ANNA UNIVERSITY, CHENNAI
AFFILIATED INSTITUTIONS
REGULATIONS 2017
M.E. ENERGY ENGINEERING
CHOICE BASED CREDIT SYSTEM

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

I. To prepare student to excel in research or to succeed in Energy engineering profession through global, rigorous post graduate education.
II. To provide students with a solid foundation in mathematical, scientific and engineering fundamentals required to solve energy engineering 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 life problems.
IV. To inculcate students in professional and ethical attitude, effective communication skills, teamwork skills, multidisciplinary approach and an ability to relate energy engineering issues to broader social context.
V. To provide student 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:

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. Graduate will demonstrate an ability to design and conduct experiments, analyze and interpret data.
4. Graduates will demonstrate an ability 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. Graduate will be able to communicate effectively in both verbal and written form.
9. Graduate will show the understanding of impact of engineering solutions on the society and also will be aware of contemporary issues.
10. Graduate will develop confidence for self education and ability for life-long learning.

PEO / PO Mapping

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

II Semester (Elective III, IV & V)

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

Semester Course wise PEO mapping

YEAR	SEM	Subject Name	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
YEAR I	SEM 1	Advanced Numerical Methods	✓	✓						✓	✓	✓
		Fluid Mechanics and Heat Transfer	✓	✓						✓	✓	✓
		Thermodynamic Analysis of Energy Systems	✓	✓						✓	✓	✓
		Energy Resources	✓	✓						✓	✓	✓
		Hydrogen and Fuel Cell Technologies	✓	✓		✓				✓		✓
		Solar Energy Technologies		✓						✓		✓
		Wind Energy Technologies	✓	✓		✓				✓		✓
		Bio Energy Conversion Techniques	✓	✓		✓	✓					✓
		Nuclear Engineering	✓	✓		✓	✓					✓
		Computational Fluid Dynamics for Energy Systems	✓	✓		✓				✓		✓
	SEM 2	Energy Conservation in Thermal Systems	✓	✓		✓				✓		✓
		Energy Conversion Techniques		✓	✓				✓	✓	✓	✓
		Measurement and Control for Energy Systems	✓	✓		✓				✓		✓
		Energy Systems Modeling and Analysis	✓	✓						✓	✓	✓

		Design of Heat Exchangers	✓	✓						✓	✓	✓
		Electrical Drives and Controls		✓		✓			✓	✓		✓
		Power Generation, Transmission and Utilization		✓		✓			✓	✓		✓
		Power Electronics for Renewable Energy Systems		✓		✓			✓	✓		✓
		Design and Analysis of Turbomachines	✓	✓		✓				✓		✓
		Energy Forecasting, Modeling and Project Management			✓	✓			✓	✓		✓
		Energy Efficient Buildings	✓			✓		✓	✓	✓	✓	✓
		Nanomaterials for Energy Applications	✓	✓	✓					✓	✓	✓
YEAR II	**SEM 3**	Energy Conservation in Electrical Systems	✓	✓		✓	✓	✓	✓		✓	✓
		Advanced Power Plant Engineering	✓	✓	✓					✓		✓
		Steam Generator Technology	✓	✓	✓					✓		✓
		Fluidized Bed Systems		✓	✓					✓		✓
		Advanced Energy Storage Technologies		✓	✓					✓		✓
		Waste Management and Energy Recovery		✓	✓					✓		✓
		Environmental Engineering and Pollution Control	✓	✓	✓					✓		✓
		Research Methodology	✓	✓	✓			✓	✓	✓		✓
		Technical Seminar – II	✓	✓				✓			✓	✓
		Project work Phase – I	✓	✓	✓		✓	✓		✓	✓	✓
	SEM 4	Project work Phase – II	✓	✓	✓		✓	✓		✓	✓	✓

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M.E. ENERGY ENGINEERING
CHOICE BASED CREDIT SYSTEM
I TO IV SEMESTERS (FULL TIME) CURRICULUM AND SYLLABUS

SEMESTER I

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	MA5153	Advanced Numerical Methods	FC	5	3	2	0	4
2	EY5151	Fluid Mechanics and Heat Transfer	FC	3	3	0	0	3
3	EY5101	Thermodynamic Analysis of Energy Systems	FC	5	3	2	0	4
4	EY5152	Energy Resources	FC	3	3	0	0	3
5		Professional Elective I	PE	3	3	0	0	3
6		Professional Elective II	PE	3	3	0	0	3
PRACTICAL								
7	EY5111	Energy Laboratory	PC	4	0	0	4	2
			TOTAL	**26**	**18**	**4**	**4**	**22**

SEMESTER II

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1	EY5201	Energy Conservation in Thermal Systems	PC	3	3	0	0	3
2	EY5202	Energy Conversion Techniques	PC	3	3	0	0	3
3	EY5203	Measurement and Control for Energy Systems	PC	3	3	0	0	3
4		Professional Elective III	PE	3	3	0	0	3
5		Professional Elective IV	PE	3	3	0	0	3
6		Professional Elective V	PE	3	3	0	0	3
PRACTICAL								
7	TE5261	Thermal Systems Simulation Laboratory	PC	4	0	0	4	2
8	EY5211	Technical Seminar - I	EEC	2	0	0	2	1
			TOTAL	**24**	**18**	**0**	**6**	**21**

SEMESTER III

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	EY5301	Energy Conservation in Electrical Systems	PC	3	3	0	0	3
2.		Professional Elective VI	PE	3	3	0	0	3
3.		Professional Elective VII	PE	3	3	0	0	3
PRACTICAL								
4.	EY5311	Technical Seminar - II	EEC	2	0	0	2	1
5.	EY5312	Project Work Phase - I	EEC	12	0	0	12	6
			TOTAL	**23**	**9**	**0**	**14**	**16**

