I PHOTOVOLTAIC BASICS 9

Structure and working of Solar Cells - Types, Electrical properties and Behaviour of Solar Cells - Cell properties and design - PV Cell Interconnection and Module Fabrication - PV Modules and arrays - Basics of Load Estimation.

UNIT II STAND ALONE PV SYSTEMS 10

Schematics, Components, Batteries, Charge Conditioners - Balance of system components for DC and/or AC Applications - Typical applications for lighting, water pumping etc.

UNIT III GRID CONNECTED PV SYSTEMS 10

Schematics, Components , Charge Conditioners, Interface Components - Balance of system Components - PV System in Buildings.

UNIT IV HYBRID SYSTEMS 8

Solar, Biomass, Wind, Diesel Hybrid systems - Comparison and selection criteria for a given application.

UNIT V DESIGN OF PV SYSTEMS 8

Radiation and load data - Design of System Components for different PV Applications - Sizing and Reliability - Simple Case Studies.

TOTAL: 45 PERIODS

OUTCOMES

- To explain basics of solar photovoltaic systems.
- To know in depth of its types and design of various PV-interconnected systems.

REFERENCES

1. CS Solanki: Solar Photovotaics – Fundamentals, Technologies and Applications, PHI Learning Pvt. Ltd., 2011.
2. Martin A. Green, Solar Cells Operating Principles, Technology, and System Applications Prentice-Hall, 2008.
3. Nelson, J The Physics of Solar Cells. Imperial College Press, 2003. Thomas Markvart, Solar Electricit, John Wiley and Sons, 2001.
4. Stuart R. Wenham, Martin A. Green, Muriel E. Watt, Richard Corkish (Editors), Applied

Photovoltaics, Earthscan, 2008.
5. Michael Boxwell, The Solar Electricity Handbook, Code Green Publishing, UK, 2009.
6. Rik DeGunther, Solar Power Your Home for Dummies, Wiley Publishing Inc, 2008.
7. Photovoltaics: Design and Installation Manual, Published by Solar Energy International.

SY7202 SOLAR THERMAL TECHNOLOGIES L T P C
3 0 0 3

OBJECTIVE

- To clarify impression of various solar thermal energy collectors
- To delineate the other applications and the devices used to collect solar energy
- To summarize the basic economics of solar energy collection system

UNIT I SOLAR COLLECTORS 8

Flat plate - Evaculated tube – Concentrated - Pool and Air collectors Construction – Function - Suitability – Comparison - Storage Tank - Solar Fluids.

UNIT II SOLAR WATER HEATING SYSTEMS 9

Integral Collector Storage System - Thermosyphon System - Open Loop, Drain Down, Drain Back, Antifreeze Systems - Refrigerant Solar Water Heaters - Solar Heated Pools - Solar Heated Hot Tubs and Spas.

UNIT III SOLAR SPACE CONDITIONING SYSTEMS 9

Liquid Type Solar Heating System With / Without Storage - Heat Storage Configurations - Heat Delivery Methods - Air-Type Solar Heating Systems - Solar Refrigeration and Air Conditioning.

UNIT IV OTHER SOLAR APPLICATIONS 9

Solar Cooking – Distillation - Desalination - Solar Ponds – Solar Passive Architecture – Solar Drying – Solar Chimney.

UNIT V SOLAR ECONOMICS 10

Application of economic methods to analyze the feasibility of solar systems to decide project / policy alternatives - Net energy analysis - and cost requirements for active and passive heating and cooling - for electric power generation - and for industrial process-heating.

TOTAL :45 PERIODS

OUTCOME

- The impression of various solar thermal energy collectors were clarified.
- The other applications and the devices used to collect solar energy were incorporated.
- The basic economics of solar energy collection system was understood.

REFERENCES

1. H P Garg, M Dayal, G Furlan, Physics and Technology of Solar Energy- Volume I: Solar Thermal Applications, Springer, 2007.
2. Sukhatme and Nayak, Solar Energy: Principles Of Thermal Collection And Storage, Tata McGraw.Hill, 2008.
3. Bob Ramlow & Benjamin Nusz, Solar Water Heating, New Society Publishing, 2006.
4. John Canivan, Solar Thermal Energy, Sunny Future Press - 2003.
5. Charles Christopher Newton - Concentrated Solar Thermal Energy- Published by VDM Verlag, 2008.
6. H.P.Garg, S.C.Mullick, A.K.Bhargava, D.Reidal, Solar Thermal Energy Storage Springer, 2005.
7. Anne Grete Hestnes, Robert Hastings, Bjarne Saxhof, Solar Energy Houses: Strategies, Technologies Examples, Earthscan Publications, 2003

SY7211 SOLAR PHOTOVOLTAIC LABORATORY L T P C
0 0 4 2

OBJECTIVE

- To construct a practical knowledge on various devices of solar PV systems and trying with an assortment of parameters
- To re-iterate and analyze the numerical results from trial and error
- Generate perception on practice usages of solar PV gadgets/ industrial utilities

EXPERIMENTS

1. Study on Solar Cell Characteristics
2. Testing of SPV Stand alone Systems
3. Testing on Solar Home Systems
4. Optimization of SPV Systems with Load Resizing
5. Testing of Simple Hybrid Systems
6. Testing of Solar PV Water Pumps
7. Studies on Charging and Discharging Cycles of the batteries.

TOTAL :60 PERIODS

OUTCOME

The student will be able to understand

- The various characteristics of the solar cell under local climatic working conditions
- The performance of the Solar PV cell under various specified operating temperature ranges and will be able to relate it with nominal values
- The various radiation measuring instruments related to solar photovoltaics

EQUIPMENTS REQUIRED

1. Solar PV Training Kit
2. Solar Educational Kit
3. WatchDog Timer
4. Pyrheliometer
5. Pyranometer
6. Voltmeter
7. Ammeter
8. Multimeter
9. Thermocouple
10. Manometer
11. Anemometer
12. Luxmeter

EY 7212 SEMINAR L T P C
0 0 2 1

OBJECTIVES

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

TOTAL: 30 PERIODS

SY7311 PROJECT WORK PHASE I

L T P C
0 0 12 6

OBJECTIVES

- A research project topic may be selected either from published lists or from the creative ideas of the students themselves in consultation with their project supervisor.
- To improve the student research and development activities.