SEMESTER IV

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICAL								
1	EY5411	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 THE DEGREE = 71

FOUNDATION COURSES (FC)

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	MA5153	Advanced Numerical Methods	FC	5	3	2	0	4
2.	EY5151	Fluid Mechanics and Heat Transfer	FC	3	3	0	0	3
3.	EY5101	Thermodynamic Analysis of Energy Systems	FC	5	3	2	0	4
4.	EY5152	Energy Resources	FC	3	3	0	0	3

PROFESSIONAL CORE (PC)

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	EY5111	Energy Laboratory	PC	4	0	0	4	2
2.	EY5201	Energy Conservation in Thermal Systems	PC	3	3	0	0	3
3.	EY5202	Energy Conversion Techniques	PC	3	3	0	0	3
4.	EY5203	Measurement and Control for Energy Systems	PC	3	3	0	0	3
5.	TE5261	Thermal Systems Simulation Laboratory	PC	4	0	0	4	2
6.	EY5301	Energy Conservation in Electrical Systems	PC	3	3	0	0	3

ELECTIVES FOR M.E ENERGY ENGINEERING

SEMESTER I (Elective I & II)

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	EY5071	Hydrogen and Fuel Cell Technologies	PE	3	3	0	0	3
2	EY5001	Solar Energy Technologies	PE	3	3	0	0	3
3	EY5002	Wind Energy Technologies	PE	3	3	0	0	3
4	EY5003	Bio Energy Conversion Techniques	PE	3	3	0	0	3
5	EY5091	Nuclear Engineering	PE	3	3	0	0	3
6	EY5004	Computational Fluid Dynamics for Energy Systems	PE	3	3	0	0	3

SEMESTER II (Elective III, IV & V)

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	EY5005	Energy Systems Modeling and Analysis	PE	3	3	0	0	3
2	TE5072	Design of Heat Exchangers	PE	3	3	0	0	3
3	EY5006	Electrical Drives and Controls	PE	3	3	0	0	3
4	EY5007	Power Generation, Transmission and Utilization	PE	3	3	0	0	3
5	EY5008	Power Electronics for Renewable Energy Systems	PE	3	3	0	0	3
6	EY5092	Design and Analysis of Turbomachines	PE	3	3	0	0	3
7	EY5009	Energy Forecasting, Modeling and Project Management	PE	3	3	0	0	3
8	EY5010	Energy Efficient Buildings	PE	3	3	0	0	3
9	EY5011	Nanomaterials for Energy Applications	PE	3	3	0	0	3

SEMESTER III (Elective VI & VII)

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1	TE5074	Advanced Power Plant Engineering	PE	3	3	0	0	3
2	EY5072	Steam Generator Technology	PE	3	3	0	0	3
3	EY5073	Fluidized Bed Systems	PE	3	3	0	0	3
4	EY5012	Advanced Energy Storage Technologies	PE	3	3	0	0	3
5	EY5013	Waste Management and Energy Recovery	PE	3	3	0	0	3
6	TE5291	Environmental Engineering and Pollution Control	PE	3	3	0	0	3
7	MF5072	Research Methodology	PE	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	EY5211	Technical Seminar - I	EEC	2	0	0	2	1
2.	EY5311	Technical Seminar - II	EEC	2	0	0	2	1
3.	EY5312	Project Work Phase - I	EEC	12	0	0	12	6
4.	EY5411	Project Work Phase - II	EEC	24	0	0	24	12

MA5153 ADVANCED NUMERICAL METHODS L T P C
(Common to Environmental Science and Technology, Chemical Engineering and PRPC) 3 2 0 4

OBJECTIVES :

The course will develop numerical methods aided by technology to solve algebraic, transcendental and differential equations and to apply finite element methods for solving the boundary value problems in differential equations. The course will further develop problem solving skills and understanding of the application of various methods in solving engineering problems. This will also serve as a precursor for future research.

UNIT I ALGEBRAIC EQUATIONS 12 +3

Systems of linear equations : Gauss elimination method – Pivoting techniques – Thomas algorithm for tri diagonal system – Jacobi, Gauss Seidel, SOR iteration methods – Conditions for convergence - Systems of nonlinear equations : Fixed point iterations, Newton's method, Eigenvalue problems : Power method and Given's method.

UNIT II ORDINARY DIFFERENTIAL EQUATIONS 12+3

Runge - Kutta methods for system of IVPs – Numerical stability of Runge - Kutta method – Adams - Bashforth multistep method, Shooting method, BVP : Finite difference method, Collocation method and orthogonal collocation method.

UNIT III FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATIONS 12+3

Parabolic equations : Explicit and implicit finite difference methods – Weighted average approximation - Dirichlet's and Neumann conditions – Two dimensional parabolic equations – ADI method : First order hyperbolic equations – Method of numerical integration along characteristics – Wave equation : Explicit scheme – Stability.

UNIT IV FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS 12+3

Laplace and Poisson's equations in a rectangular region : Five point finite difference schemes, Leibmann's iterative methods, Dirichlet's 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+3

Basics of finite element method : Weak formulation, Weighted residual method – Shape functions for linear and triangular element – Finite element method for two point boundary value problems, Laplace and Poisson equations.

TOTAL : 60 +15 = 75 PERIODS

OUTCOMES :

After completing this course, students should demonstrate competency in the following skills:

- Solve an algebraic or transcendental equation, linear system of equations and differential equations using an appropriate numerical method.
- Solving the initial boundary value problems and boundary value problems using finite difference and finite element methods.
- Selection of appropriate numerical methods to solve various types of problems in engineering and science in consideration with the minimum number of mathematical operations involved, accuracy requirements and available computational resources.