EVALUATION

Project work evaluation is based on Regulations of Credit system University Departments - Post graduate programmes of Anna University

TOTAL : 90 PERIODS

OUTCOME

The students' would apply the knowledge gained from theoretical and practical courses in solving problems, so as to give confidence to the students to be creative, well planned, organized, coordinated in their project work phase – II.

SY7411 PROJECT WORK PHASE II

L T P C
0 0 24 12

OBJECTIVES

- The objective of the research project work is to produce factual results of their applied research idea in the thermal Engineering, from phase – I.
- The progress of the project is evaluated based on a minimum of three reviews.
- The review committee may be constituted by the Head of the Division.
- A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Division based on oral presentation and the project report
- To improve the student research and development activities.

EVALUATION

- Project work evaluation is based on Regulations of Credit system University Departments - Post graduate programmes of Anna University

TOTAL = 180 PERIODS

OUTCOME

The students' would apply the knowledge gained from theoretical and practical courses in solving problems, so as to give confidence to the students to be creative, well planned, organized, coordinated project outcome of the aimed work.

EY7071 ADVANCED ENERGY STORAGE TECHNOLOGIES L T P C
3 0 0 3

OBJECTIVES

- To develop the ability to understand / analyse the various types of energy storage.
- To study the various applications of energy storage systems.

UNIT I INTRODUCTION 6

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

UNIT II THERMAL STORAGE SYSTEM 9

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

UNIT III ELECTRICAL ENERGY STORAGE 10

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

UNIT IV HYDROGEN AND BIOGAS STORAGE 9

Hydrogen storage options – compressed gas – liquid hydrogen – Metal Hydrides, chemical Storage, Biogas storage - comparisons. Safety and management of hydrogen and Biogas storage - Applications.

UNIT V ALTERNATE ENERGY STORAGE TECHNOLOGIES 12

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

TOTAL : 45 PERIODS

OUTCOME

- Able to analyze various types of energy storage devices and perform the selection based on tecno-economic view point.

REFERENCES

1. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002.
2. Fuel cell systems Explained, James Larminie and Andrew Dicks, Wiley publications, 2003.
3. Electrochemical technologies for energy storage and conversion, Ru-shiliu, Leizhang, Xueliang sun, Wiley publications, 2012.

EY7073 ELECTRICAL DRIVES AND CONTROLS L T P C
3 0 0 3

OBJECTIVES

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

UNIT I CONVENTIONAL MOTOR DRIVES 9

Characteristics of DC and AC motor for various applications - starting and speed control - methods of breaking

UNIT II PHYSICAL PHENOMENA IN ELECTRICAL MACHINES 9

Various losses in motors-Saturation and Eddy current effects - MMF harmonics and their influence of leakage-stray losses - vibration and noise.

UNIT III SOLID STATE POWER CONTROLLERS 9

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

UNIT IV SUPERCONDUCTIVITY 9

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

UNIT V SOLID STATE MOTOR CONTROLLERS 9

Single and Three Phase fed DC motor drives - AC motor drives - Voltage Control - Rotor resistance control - Frequency control - Slip Power Recovery scheme

TOTAL: 45 PERIODS

OUTCOME

The student will be able to understand

- The principle of conventional motor drives, concepts of various losses and harmonic effects in motors and superconductivity theory.
- The concept of Solid State motor controllers and their applications.

REFERENCES

1. Subrahmanyam, Electric Drives : Concepts & Applications 2/E, Tata McGraw-Hill Education, 2011
2. Robert A. Huggins, Energy Storage , Springer(2010)
3. Rene Husson, Modelling and Control of Electrical machines, Elsevier Science Ltd, 2009
4. D.Singh, K.B.Khanchandani, Power Electronics, Tata McGraw-Hill Education Ltd, 2006
5. Austin Hughes, Electric Motor & Drives, Newnes, 2006.

EY7074	ENERGY FORECASTING, MODELING AND PROJECT MANAGEMENT	L T P C
		3 0 0 3

OBJECTIVES

- To develop forecasting models and optimization models for energy planning.
- To equip the students in writing project proposals and making project cost estimation.
- To evaluate the limit cost of energy for various renewable energy systems

UNIT I ENERGY SCENARIO 10

Role of energy in economic development and social transformation: Energy & GDP,GNP and its dynamics - Energy Sources and Overall Energy demand and Availability - Energy Consumption in various sectors and its changing pattern - Status of Nuclear and Renewable Energy: Present Status and future promise

UNIT II FORECASTING MODEL 10

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

UNIT III OPTIMIZATION MODEL 10

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

UNIT IV PROJECT MANAGEMENT 10

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

UNIT V ENERGY POLICY 5

National & State Level Energy Issues - National & State Energy Policy - Energy Security - National solar mission - state solar energy policy - Framework of Central Electricity Authority (CEA), Central & States Electricity Regulatory Commissions (CERC & ERCs)

TOTAL: 45 PERIODS

OUTCOME

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

REFERENCES

1. S. Makridakis, Forecasting Methods and applications. Wiley 1983.
2. Yang X.S. Introduction to mathematical optimization: From linear programming to Metaheuristics, Cambridge, Int. Science Publishing, 2008.
3. Austin H. Church, centrifugal pumps and blowers, John Wiley and sons, 1980.
4. Fred Luthans, Organisational Behaviour, McGraw Hill, Inc, USA, 1992.
5. Armstrong, J.Scott (ed.) Principles of forecasting: a hand book for researchers and practitioners, Norwell, Masschusetts:Kluwer Academic Publishers.2001
6. Dhandapani Alagiri, Energy Security in India Current Scenario, The ICFAI University Press,2006
7. Sukhvinder Kaur Multani, Energy Security in Asia Current Scenario, The ICFAI University Press, 2008.