REFERENCES :
1. Burden, R.L., and Faires, J.D., "Numerical Analysis – Theory and Applications", 9th Edition, Cengage Learning, New Delhi, 2016.
2. Gupta S.K., "Numerical Methods for Engineers", New Age Publishers, 1995.
3. Jain M. K., Iyengar S. R., Kanchi M. B., Jain, "Computational Methods for Partial Differential Equations", New Age Publishers ,1993.
4. Sastry, S.S., "Introductory Methods of Numerical Analysis", 5th Edition, PHI Learning, 2015.
5. Saumyen Guha and Rajesh Srivastava, "Numerical methods for Engineering and Science", Oxford Higher Education, New Delhi, 2010.
6. Smith, G. D., "Numerical Solutions of Partial Differential Equations: Finite Difference Methods", Clarendon Press, 1985.

EY5151 FLUID MECHANICS AND HEAT TRANSFER L T P C
3 0 0 3

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 9

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 9

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 9

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 9

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 9

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

TOTAL: 45 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. Bansal,R.K., Fluid Mechanics, Saurabh and Co., New Delhi, 1985.
3. Ghoshdastidar.P.S., Heat Transfer, Oxford University Press, 2004
4. Holman.J.P., Heat Transfer, Tata McGraw Hill, 2002.
5. Ozisik. M.N., Heat Transfer – A Basic Approach, McGraw Hill Co., 1985.
6. Streeter, V.L., Wylie, E.B., and Bedford, K.W., Fluid Mechanics, WCB McGraw Hill, Boston, 1998.

EY5101 THERMODYNAMIC ANALYSIS OF ENERGY SYSTEMS

L	T	P	C
3	2	0	4

OBJECTIVES

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

UNIT I AVAILABILITY ANALYSIS AND THERMODYNAMIC PROPERTY RELATION (10+3)

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 (10+3)

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 (10+3)

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

UNIT IV COMBUSTION CHEMISTRY (8+3)

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 (7+3)

Combustion in IC Engines and Gas turbines. Knocking & 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: 45+30 = 70 PERIODS

OUTCOMES

After completion of the syllabus student will able to :

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

REFERENCES

1. Bejan A., “Advanced Engineering Thermodynamics”, John Wiley and Sons, 1988.
2. Cohen H., Rogers G.F.C. and Saravanmotto H.I.H., “Gas Turbine Theory”, John Wiley, 5th Edition 2001.
3. Ganesan V., “Gas Turbines”, Tata McGrawHill, 2011.
4. Ganesan V., “Internal Combustion Engines”, Tata McGraw Hill, 2006.
5. Kenneth Wark J.R., “Advanced Thermodynamics for Engineers”, McGrew – Hill Inc., 1995.
6. Khajuria P.R. and Dubey S.P., “Gas Turbines and Propulsive Systems”, Dhanpat Rai Publications, 2003.
7. Kuo K.K., “Principles of Combustion”, John Wiley and Sons, 2005.
8. Winterbone D.E., “Advanced Thermodynamics for Engineers”, Arnold, 1997.

EY5152 ENERGY RESOURCES L T P C

3 0 0 3

OBJECTIVES

- To explain concept of various forms of Non-renewable and renewable energy.
- To outline division aspects and utilization of renewable energy sources for both domestics and industrial applications.
- To study the environmental and cost economics of using renewable energy sources compared to fossil fuels.

UNIT I COMMERCIAL ENERGY 9

Coal, Oil, Natural gas, Nuclear power and Hydro - their utilization pattern in the past, present and future projections of consumption pattern - Sector-wise energy consumption – environmental impact of fossil fuels – Energy scenario in India – Growth of energy sector and its planning in India.

UNIT II SOLAR ENERGY 9

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

UNIT III WIND ENERGY 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 IV 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 Plant - applications - alcohol production from biomass – bio diesel production – Urban waste to energy conversion - Biomass energy programme in India.

UNIT V OTHER TYPES OF ENERGY 9

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

TOTAL = 60 PERIODS

OUTCOMES

After completion of the syllabus student able to :

- Understand the commercial energy and renewable energy sources.
- Know the working principle of various energy systems.

REFERENCES

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

EY5111	ENERGY LABORATORY	L	T	P	C
		0	0	4	2

OBJECTIVES

- To conduct experiments on various Energy Engineering devices to study the performance and its applications.

1. Performance study in a solar water heater.
2. Characteristics study of solar photovoltaic devices.
3. Performance study of biogas plant.
4. Fuel characterization study in different fuels (proximate analysis, calorific value, viscosity, specific gravity etc.,)
5. Measurements of direct and diffused solar radiation.
6. Performance study on boiler.
7. Performance characteristics of motor test rig.
8. Computation of pump & pumping system characteristics (pump curve, system curve and BEP)

9 Analysis on fans characteristic curves
10 Performance study on various Heat Exchangers.
11 Performance characteristics of Vapour Compression Refrigeration test rig.
12 Study on fuel cell Systems.
13 Study on thermal storage systems
14 Study on biomass gasifiers.
15 Study on various alternate fuels for IC engines.