EY7075 ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL **L T P C**
3 0 0 3

OBJECTIVES

- To impart knowledge on the atmosphere and its present condition and, global warming.
- To detail on the sources of air, water and noise pollution and possible solutions for mitigating their degradation

UNIT I INTRODUCTION 8

Man & Environment – Types of Pollution – Global Environmental issues – Environmental Impact Assessment – Global Warming Issues – CO_2 Mitigation – Basic definition of Pollution Indicators – Noise Pollution

UNIT II WATER POLLUTION 9

Pollutants in Water & Wastewater – Physical and Chemical Treatment Methods – (An Overview) Neutralization – Aeration –Colour / Odour Removal - Sludge dewatering – Biological Treatment including Aerobic & Anaerobic Treatment

UNIT III AIR POLLUTION 10

Sources – Ambient Air Quality Standards – Emission Limits – Equipment for Ambient Air & Stack Monitoring – Principles of operation of Particulate Control Equipments (ESPs, Bag Filters, Cyclone Separators etc.,) – Vehicular Pollution and its Control

UNIT IV SOLID & HAZARDOUS WASTE MANAGEMENT 11

Types & Sources – Types (Municipal, Biomedical, Industrial, Hazardous etc.,) – Waste Generation – Composition – Physical / Chemical / Biological Properties – Transformation Technologies for Waste Treatment – Landfill Management – Leachate Generation – e Waste Disposal

UNIT V GLOBAL WARMING & CLIMATE CHANGE 7

Impact of Global Warming / Climate Change on various sectors – Green House Gases & Effect – Carbon Cycle – CDM – Carbon Trading – Carbon Sequestration – Carbon Capture & Storage - UNFCCC – IPCC Protocols

TOTAL: 45 PERIODS

OUTCOME

- Types and effects of each type of pollution on man – earth will be made known.
- Technical aspects of Global Warming will make them understand the impact they have on climate
- Cursory / superficial formation - the students – had in Hazardous waste, waste disposal hitherto will be deep & sensible enough after studying this subject

REFERENCES

1. G. Masters: Introduction to Environmental Engineering and Science, Prentice Hall of India Pvt Ltd, New Delhi, 2003
2. Peavy, H.S. and D.R. Rowe, G.Tchobanoglous: Environmental Engineering - McGraw- Hill BookCompany, NewYork, 1985
3. Ludwig, H. W.Evans: Manual of Environmental Technology in Developing Countries, International Book Company, Absecon Highlands, N.J, 1991
4. Arcadio P Sincero and G. A. Sincero, Environmental Engineering – A DesignApproach, Prentice Hall of India Pvt Ltd, New Delhi, 2002.

EY7076 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS L T P C

3 0 0 3

OBJECTIVES

- To impart knowledge on Standalone, Grid connected and Hybrid renewable energy systems.
- To understand the different types of Electrical Machines and Power Converters employed for renewable energy conversion systems

UNIT I INTRODUCTION 9

Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems

UNIT II ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION 9

Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG

UNIT III POWER CONVERTERS 9

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

UNIT IV ANALYSIS OF WIND AND PV SYSTEMS 9

Stand alone operation of fixed and variable speed wind energy conversion systems and solar system-Grid connection Issues -Grid integrated PMSG and SCIG Based WECS Grid Integrated solar system

UNIT V HYBRID RENEWABLE ENERGY SYSTEMS 9

Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PVMaximum Power Point Tracking (MPPT).

TOTAL:45 PERIODS

OUTCOME

- The student will be able to understand the concepts of Standalone, Grid connected and Hybrid Energy Systems and different types of Electrical Machines and Power Converters employed for Renewable Energy Conversion Systems.

REFERENCES

1. Leon Freris, David Infield, “Renewable energy in power systems”, John Wiley & Sons, 2008.
2. Rashid .M. H “power electronics Hand book”, Academic press, 2007.
3. Rai. G.D, “Non conventional energy sources”, Khanna publishes, 2010.
4. Ali Keyhani, Design of Smart Power Grid Renewable Energy Systems, John Wiley & Sons, 2011.
5. Wind Electric Systems: S.N.Bhadra,D.Kastha, OXFORD university press, 2005.

EY7077 POWER GENERATION, TRANSMISSION AND DISTRIBUTION L T P C
3 0 0 3

OBJECTIVE

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

UNIT I CONVENTIONAL POWER GENERATION 12

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

UNIT II NON CONVENTIONAL POWER GENERATION 9

Wind power generation - characteristics of wind power-design of windmills - Tidal power generation - Single and two- basin systems -Turbines for tidal power - Solar power generation - Energy from biomass, biogas and waste

UNIT III ELECTRICAL POWER TRANSMISSION 9

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

UNIT IV UTILISATION OF ELECTRICAL ENERGY 9

Selection of Electrical Drives - Electrical characteristics and mechanical considerations -size, rating and cost, Transformer characteristics – illumination - laws of illumination -polar curve – incandescent - fluoroscent and vapour lamps - Design of OLTC lighting Scheme of industry-electrical welding - energy efficient aspects of devices

UNIT V ECONOMICS OF POWER GENERATION 6

Daily load curves - load factor - diversity factor - load deviation curve - load management - number and size of generating unit, cost of electrical energy – tariff - power factor improvement

TOTAL:45 PERIODS

OUTCOME

The student will be able to understand

(i) The Operation of Conventional Power Plants (Steam, Hydro, Nuclear and Gas Turbine plants) and concepts of Renewable Energy Power generation.

(ii) The Economics of Power generation and Utilization of Electrical Energy for Various applications.

REFERENCES

1. S.N.Singh, Electrical Power generation, Transmission and Distribution 2nd Edition, PHI Learning Private Limited, 2010.
2. C.L.Wadhwa, Generation Distribution and utilization of Electrical Energy, New Age International, 2012.
3. J.W.Twidell and A.D.Weir, Renewable Energy Sources, Taylor and Francis, 2006.
4. Mohammed E. El Hawary, Introduction to Electrical Power Systems, John Wiley & Sons, 2008.
5. R. Krishnan, Electric Motor Drives, Prentice hall, 2001.

IC 7071 COMPUTATIONAL FLUID DYNAMICS

L	T	P	C
3	0	0	3

OBJECTIVES

- This course aims to introduce numerical modeling and its role in the field of heat, fluid flow and combustion it will enable the students to understand the various discretisation methods and solving methodologies and to create confidence to solve complex problems in the field of heat transfer and fluid dynamics.
- To develop finite volume discretized forms of the CFD equations.
- To formulate explicit & implicit algorithms for solving the Euler Equations & Navier Strokes Equations.
-

UNIT I GOVERNING DIFFERENTIAL EQUATIONS AND DISCRETISATION TECHNIQUES 8

Basics of Heat Transfer, Fluid flow – Mathematical description of fluid flow and heat transfer – Conservation of mass, momentum, energy and chemical species - Classification of partial differential equations – Initial and Boundary Conditions – Discretisation techniques using finite difference methods – Taylor's Series - Uniform and non-uniform Grids, Numerical Errors, Grid

Independence Test.

UNIT II DIFFUSION PROCESSES : FINITE VOLUME METHOD 10

Steady one-dimensional diffusion, Two and three dimensional steady state diffusion problems, Discretisation of unsteady diffusion problems – Explicit, Implicit and Crank-Nicholson's schemes, Stability of schemes.