TOTAL: 60 PERIODS

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

- Understand the working principle of different renewable energy sources.
- Measure the properties of different fuels.
- Procedure to be adopted for performance analysis and optimization of energy utilities

EQUIPMENTS REQUIRED

1.	100 LPD Solar flat plate water heater test rig	- 1 No
2.	SPV Educational Kit	- 1 No
3.	Biogas plant (fixed dome or floating drum)	- 1 No
4.	Bomb calorimeter	- 1 No
5.	Junker's gas calorimeter	- 1 No
6.	Viscometer	- 1 No
7.	Hydrometer	- 1 No
8.	Flash and fire point apparatus	- 1 No
9.	Proximate analyser (Muffle furnace and micro weigh balance)	- 1 No
10.	Pyranometer / Solarimeter	- 1 No
11.	Non-IBR boiler	- 1 No
12.	5 HP motor efficiency test rig	- 1 No
13.	Pump test rig	- 1 No
14.	Fan test rig	- 1 No
15.	Heat Exchangers (plate, pipe-in-pipe, shell and tube)	- 1 No each
16.	Vapour Compression Refrigeration Test Rig	- 1 No

EY5201 ENERGY CONSERVATION IN THERMAL SYSTEMS L T P C
3 0 0 3

OBJECTIVES

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

UNIT I INTRODUCTION 7

Indian Energy Scenario – Basics of Energy and its various forms - Primary / Secondary Energy Sources – Energy Conservation – Energy Intensive Industries – Barriers - EC Act 2003 : Salient Features - Schemes of Bureau of Energy Efficiency (BEE) including Designated consumers, State Designated Agencies - Integrated energy policy - National action plan on climate change.

UNIT II ENERGY AUDIT AND MANAGEMENT 10

Definition, energy audit, need, 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 and energy substitution, energy audit instruments and metering, precautions, smart metering. roles and responsibilities of energy manager, accountability. energy consumption, production, cumulative sum of differences (CUSUM) – Cost / Energy Share Diagram – Break Even Analysis – Depreciation – Financial Analysis Techniques – CUSUM Technique – Energy Management Information Systems (EMIS) ESCO Concept – ESCO Contracts.

UNIT III PERFORMANCE STUDY OF THERMAL UTILITIES – 1 10

Fuels and Combustion : Introduction to fuels - properties of fuel: oil, coal and gas, Boiler – Stoichiometry – Combustion Principles – Heat Loss Estimation – Steam Traps – Steam Piping & Distribution – Thermic Fluid Heaters – Furnaces – Insulation & Refractories.

UNIT IV PERFORMANCE STUDY OF THERMAL UTILITIES – 2 11

Cogeneration – Principles & Operation – Power Ratio - Economics of Cogeneration Scheme – Case Study on Cogeneration – WHR – Sources & Grades – Types (Heat Wheel, Recuperators, Regenerators , Heat Pipe etc) – Scheme Evaluation – Economics of WHR Systems – Thermal Energy Storage – Basics & Concepts as an ENCON scheme.

UNIT V PERFORMANCE STUDY OF THERMAL UTILITIES – 3 7

Basics of R & A/C – COP / EER / SEC Evaluation – Psychometric Chart Analysis – Types & Applications of Cooling Towers – Basics – Performance Analysis – DG Set – Performance Prediction – Cost of Power Generation – Scope for Energy Conservation in all these.

TOTAL: 45 PERIODS

OUTCOME

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

REFERENCES

1. Diamant R.M.E., “Total Energy”, Pergamon, Oxford, 1970.
2. Hamies “Energy Auditing and Conservation; Methods Measurements, Management and Case study”, Hemisphere, Washington, 1980.
3. Handbook on Energy Efficiency, TERI, New Delhi, 2001.
4. Smith C.B., “Energy Management Principles”, Pergamon Press, New York, 1981.
5. Trivedi P.R., Jolka K.R., “Energy Management”, Commonwealth Publication, New Delhi, 1997.
6. Write Larry C., “Industrial Energy Management and Utilization”, Hemisphere Publishers, Washington, 1988.
7. Guide book for National Certification Examination for Energy Managers and Energy Auditors (Could be downloaded from www.energymanagertraining.com)

EY5202 **ENERGY CONVERSION TECHNIQUES** **L T P C**
3 0 0 3

OBJECTIVES

To analyze the working principle, pros and cons of

- Conventional energy conversion techniques
- Direct energy conversion systems
- Need and necessity of energy storage systems and their desirable characteristics & Fuel cells

UNIT I CONVENTIONAL ENERGY CONVERSION CYCLES 8

Reversible and irreversible cycles – Thermodynamics analysis of Carnot – Stirling – Ericsson – Otto – Diesel – Dual – Lenoir – Atkinson – Brayton - Rankine.

UNIT II DIRECT CONVERSION OF THERMAL TO ELECTRICAL ENERGY 8

Thermoelectric Converters –Thermionic converters – MHD – Ferro electric converter – Nernst effect generator.

UNIT III CHEMICAL & ELECTROMAGNETIC ENERGY TO ELECTRICAL ENERGY 9

Batteries – types – working – performance governing parameters – Hydrogen energy – Solar photovoltaic cells.

UNIT IV ENERGY STORAGE SYSTEMS 9

Energy Storage Technologies - Mechanical energy, Electrical energy, Chemical energy, Thermal energy.

UNIT V FUEL CELLS 11

Basics – types – working - comparative analysis – thermodynamics and kinetics of fuel cell process – performance of fuel cell – applications - advantages and drawbacks.

TOTAL: 45 PERIODS

OUTCOME

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

REFERENCES

1. ArchieW.Culp, “Principles of Energy Conversion”, McGraw-Hill Inc., Singapore, 1991.
2. Barclay F.J., “Fuel Cells, Engines and Hydrogen”, Wiley, 2009.
3. Hart A.B. and Womack G.J., “Fuel Cells: Theory and Application”, Prentice Hall Newyork Ltd., London 1989.
4. Ibrahim Dincer and Mark A. Rosen, “Thermal Energy Storage Systems and Applications”, John Wiley & Sons 2002.
5. Kettari M.A., “Direct Energy Conversion”, Addison-Wesley Pub. Co 1997.
6. Kordesch K. and Simader G., “Fuel Cell and Their Applications”, Wiley-Vch, Germany 1996.