UNIT III CONVECTION - DIFFUSION PROCESSES : FINITE VOLUME METHOD 9

One dimensional convection – diffusion problem, Central difference scheme, upwind scheme – Hybrid and power law discretization techniques – QUICK scheme.

UNIT IV FLOW PROCESSES : FINITE VOLUME METHOD 8

Discretisation of incompressible flow equations – Pressure based algorithms, SIMPLE, SIMPLER & PISO algorithms

UNIT V MODELLING OF COMBUSTION AND TURBULENCE 10

Mechanisms of combustion and Chemical Kinetics, Overall reactions and intermediate reactions, Reaction rate, Governing equations for combusting flows. Simple Chemical Reacting System (SCRS), Turbulence - Algebraic Models, One equation model & $k - \varepsilon$, $k - \omega$ models - Standard and High and Low Reynolds number models.

TOTAL: 45 PERIODS

OUTCOME:

- On successful completion of this course the student will be able to apply the concepts of CFD to analyse the fluid flow and heat transfer in thermal systems.

IC7251 INSTRUMENTATION FOR THERMAL SYSTEMS L T P C
3 0 0 3

OBJECTIVES

- To understand the working of measuring instruments and errors associated with them
- To carry out error analysis and uncertainty of measurements
- To develop skills on the measurement and control applicable to a thermal systems

UNIT I MEASUREMENT CHARACTERISTICS 8

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

UNIT II MEASUREMENTS IN THERMAL SYSTEMS 10

Basic Electrical measurements, Transducers and its types, Signal conditioning and processing - Measurement of temperature, pressure, velocity, flow – basic and advanced techniques, and radiation properties of surfaces

UNIT III MESAURMENT OF FUEL PROPERTIES AND POLLUTANTS 10

Thermo / Physical / Chemical and transport properties of solids, liquids and gaseous fuels, Analysers – Flame Ionisation Detector, Non-Dispersive Infrared Analyser, Chemiluminescent detector, Smoke meters, and Gas chromatography

UNIT IV CONTROL SYSTEMS, COMPONENTS AND CONTROLLERS 10

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

UNIT V DESIGN OF MEASUREMENT AND CONTROL SYSTEMS 7

Data logging and acquisition - Sensors for error reduction, elements of computer interfacing, Timers, and Counters, Designing of measurement and control systems for specific applications - Fault finding – Computer based controls

TOTAL:45 PERIODS

OUTCOME

- On successful completion of this course the student will be able to plan their experiments and understand the suitability, accuracy and uncertainty associated with the instrument used for measuring thermal system parameters**.**

REFERENCES

1. Holman, J.P., Experimental methods for Engineers, Tata McGraw-Hill, 7th Ed.2001.
2. Barney G.C, Intelligent Instrumentation, Second Edition, Prentice Hall of India, 1988.
3. Bolton.W, Industrial Control & Instrumentation, Universities Press, Second Edition, 2001.
4. Doblin E.O, Measurement System Application and Design, Second Edition, McGraw Hill, 1978.
5. Nakra, B.C., Choudhry K.K., Instrumentation, Measurements and Analysis Tata McGraw Hill, New Delhi, 2nd Edition 2003.
6. Morris.A.S, Principles of Measurements and Instrumentation, Prentice Hall of India, 1998.

RA7071 FUZZY LOGIC AND NEURAL NETWORKS L T P C

3 0 0 3

OBJECTIVE

- To understand the concept of ANN and different search techniques.
- To impart knowledge on MATLAB implementation of Fuzzy control.

UNIT I INTRODUCTION 9

Approaches to intelligent control. Architecture for intelligent control. Symbolic reasoning system, rule-based systems, the AI approach. Knowledge representation. Expert systems.

UNIT II ARTIFICIAL NEURAL NETWORKS 9

Concept of Artificial Neural Networks and its basic mathematical model, McCulloch-Pitts neuron model, simple perceptron, Adaline and Madaline, Feed-forward Multilayer Perceptron. Learning and Training the neural network. Data Processing: Scaling, Fourier transformation, principal- component analysis and wavelet transformations. Hopfield network, Self-organizing network and Recurrent network. Neural Network based controller

UNIT III FUZZY LOGIC SYSTEM 9

Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control. Fuzzification, inferencing and defuzzification. Fuzzy knowledge and rule bases. Fuzzy modeling and control schemes for nonlinear systems. Self-organizing fuzzy logic control. Fuzzy logic control for nonlinear time-delay system.

UNIT IV GENETIC ALGORITHM 9

Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm. Concept on some other search techniques like tabu search and ant-colony search techniques for solving optimization problems.

UNIT V APPLICATIONS 9

GA application to power system optimization problem, Case studies: Identification and control of linear and nonlinear dynamic systems using Matlab-Neural Network toolbox.
Stability analysis of Neural-Network interconnection systems. Implementation of fuzzy logic controller using Matlab fuzzy-logic toolbox. Stability analysis of fuzzy control systems

TOTAL : 45 PERIODS

OUTCOME

The student will be able to understand

- The concepts of ANN and different search techniques.
- MATLAB implementation of Fuzzy Logic Control.

REFERENCES

1. Timothy J.Ross, Fuzzy Logic with Engineering Applications, Wiley 2011.
2. Dan W. Patterson, Introduction to Artificial Intelligence and Expert Systems, PHI Learning,2009.
3. S.Rajasekaran, G.A.Vijayalakshmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms, PHI Learning Private Limited, 2004.
4. Laurene Fausett, Fundamentals of Neural Networks, Pearson Education India, 2006.
5. Russell, Artificial Intelligence, Pearson Education India, 2003.

SY7001 EMBEDDED SYSTEMS L T P C

3 0 0 3

OBJECTIVES

- To understand the architecture of embedded processors, microcontrollers, and peripheral devices.
- To appreciate the nuances of programming micro-controllers in assembly for embedded systems.
- To understand the challenges in developing operating systems for embedded systems.

UNIT I INTRODUCTION TO EMBEDDED SYSTEMS 9

Basic operational concepts of a computer - Bus structure - Signed integer representation - Overflow in integer arithmetic - Carry look ahead addition - Booth algorithm - Fast multiplication, restoring division - Single and double precision representation of floating point numbers - Challenges of Embedded Systems –Embedded system design process.

UNIT II MEMORY AND INPUT / OUTPUT MANAGEMENT 9

Basic I/O operation - Usage of stack and frame pointer - Encoding of machine instructions – Interrupt handling - Interrupt hardware - Controlling device requests - Bus arbitration – Synchronous and asynchronous bus – Memory system mechanisms – Memory and I/O devices and interfacing.

UNIT III PROCESSES AND OPERATING SYSTEMS 9

Multiple tasks and processes – Context switching – Scheduling policies – Interprocess communication mechanisms – Performance issues.

UNIT IV ADVANCED COMMUNICATION PRINCIPLES 9

Communication and protocols for parallel, series and wireless communication, embedded system examples, introduction to PLA, PAL, FPGA & ASIC.

UNIT V EMBEDDED SYSTEM DEVELOPMENT 9

Meeting real time constraints – Multi-state systems and function sequences. Embedded software development tools – Emulators and debuggers. Design issues – Design methodologies – Case studies – Complete design of example embedded systems.

TOTAL :45 PERIODS

OUTCOME

- The architecture of embedded processors, microcontrollers, and peripheral devices were understood.
- The challenges in developing operating systems for embedded systems were incorporated.

REFERENCES

1. Wayne Wolf, “Computers as Components:Principles of Embedded Computer System Design”, Elsevier, 2006.
2. Muhammed Ali Mazidi, Janice Gillispie Mazidi and Rolin D.McKinlay, “The 8051 Microcontroller and Embedded Systems”, Pearson Education, Second edition, 2007.
3. Andrew N Sloss, D. Symes, C. Wright, ” Arm system developers guide”, Morgan Kauffman/ Elsevier, 2006.
4. Michael J. Pont, “Embedded C”, Pearson Education , 2007.
5. Steve Heath, “Embedded System Design”, Elsevier, 2005.
6. Jonathan W. Valvano, ‘Embedded Microcomputer Systems: Real Time Interfacing’, Thomson, Fourth Reprint, 2005.
7. David E. Simon, ‘An Embedded Software Primer’, Pearson Education, 2006.
8. Carl Hamacher, Zvonko Vranesic, Safwat Zaky, ‘Computer Organization’, McGraw Hill, 5th Ed.

SY7002 MATERIALS FOR SOLAR DEVICES L T P C

3 0 0 3

OBJECTIVE

- To explain the concept and the diverse materials used for solar devices
- To explicate in depth knowledge of about solar cells, thermal energy storage and electrical energy storages
- To gather some idea of system balance and analysis with reference to its cost

UNIT I MATERIALS FOR SOLAR COLLECTORS 9

Collector Materials for Low, Medium and High Temperature Applications - Glazing Materials, Optical Materials - Absorber Coatings, Insulations, Desiccants, Use of Plastics - Reliability and Durability of Solar Collectors - Environmental Degradation of Low Cost Solar Collectors.

UNIT II MATERIALS FOR SOLAR CELLS 9

Silicon, Cadmium Telluride, Galium-Arsenic, GaInP / GaAs / Ge - Thin Film, Single Crystalline, Polycrystalline Materials - Multi Junction and Tandem Junction Solar Cells - Low Cost and High Efficiency Materials - Conversion Efficiency of Solar Cells.

UNIT III THERMAL ENERGY STORAGE MATERIALS 9

Thermal Storage Concepts - Materials for Sensible and Latent Heat Energy Storage. Organic, Inorganic Eutectic Materials, Materials for Low and High Temperature Storage Applications.

UNIT IV ELECTRICAL ENERGY STORAGE MATERIALS 9

Chemical storage Concepts - Rechargeable Batteries – Types, Operating range, Comparison and suitability for various applications - Super Capacitors.

UNIT V BALANCE OF SYSTEM MATERIALS & COST ANALYSIS 9

Functional requirements of other materials for components like Invertors, Charge Controllers, Wires, Pipes, Valves, etc. and identification of suitable materials - Simple Cost Analysis for alternative selection of materials - Case studies.

TOTAL : 45 PERIODS

OUTCOME

- To explain the concept and the diverse materials used for solar devices
- To explicate in depth knowledge of about solar cells, thermal energy storage and electrical energy storages
- To gather some idea of system balance and analysis with reference to its cost

REFERENCES

1. Ibrahim Dincer and Marc A Rosan, Thermal Energy Storage: Systems and Applications, John Wiley, 2003.
2. Sukhatme and Nayak , Solar Energy: Principles Of Thermal Collection & Storage, Tata McGraw-Hill, 2008.
3. Nelson, J, The Physics of Solar Cells, Imperial College Press, 2003.
4. Jef Poortmans and Vladimir Arkhipov, Thin Film Solar Cells, John Wiley and Sons, 2008. Thomas Markvart, Solar Electricity, John Wiley and Sons, 2007.
5. A.R. Jha, Solar Cell Technology and Applications, Aurbach Publications, 2010.
6. H.P.Garg., S.C.Mullick, A.K.Bhargava, D.Reidal, Solar Thermal Energy Storage, Springer,2005. .
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SY7003 SOLAR ENERGY APPLIANCES L T P C

3 0 0 3

OBJECTIVE

- To learn the fundamental concepts about solar energy systems and devices
- To study the performance of each system in detail along with practical case studies

UNIT I SOLAR LIGHTING 9

Solar cell – Working principle of a solar cell – Solar home lighting systems – Solar street lighting systems - Solar lanterns – Applications - Rural electrification process – Case studies.

UNIT II SOLAR COOKING **9**

Introduction – Types of solar cookers – Advantages and disadvantages - Box type – Parabolic dish cooker - Performance evaluation of solar cookers – Testing of a solar cooker – Applications of solar cooking - Case studies.

UNIT III SOLAR DRYING **9**

Introduction – Need for solar drying - Basics of solar drying – Types of solar dryers – Direct type solar dryer – Mixed mode type solar dryer – Forced circulation type dryers – Hybrid dryer – Bin type dryer – Solar timber drying – Applications - Case studies.

UNIT IV SOLAR DESALINATION **9**

Introduction – Necessity for desalination – Study on various desalination techniques – Comparison between conventional and solar desalination – Basics of solar still - Simple solar still – Material problems in solar still – Solar disinfection and its methods – Case studies on various desalination techniques.

UNIT V SOLAR FURNACES **9**

Introduction – Types of solar furnaces – Components of solar furnaces – Concentrator – Heliostat – Sun tracking – Typical solar furnace designs – Single concentrator furnace – Single heliostat solar furnace - Multiple heliostats solar furnace - Case studies on solar furnaces.