EY5203 MEASUREMENT AND CONTROL FOR ENERGY SYSTEMS L T P C
3 0 0 3

OBJECTIVES

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

UNIT I MEASUREMENT CHARACTERISTICS 5

Introduction to measurements, Errors in measurements, Statistical analysis of data, Regression analysis, Correlation, Estimation of uncertainty and Presentation of data, Design of experiments – Experimental design factors and protocols.

UNIT II MEASUREMENTS IN ENERGY SYSTEMS 15

Basic Electrical measurements, Transducers and its types, Signal conditioning and processing - Measurement of temperature, pressure, velocity, flow rate, thermo-physical and transport properties of solids liquids and gases, Radiation properties of surfaces, Vibration and noise - Computer assisted data acquisition, Data manipulation and data presentation.

UNIT III CONTROL SYSTEMS 7

Introduction, Open and closed loop control systems, Transfer function. Types of feedback and feedback control system characteristics – Effect of disturbances – Dynamic characteristics.

UNIT IV CONTROL COMPONENTS AND CONTROLLER 9

Process characteristics, Control system parameters – DC and AC servomotors, servo amplifier, potentiometer, synchro transmitters, synchro receivers, synchro control transformer, stepper motors - continuous, discontinuous and composite control modes – Analog and Digital controllers.

UNIT V DESIGNING OF MEASUREMENT AND CONTROL SYSTEMS 9

Designing of temperature, pressure, flow and liquid level measurement and control system – Performance – Steady state accuracy – Transient response – Frequency response – Fault finding – Computer based controls.

TOTAL: 45 PERIODS

OUTCOMES

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

REFERENCES

1. Alan S Morris and Reza Langari, “Measurements and Instrumentation – Theory and Application”, Elsevier Inc, 2012.
2. Bolten. W, “Industrial Control and Instrumentation”, University Press, 2004.
3. Curtis D Johnson, ‘Process Control Instrumentation Technology”, PHI Learning Private Limited, 2011.
4. Doblin E.O, ‘Measurement System Application and Design”, Second Edition, McGraw Hill, 1978.
5. Holman J.P., “Experimental methods for Engineers”, McGraw – Hill, 2008.
6. Nakra, B.C., Choudhry K.K., “Instrumentation, Measurements and Analysis”, Tata McGraw Hill, New Delhi, 2nd Edition 2003.
7. Venkateshan.S.P, “Mechanical Measurements”, Ane Books Pvt Ltd, 2010

TE5261 THERMAL SYSTEMS SIMULATION LABORATORY

L	T	P	C
0	0	4	2

OBJECTIVES:

- To learn the modeling and simulation analysis of various thermal engineering application using analysis softwares.

LIST OF EXPERIMENTS

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

TOTAL: 60 PERIODS

OUTCOMES:

- On successful completion of this course the student will have knowledge in various heat transfer simulation study on different thermal engineering applications by using analysis softwares.

DYNAMIC LINKING OF MAT LAB AND REF PROP SOFTWARE
SIMPLE CFD PROBLEMS FOR PRACTICE

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

SIMULATION LAB – REQUIREMENT:

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

EY5211 TECHNICAL SEMINAR - I

L	T	P	C
0	0	2	1

OBJECTIVES:

- To Enhance the ability of self-study
- To Improve the presentation and communication skills
- To Increase the breadth of knowledge.

GUIDELINES

- The student is expected to present a Seminar in one of the current topics in the field of Energy Engineering related issues / technology.
- The Seminar shall be of 30 minutes duration and give presentation to the Seminar Assessment Committee (SAC).
- A faculty guide is to be allotted and he / she will guide and monitor the progress of the student and maintain attendance also.

- In a session of two periods per week, 4 students are expected to present the Seminar.
- Students are encouraged to use various teaching aids such as power point presentation and demonstrative models.
- Students are required to prepare a seminar report in the prescribed format given by the Department.

EVALUATION

Technical Seminar I evaluation is based on Regulations of Post graduate programmes of Anna University.

TOTAL: 30 PERIODS

OUTCOMES:

At the end of the course, the student will be able to

- Identify and choose appropriate topic of relevance.
- Assimilate literature on technical articles of specified topic and develop comprehension.
- Prepare technical report.
- Design, develop and deliver presentation on specified technical topic

EY5301 ENERGY CONSERVATION IN ELECTRICAL SYSTEMS L T P C
3 0 0 3

OBJECTIVES

- To study the concepts of power factor, load management etc.
- To study the various measures for energy conservation in electrical devices both static & rotating machineries
- To study the emission related aspects & also a couple of case studies related to ENCON

UNIT I BASICS OF ELECTRICAL ENERGY USAGE 9

Fuel to Power : Cascade Efficiency – Electricity Billing : Components & Costs – kVA – Need & Control – Determination of kVA demand & Consumption – Time of Day Tariff – Power Factor Basics – Penalty Concept for PF – PF Correction – Demand Side Management (a brief).

UNIT II TRANSFORMERS & MOTORS 9

Transformer – Basics & Types – AVR & OLTC Concepts – Selection of Transformers – Performance Prediction - Energy Efficient Transformers - Motors : Specification & Selection – Efficiency / Load Curve – Load Estimation – Assessment of Motor Efficiency under operating conditions – Factors affecting performance – Ill effects of Rewinding & Oversizing - Energy Efficient Motors - ENCON Scope.

UNIT III FANS, PUMPS AND COMPRESSORS 11

Basics – Selection – Performance Evaluation – Cause for inefficient operation – Scope for energy conservation – Methods (General & Latest) adopted for effecting ENCON – Economics of ENCON adoption in all the 3 utilities.

UNIT IV ILLUMINATION & ENERGY EFFICIENCY DEVICES 8

Specification of Luminaries – Types – Efficacy – Selection & Application – ENCON Avenues & Economic Proposition - New Generation Luminaries (LED / Induction Lighting) - Soft Starters / Auto Star – Delta – Star Starters / APFC / Variable Speed & Frequency Drives – Time Sensors – Occupancy Sensors.

UNIT V CASE STUDIES & CO_2 MITIGATION 8

Case Study Evaluation for 3/4 Typical Sectors – PAT Scheme (an introduction) – CO_2 Mitigation, Energy Conservation & Cost Factor.

TOTAL: 45 PERIODS

OUTCOMES

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

REFERENCES

1. Guide book for National Certification Examination for Energy.
2. Hamies, “Energy Auditing and Conservation ; Methods Measurements, management and Case Study”, Hemisphere, Washington, 1980.
3. Handbook on Energy Efficiency, TERI, New Delhi, 2001.
4. Kraushaar and Ristenen, “Energy and Problems of a Technical Society”, 1993.
5. Peters et al. Sustainable Energy, beta – test – draft.
6. Trivedi P.R. and Jolka K.R., “Energy Management”, Commonwealth Publication, New Delhi, 1997.
7. Managers and Energy Auditors (Could be downloaded from www.energymanager training. com)

EY5311 TECHNICAL SEMINAR - II L T P C

0 0 2 1

OBJECTIVES:

- To enhance the reading ability required for identification of his/her field of interest.
- To develop skills regarding professional communication and technical report writing.
- To establish the fact that student is not a mere recipient of ideas, but a participant in discovery and inquiry.
- To learn how to prepare and publish technical papers.

GUIDELINES

- The student is expected to present a seminar in one of the current topics in the field of Energy Engineering related issues / technology.
- The seminar shall be of 30minutes duration and give presentation to the Seminar Assessment Committee (SAC).
- The committee shall evaluate the seminar based on the style of presentation, technical context, and coverage of the topic, adequacy of references, depth of knowledge and the overall quality.
- A faculty guide is to be allotted and he / she will guide and monitor the progress of the student and maintain attendance also.
- Each student has to submit a seminar report in the prescribed format given by the Institution.
- In a session of two periods per week, 4 students are expected to present the seminar.
- Students are encouraged to use various teaching aids such as power point presentation and demonstrative models.
- It is recommended that the report for Technical Seminar II may be in the form of a technical paper which is suitable for publishing in Conferences / Journals as a review paper.

EVALUATION
Technical Seminar II evaluation is based on Regulations of Post graduate programmes of Anna University.

TOTAL: 30 PERIODS

OUTCOMES:
At the end of the course, the student will be able to

- Develop the capacity to observe intelligently and propose and defend opinions and ideas with tact and conviction.
- Develop skills regarding professional communication and technical report writing.
- Learn the methodology of publishing technical papers.

EY5312	PROJECT WORK PHASE – I	L	T	P	C
		0	0	12	6

OBJECTIVES:

- To improve the skills in reading technical magazines, conference proceedings and journals.
- To develop the skill of identifying research problems/projects in the field of Energy Engineering.
- To familiarize with the design and analysis tools required for the project work and plan the experimental platform, if any, required for project work.

GUIDELINES

- Each student has to identify the topic of project related to the field of Energy Engineering.
- The candidate has to be in regular contact with his guide and the topic of dissertation must be mutually decided by the guide and student
- The topic has to be approved by a review committee constituted by the department.
- The work has to be presented periodically in front of the review committee.
- The preparation of report consisting of a detailed problem statement and a literature review.
- The preliminary results (if available) of the problem may also be discussed in the report.
- The project report should be presented in standard format as provided by the Anna University.

EVALUATION
Project Work Phase - I evaluation is based on Regulations of Post graduate programmes of Anna University.

TOTAL: 180 PERIODS

OUTCOMES:

- 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.

EY5411 **PROJECT WORK PHASE – II** **L T P C**
0 0 24 12

OBJECTIVES:

- To improve the skills in publishing technical papers in conference proceedings and journals.
- To produce factual results of their applied research idea in the Energy Engineering, from phase – I.

GUIDELINES

- Each student has to complete project (phase II) under the guidance of a faculty member, as specified in Phase I.
- The candidate has to be in regular contact with his guide and the topic of dissertation must be mutually decided by the guide and student
- The topic has to be approved by a review committee constituted by the department.
- The work has to be presented periodically in front of the review committee.
- The candidate has to prepare a detailed project report consisting of introduction of the problem, problem statement, literature review, objectives of the work, methodology (experimental set up or numerical details as the case may be) of solution and results and discussion.
- The report must bring out the conclusions of the work and future scope for the study.
- The project report should be presented in standard format as provided by the Anna University.

EVALUATION

Project Work Phase - II evaluation is based on Regulations of Post graduate programmes of Anna University.

TOTAL: 360 PERIODS

OUTCOMES:

- 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.

EY5071 **HYDROGEN AND FUEL CELL TECHNOLOGIES** **L T P C**
3 0 0 3

OBJECTIVES

- To study in detail on the hydrogen production methodologies, possible applications and various storage options.
- To understand the working principle of a typical fuel cell, its types and to elaborate on its thermodynamics and kinetics.
- To study the cost effectiveness and eco-friendliness of Fuel Cells.