TOTAL : 45 PERIODS

OUTCOME

- The fundamental concepts about solar energy systems and devices are incorporated.
- The performance of the systems along with practical case studies were done.

REFERENCES

1. Suhatme and Nayak, Solar Energy: Principles of Thermal Collection and Storage, Tata McGraw Hill, 2008.
2. HP Garg and J Prakash: Solar Energy: Fundamentals and Applications, Tata McGraw Hill, 2010.
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SY7004 SOLAR ENERGY FOR INDUSTRIAL PROCESS HEATING **L T P C**
3 0 0 3

OBJECTIVE

- To learn the basic concepts of solar energy related industrial process heat
- To study the techno-economic details for the related process heat industries

UNIT I INTRODUCTION **9**

Solar energy – Availability and utilization - Historical background of solar industrial process heat (IPH) - Need of the day – Opportunities and challenges of industrial process heat - Characteristics of industrial process heat.

UNIT II SOLAR ENERGY COLLECTORS FOR INDUSTRIAL PROCESS HEAT 9

Flat plate collector - Materials for flat plate collector and their properties– Evacuated tube collector - Solar point collector - Concentrating collectors - types and applications of concentrating collectors - Thermal Analysis of Collectors and Useful Heat Gained by the fluid - fin efficiency - collector efficiency factor - Heat Removal Factor

UNIT III INDUSTRIAL PROCESS HEAT SYSTEM 9

Introduction – Hot water industrial process heat system – Hot air industrial process heat system – Steam industrial process heat system – Problems involved with industrial process heat system – Case studies on industrial process heat.

UNIT IV APPLICATIONS OF SOLAR INDUSTRIAL PROCESS HEAT 9

Industrial sectors and processes with the potential for solar thermal uses - Food and beverage industries - The textile and chemical industries - Power generation applications – Washing process – Drying process – Distillation and chemical process.

UNIT V TECHNO-ECONOMIC ANALYSIS 9

Introduction – Heat loss calculations of thermal systems – flat plate collector – concentrating collector - Food and beverage systems – The textile and chemical process systems - Washing process – Drying process – Distillation and chemical process – Installation cost – operating cost – interest rate – payback period – sellback - Penalties for emissions or rewards for their reduction.

TOTAL: 45 PERIODS

OUTCOME

- The basic concepts of solar energy-related industrial process heat systems were understood.
- The techno-economic details for the related process heat industries were incorporated.

REFERENCES

1. HP Garg and J Prakash: Solar Energy: Fundamentals and Applications,Tata McGraw Hill, 2010.
2. JA Duffie and WA Beckman, Solar Engineering of Thermal Processes, John Wiley & sons, 2006.
3. Soteris A. Kalogirou, Solar Energy Engineering: Processes and Systems, Academic Press, 2009.
4. Tom P. Hough, Solar energy: recent developments,Nova Publishers, 2007.
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6. John D. Myers, Solar applications in industry and commerce, Prentice-Hall, 2008.
7. Unites States Dept. of Energy. Office of Conservation and Solar Applications, Solar Energy for Agricultural and Industrial Process Heat, Program Summary, Department of Energy, Office of Conservation and Solar Applications., 2009.

SY7005 SOLAR ENERGY UTILIZATION L T P C

3 0 0 3

OBJECTIVE

- To learn the fundamental concepts of solar energy and radiation collecting instruments
- To study about approaches for the storage of solar energy along with solar energy collectors

UNIT I SOLAR RADIATION 9

History of solar energy utilization - Solar radiation and modeling - Empirical equations for predicting the availability of solar radiation – Measurement of global, direct and diffuse radiation – Radiation computations on inclined surfaces – Angstrom’s turbidity - Solar chart - Standard radiation scale.

UNIT II SOLAR RADIATION MEASUREMENT AND ESTIMATION 10

Measurement of solar radiation - Solar energy measuring instruments – Pyranometer – Pyrheliometer – Sunshine recorder - Estimation of average solar radiation - Ratio of beam and total radiation on tilted surface of that on horizontal surface.

UNIT III SOLAR COLLECTORS 9

Flat plate collector - Materials for flat plate collector and their properties - Thermal Analysis of Flat-plate Collector and Useful Heat Gained by the fluid - fin efficiency - collector efficiency factor - Heat Removal Factor - Focusing collectors - Types and applications of focusing collectors

UNIT IV SOLAR ENERGY APPLICATIONS 9

Introduction and principle of operation of solar cooker - solar air heater - solar water heater - solar distillation - solar pond - solar thermal power generation – Greenhouse - Solar PV system.

UNIT V STORAGE OF SOLAR ENERGY 8

Types of Energy Storage - Thermal Storage - Electrical Storage - Chemical Storage - hydro-storage

`TOTAL: 45 PERIODS

OUTCOME

- The fundamental concepts of solar energy and radiation collecting instruments were studied.
- The approaches for thermal energy storages along with solar energy collectors were incorporated.

REFERENCES

1. Rai, G.D., Solar Energy Utilization, Khanna Publishers, N. Delhi, 2010.
2. Sukhatme S.P., Solar Energy, Tata McGraw Hills P Co.,3rd Edition, 2008.
3. Jean Smith Jensen, Applied solar energy research: a directory of world activities and bibliography of significant literature, Volume2, Association for Applied Solar Energy, Stanford Research Institute, 2009.
4. Duffie, J.A., and Beckman, W.A. Solar Energy Thermal Process, John Wiley and Sons, New York, 2006.
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7. Anna Mani, S Rangarajan: Handbook of Solar Radiation Data for India, Allied Publishers, 2006.

SY7006 SOLAR PASSIVE ARCHITECTURE L T P C

3 0 0 3

OBJECTIVE

- To learn the fundamental concepts of solar passive building architecture.
- To know the concepts of passive solar heating and cooling of buildings, human comfort conditions and building rating systems and policies.

UNIT I INTRODUCTION 9

Need for passive architecture - Building form and functions – General aspects of solar passive heating and cooling of buildings – Thumb rules - Thermal comfort – Sun’s motion - Building orientation and design – Heat transfer in buildings.

UNIT II PASSIVE SOLAR HEATING OF BUILDINGS 9

Direct gain – Indirect gain – Isolated gain - Passive heating concept - Thermal modeling of passive concepts – Thermal storage wall and roof – Sunspace – Prediction of heating loads in a building.

UNIT III PASSIVE COOLING OF BUILDINGS 9

Passive cooling concept - Solarium Passive cooling - Ventilation cooling - Nocturnal radiation cooling - Evaporative cooling - Roof surface evaporative cooling (RSEC) - Direct evaporative cooling using drip-type (desert) coolers – Radiation cooling - Earth coupling - Basic principles and systems.

UNIT IV CLIMATE AND HUMAN THERMAL COMFORT 9

Factors affecting climate - Climatic zones and their characteristics - Urban climate - Microclimate - Implications of climate on building design - Principles of energy conscious design - Building materials - Embodied energy of building materials - Alternative building materials

UNIT V BUILDING RATING SYSTEMS 9

Zero energy building concept and rating systems - Energy conservation building codes - Energy management of buildings – Green globe assessment Standards –BREEAM – CASBEE – Green star– Review of CDM Techniques - GRIHA and others.

TOTAL :45 PERIODS

OUTCOME

- The fundamental concepts of solar passive architecture were understood along with examples and case studies.
- The concepts of passive solar heating and cooling of buildings, human comfort conditions and building rating systems and policies were studied.

REFERENCES

1. Jan F. Kreider, The solar heating design process: active and passive systems, McGraw-Hill, 2007.
2. David A. Bainbridge, Ken Haggard, Kenneth L. Haggard, Passive Solar Architecture: Heating, Cooling, Ventilation, Daylighting, and More Using Natural Flows, Chelsea Green Publishing, 2011.
3. VVN Kishore, Renewable Energy Engineering and Technology – A Knowledge Compendium, TERI Press, 2008.
4. HP Garg and J Prakash: Solar Energy: Fundamentals and Applications, Tata McGraw Hill, 2010.
5. Tom P. Hough, Trends in Solar Energy Research, Nova Publishers, 2006.
6. Source Wikipedia, Books LIc, Solar Architecture: Passive Solar Building Design, Active Solar, Daylighting, Passive House, Cool Roof, Earthship, Solar Air Conditioning, General Books LLC, 2010.
7. JA Duffie and WA Beckman: Solar Engineering of Thermal Processes, Third Edition, John Wiley & Sons, 2006.
8. S Sukhatme and J Nayak: Solar Energy: Principles of Thermal Collection and Storage, Third Edition, Tata McGraw Hill, 2008.

SY7007	**SOLAR POWER GENERATION TECHNOLOGIES AND POLICIES**	**L T P C** **3 0 0 3**

OBJECTIVES

- To learn the fundamental concepts of solar energy power generating systems and devices
- To comprehend Indian governmental regulatory policy on renewable energy technology particularly on solar energy and the policy management challenges.

UNIT I SOLAR THERMAL POWER GENERATION 10

Solar Parabolic trough - Design considerations, tracking and control systems - Thermal design of receivers - Solar parabolic dish - Design considerations, Sterling engine, Brayton cycle, tracking and control systems - Solar tower concepts - Tower design - Heliostat design - Receiver types, tracking and control systems - Performance study, site selection and land requirement for the above technologies - Techno-economic analysis of solar thermal power plants.

UNIT II SOLAR PHOTOVOLTAIC POWER GENERATION 10

Solar PV technologies overview - Stationary and concentrated PV - Inverter and control technologies - Master slave inverter system design - Standalone systems - Grid connected systems - Hybridization, synchronization and power evacuation - Site selection and land requirements - Techno-economic analysis of solar PV power plants - Environmental considerations.

UNIT III SOLAR ENERGY POLICY PLANNING. 9

Elements in policy making in solar energy - Components of policy making - Essentials and other requirements - Pre-requirements of policy planning - Models for planning for effective policy making - Data requirements for policy plans - Monitoring and assessments of policies - Global policy pronouncement

UNIT IV SOLAR ENERGY REGULATIONS AND POLICY PROGRAMMES 9

Legislations guiding solar energy sector - Critical review of various programs of government - State regulations - Jawaharlal Nehru National Solar Mission (JNNSM) - JNNSM Regulations regarding grid interconnected solar energy systems – Solar Energy policy, 2012.

UNIT V POLICY MANAGEMENT CHALLENGES 7

Challenges for planning and policies - Issues of subsidization - Entrepreneurship development and management challenges - Issues in entrepreneurship development and management challenges in renewable energy sector in India – Production – Storage - Transmission and distribution - End-use - Pricing, etc

TOTAL: 45 PERIODS

OUTCOME

- The fundamentals of solar energy power generating systems and devices were learnt.
- The Indian governmental policies on renewable energy and the policy management challenges particularly on solar energy technology were studied in detail.

REFERENCES

1. Stefan C. W. Krauter, Solar Electric Power Generation - Photovoltaic Energy Systems: Modeling of optical and thermal performance, electrical yield, energy balance, effect on reduction of greenhouse gas emissions, Springer, 2006.
2. JA Duffie and WA Beckman: Solar Engineering ofThermal Processes, Third Edition, John Wiley & Sons, 2006.
3. Jayarama Reddy, Solar Power Generation: Technology, New Concepts & Policy, CRC Press, 2012.
4. VVN Kishore, Renewable Energy Engineering and Technology – A Knowledge Compendium TERI Press, 2008.
5. CS Solanki: Solar Photovotaics – Fundamentals, Technologies and Applications, PHI Learning Pvt. Ltd., 2011.
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7. S Sukhatme and J Nayak: Solar Energy: Principles of Thermal Collection and Storage, Third Edition, Tata McGraw Hill, 2008.
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SY7008 **SOLAR POWER PLANTS** **L T P C**

3 0 0 3

OBJECTIVES:

- To explain concept of various power cycles involved in the solar power plants
- To outline the variety of solar systems used to collect solar energy
- To summarize basic economics of solar power plants

UNIT I INTRODUCTION **8**

Power Plant Scenario - Classification, Basic Principles and Features - Comparison and selection Criteria.

UNIT II SOLAR POWER CYCLES **9**

Vapour cycles. Organic cycles. Combined cycles. Binary Cycles. Striling and other cycles.

UNIT III SOLAR THERMAL POWER PLANTS **10**

Collector, Receiver, Energy Transfer Power cycles - Tower, Trough and Dish Systems - Concentrating Dish Systems - Concentrating Linear Fresnel Reflectors - Combined and Binary Cycles - Solar Chimneys - Hybrid Systems.

UNIT IV SOLAR PV POWER PLANTS **10**

National / International PV Power Programmes - Photovoltaic Power Systems - System Integration - Energy Storage - Power Electronics - Stand-Alone Systems - Grid-Connected Systems - Concentrating Photovoltaics (CPV) - Electrical Performance.