UNIT I HYDROGEN – BASICS AND PRODUCTION TECHNIQUES 9

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

UNIT II HYDROGEN STORAGE AND APPLICATIONS 9

Hydrogen storage options – compressed gas – liquid hydrogen – Hydride – chemical Storage – comparisons. Safety and management of hydrogen. Applications of Hydrogen.

UNIT III FUEL CELLS 9

History – principle - working - thermodynamics and kinetics of fuel cell process – performance evaluation of fuel cell – comparison on battery Vs fuel cell.

UNIT IV FUEL CELL – TYPES 9

Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerits.

UNIT V APPLICATION OF FUEL CELL AND ECONOMICS 9

Fuel cell usage for domestic power systems, large scale power generation, Automobile, Space. Economic and environmental analysis on usage of Hydrogen and Fuel cell. Future trends in fuel cells.

TOTAL: 45 PERIODS

OUTCOME

After completion of the syllabus student able to :
Know the working of various fuel cells, their relative advantages / disadvantages and hydrogen generation/storage technologies.

REFERENCES

1. Barclay F.J., Fuel Cells, Engines and Hydrogen, Wiley, 2009.
2. Bent Sorensen (Sørensen), Hydrogen and Fuel Cells: Emerging Technologies and Applications, Elsevier, UK 2005.
3. Hart A.B. and G.J.Womack, Fuel Cells: Theory and Application, Prentice Hall, New York Ltd., London 1989.
4. Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA 2002.
5. Kordesch K. and G.Simader, Fuel Cell and Their Applications, Wiley-Vch, Germany 1996.
6. Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma, 2005.
7. Viswanathan B. and Aulice Scibioh.M, Fuel Cells – Principles and Applications, Universities Press, 2006.

EY5001 SOLAR ENERGY TECHNOLOGIES L T P C
3 0 0 3

OBJECTIVES

- To learn and study the radiation principles with respective solar energy estimation
- To understand PV technology principles and techniques of various solar cells / materials for energy conversion
- To learn economical and environmental merits of solar energy for variety applications**.**

UNIT I SOLAR RADIATION AND COLLECTORS 9

Solar angles – Sun path diagrams – Radiation - extra terrestrial characteristics - measurement and estimation on horizontal and tilted surfaces - flat plate collector thermal analysis - testing methods-evacuated tubular collectors - concentrator collectors – classification - design and performance parameters - tracking systems - compound parabolic concentrators - parabolic trough concentrators - concentrators with point focus - Heliostats – performance of the collectors.

UNIT II SOLAR THERMAL TECHNOLOGIES 9

Principle of working, types, design and operation of - Solar heating and cooling systems - Thermal Energy storage systems – Solar Desalination – Solar cooker : domestic, community – Solar pond – Solar drying.

UNIT III SOLAR PV FUNDAMENTALS 9

Semiconductor – properties - energy levels - basic equations of semiconductor devices physics. Solar cells - p-n junction: homo and hetro junctions - metal-semiconductor interface - dark and illumination characteristics - figure of merits of solar cell - efficiency limits - variation of efficiency with band-gap and temperature - efficiency measurements - high efficiency cells – Solar thermo-photovoltaics.

UNIT IV SPV SYSTEM DESIGN AND APPLICATIONS 9

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

UNIT V SOLAR PASSIVE ARCHITECTURE 9

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

TOTAL: 45 PERIODS

OUTCOMES

After completion of the syllabus student able to:

- Suggest and design solar thermal based applications.
- Designing of solar photovoltaic based power systems for both domestic and industrial applications
- Apply the concept of utilization of solar energy for the said application in a economical way.

REFERENCES

1. Goswami D.Y., Kreider, J. F. and Francis., “Principles of Solar Engineering’, Taylor and Francis, 2000.
2. Chetan Singh Solanki, “Solar Photovoltatics – Fundamentals, Technologies and Applications”, PHI Learning Private limited, 2011.
3. Sukhatme S.P.,. Nayak.J.P, ‘Solar Energy – Principle of Thermal Storage and collection”, Tata McGraw Hill, 2008.
4. Solar Energy International, “Photovoltaic – Design and Installation Manual” – New Society Publishers, 2006.
5. Roger Messenger and Jerry Vnetre, “Photovoltaic Systems Engineering”, CRC Press, 2010.

EY5002 WIND ENERGY TECHNOLOGIES L T P C
3 0 0 3

OBJECTIVES

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

UNIT I WIND ENERGY FUNDAMENTALS & WIND MEASUREMENTS 9

Wind Energy Basics, Wind Speeds and scales, Terrain, Roughness, Wind Mechanics, Power Content, Class of wind turbines, Atmospheric Boundary Layers, Turbulence. Instrumentation for wind measurements, Wind data analysis, tabulation, Wind resource estimation, Betz's Limit, Turbulence Analysis.

UNIT II AERODYNAMICS THEORY & WIND TURBINE TYPES 9

Airfoil terminology, Blade element theory, Blade design, Rotor performance and dynamics, Balancing technique (Rotor & Blade), Types of loads; Sources of loads Vertical Axis Type, Horizontal Axis, Constant Speed Constant Frequency, Variable speed Variable Frequency, Up Wind, Down Wind, Stall Control, Pitch Control, Gear Coupled Generator type, Direct Generator Drive /PMG/Rotor Excited Sync Generator.