UNIT V ECONOMICS OF POWER PLANTS **8**

Methods of fixing power tariff - Simple Methods to Calculate the Plant Economy - Life Cycle Cost - Payback Period - Economic Analysis for the Selection of Alternative Decisions and the future of the Power Plants.

TOTAL : 45 PERIODS

OUTCOMES

- The concept of various power cycles involved in the solar power plants were learnt.
- The variety of solar systems used to collect solar energy were studied in detail
- The basic economics of solar power plants were understood.

REFERENCES

1. Duffie, J.A., and Beckman, W.A. Solar Energy Thermal Process, John Wiley and Sons, New York, 2006.
2. Kosuke Kurokawa (Ed.), Eergy from the Desert – Feasibility of very large scale photovoltaic power generation systems, James and James 2003.
3. Sukhatme S.P., Solar Energy, Tata McGraw Hills P Co., 3rd Edition, 2008.
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7. John McBrewster , Frederic P. Miller, Agnes F. Vandome (Eds.) Renewable Energy Commercialization, Alphascript Publishing 2009.

SY7009 SOLAR SYSTEMS FOR BUILDINGS TECHNIQUES **L T P C**
3 0 0 3

OBJECTIVES

- To explain the concept of solar thermal and electrical applications of building
- To summarize basic economics of solar buildings

UNIT I INTRODUCTION 9

Elements of Buildings - Traditional, Modern and Alternative Buildings - Concepts and Elements of Thermal Comfort - Materials and Methods of Construction - Thermal Properties of Building Elements.

UNIT II SOLAR HEAT GAIN IN BUILDINGS 9

Building orientations - Geometric Shapes / Factors - Building Thermal Resistance - Computation of R and U Values for Building Elements and their comparison - Calculation of Solar Heat incident on various building surfaces - Diurnal and Seasonal Variation - Solar Space Conditioning.

UNIT III SOLAR THERMAL SYSTEMS FOR BUILDINGS. 9

Intuitive and responsive building design - Solar Collectors, Cookers, Thermal Energy Storage Systems and their Integration with Buildings – Advantages and Limitations - Sizing, Area and Performance Calculations.

UNIT IV SOLAR PV SYSTEMS FOR BUILDINGS. 9

Solar PV Systems for stand alone and Grid Interconnected Applications - Integration of SPV components with buildings. Sizing, Area and Performance Calculations.

UNIT V ECONOMIC ANALYSIS 9

Economic analysis for alternative selection of materials - Life Cycle Analysis for Thermal and Electrical Solar Systems.

TOTAL: 45 PERIODS

OUTCOME

- Students will be able to explain the concept of solar thermal and electrical applications of buildings and will be able to sort out the basic economics of solar buildings and its components.

REFERENCES

1. Jan F. Kreider, The solar heating design process:active and passive systems, McGraw- Hill, 2007.
2. David A. Bainbridge, Ken Haggard, Kenneth L. Haggard,Passive Solar Architecture: Heating, Cooling, Ventilation,Daylighting, and More Using Natural Flows, Chelsea Green Publishing, 2011.
3. John Schaeffer, Doug Pratt, Douglas R. Pratt, Solar living sourcebook,2007.
4. A common-sense guide to alternative homebuilding, The goodhouse.
5. Joseph F. Kennedy, Catherine Wanek, Michael G. Smith, The art of natural building: design, construction, resources, New Society Publishers, 2004.
6. Sukhatme and Nayak , Solar Energy: Principles Of Thermal Collection & Storage, Tata McGraw-Hill, 2008.
7. Ibrahim Dincer and Marc A Rosan, Thermal Energy Storage: Systems & Applications, John Wiley, 2006.
8. Duffie J.A. and Beckman W.A., 'Solar Engineering of Thermal Processes', Wiley, New York.1, 2006.

SY7071 SOLAR REFRIGERATION AND AIR CONDITIONING **L T P C**
3 0 0 3

OBJECTIVES

- To learn the fundamental concepts about solar energy refrigeration and air-conditioning systems
- To study solar cooling, vapour absorption refrigeration and air-conditioning system, vapour compression systems with implementation techniques for detailed knowledge about solar refrigeration and air-conditioning systems

UNIT I INTRODUCTION 8

Introduction - Potential and scope of solar cooling - Types of solar cooling systems - Solar collectors and storage systems for solar refrigeration and air-conditioning – Refrigerants.

UNIT II SOLAR COOLING 9

Need for solar cooling - Jet ejector solar cooling systems - Fuel assisted solar cooling systems - Solar thermo acoustic cooling and hybrid air-conditioning - Solar desiccant cooling systems - Advanced solar cooling systems.

UNIT III ABSORPTION COOLING 10

Basics of absorption cooling - Principle of absorption cooling - Solar operation of vapour absorption refrigeration cycle - Open cycle absorption / desorption solar cooling alternatives – Lithium Bromide-Water absorption System – Aqua-ammonia absorption system – Intermittent absorption refrigeration System - Refrigerant storage for solar absorption cooling systems.

UNIT IV VAPOUR COMPRESSION REFRIGERATION 10

Vapour compression refrigeration cycles - Rankine cycle - Sterling cycle based solar cooling systems - Thermal modeling for continuous and intermittent solar refrigeration and air-conditioning systems.

UNIT V IMPLEMENTATION TECHNIQUES 8

PV powered refrigerator – Free cooling - Solar thermoelectric refrigeration and air-conditioning - Solar economics of cooling systems - Case studies.

TOTAL: 45 PERIODS

OUTCOME

- The fundamental concepts about solar energy refrigeration and air-conditioning systems were learnt.
- The principles, theories and the materials used for solar cooling, vapour absorption refrigeration and air-conditioning systems were studied in detail with implementation techniques.

REFERENCES

1. Rakosh Das Begamudre, Energy Conversion Systems, New Age International, 2007.
2. Tom P. Hough, Solar Energy: New Research, Nova Publishers, 2006.
3. Alefeld G. and Radermacher R. , Heat Conversion Systems , CRC Press ,2004.
4. ASHRAE Hand Book–HVAC Systems & Equipment, ASHRAE Inc. Atlanta, 2008.
5. Low Temperature Engineering Application of Solar Energy, ed. RC Jordan (ASHRAE).
6. Reinhard Radermacher, Yunho Hwang, Yunho Hwang,Vapor Compression Heat Pumps: With Refrigerant Mixtures, CRC Press, 2005.