UNIT III GEAR COUPLED GENERATOR WIND TURBINE COMPONENTS AND THEIR CONSTRUCTION 9

Electronics Sensors/Encoder/Resolvers, Wind Measurement : Anemometer & Wind Vane, Grid Sysnchronisation System, Soft Starter, Switchgear[ACB/VCB], Transformer, Cables and assembly, Compensation Panel, Programmable Logic Control, UPS, Yaw & Pitch System : AC Drives, Safety Chain Circuits, Generator Rotor Resistor controller (Flexi Slip), Differential Protection Relay for Generator, Battery/Super Capacitor Charger & Batteries/ Super Capacitor for Pitch System, Transient Suppressor/Lightning Arrestors, Oscillation & Vibration sensing.

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

Excited Rotor Synch, Generator/PMG Generator, Control Rectifier, Capacitor Banks, Step Up/Boost Converter (DC-DC Step Up), Grid Tied Inverter, Power Management, Grid Monitoring Unit (Voltage and Current), Transformer, Safety Chain Circuits.

UNIT V MODERN WIND TURBINE CONTROL & MONITORING SYSTEM 9

Details of Pitch System & 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.

TOTAL: 45 PERIODS

OUTCOME

After completion of the syllabus student able to:

- Know the energy conversion techniques in wind energy
- Learn about wind turbine components and their constructions.
- Understand the modern wind turbine control & monitoring.

REFERENCES

1. C-Wet : Wind Energy Resources Survey in India VI
2. Duffie A. and Beckmann W. A., "Solar Engineering of Thermal Processes, John Wiley, 1991.
3. Freris L.L., "Wind Energy Conversion Systems", Prentice Hall, 1990.
4. Godfrey Boyle, "Renewable Energy, Power for a Sustainable Future", Oxford University Press, 1996.
5. John D Sorensen and Jens N Sorensen, "Wind Energy Systems", Woodhead Publishing Ltd, 2011.
6. Kaldellis J.K., "Stand – alone and Hybrid Wind Energy Systems", CRC Press, 2010.
7. Mario Garcia –Sanz, Constantine H. Houpis, "Wind Energy Systems",CRC Press 2012.
8. Spera D.A., "Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering", ASME Press, 1994.
9. Twidell J.W. and Weir A., "Renewable Energy Sources", EFN Spon Ltd., 1983.

EY5003 BIO ENERGY CONVERSION TECHNIQUES L T P C
3 0 0 3

OBJECTIVES

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

UNIT I INTRODUCTION 7

Biomass: types – advantages and drawbacks – Indian scenario – characteristics – carbon neutrality – conversion mechanisms – fuel assessment studies – densification technologies – Comparison with coal – Proximate & Ultimate Analysis - Thermo Gravimetric Analysis – Differential Thermal Analysis – Differential Scanning Calorimetry.

UNIT II BIOMETHANATION 8

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, luminaries and power generation – effect on engine performance.

UNIT III COMBUSTION 10

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

UNIT IV GASIFICATION, PYROLYSIS AND CARBONISATION 12

Chemistry of gasification - types – comparison – application – performance evaluation – economics – dual fuelling in IC engines – 100 % Gas Engines – engine characteristics on gas mode – gas cooling and cleaning systems - Pyrolysis - Classification - process governing parameters – Typical yield rates. Carbonization Techniques – merits of carbonized fuels.

UNIT V LIQUIFIED BIOFUELS 8

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

TOTAL: 45 PERIODS

OUTCOME

After completion of the syllabus student able to:
Understand the concept of various biomass energy conversion technologies and its relevance towards solving the present energy crisis.

REFERENCES

1. Best Practises Manual for Biomass Briquetting, I R E D A, 1997
2. David Boyles, “Bio Energy Technology Thermodynamics and costs”, Ellis Hoknood Chichester, 1984.
3. Eriksson S. and Prior.M, “The briquetting of Agricultural wastes for fuel”, FAO Energy and Environment paper, 1990.
4. Khandelwal K.C., Mahdi S.S., “Biogas Technology – A Practical Handbook”, Tata McGraw Hill, 1986.
5. Mahaeswari R.C., “Bio Energy for Rural Energisation”, Concepts Publication,1997.
6. Rai G.D., “Non conventional energy sources”, Khanna publishes, 1993.
7. Tom B Reed, “Biomass Gasification – Principles and Technology”, Noyce Data Corporation, 1981.

EY5091 **NUCLEAR ENGINEERING** **L T P C**
3 0 0 3

OBJECTIVES

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

UNIT I NUCLEAR REACTIONS **9**

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

UNIT II REACTOR MATERIALS **9**

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

UNIT III REPROCESSING **9**

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

UNIT IV SEPARATION OF REACTOR PRODUCTS **9**

Processes to be considered - 'Fuel Element' dissolution - precipitation process – ion exchange - redox - purex - TTA - chelation -U235 - Hexone - TBP and thorax Processes - oxidative slaging and electro - refinng - Isotopes - principles of Isotope separation.

UNIT V WASTE DISPOSAL AND RADIATION PROTECTION **9**

Types of nuclear wastes - Safety control, Pollution control and abatement - International convention on safety aspects - Radiation hazards prevention.

Total = 45 PERIODS

OUTCOMES

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

REFERENCES

1. Cacuci Dan Gabriel, “Nuclear Engineering Fundamentals”, Springer, 2010.
2. Collier J.G. and Hewitt.G.F, "Introduction to Nuclear Power", Hemisphere Publishing, New York, 1987.
3. Glasstone S. and Sesonske A., “Nuclear Reactor Engineering”, 3rd Edition, Von Nostrand, 1984.
4. J. Kenneth Shultis and Richard E Faw, “Fundamentals of Nuclear Science and Engineering,” CRC Press, 2008.
5. Kenneth D. Kok, “Nuclear Engineering”, CRC Press, 2009.
6. Lalter A.E. and Reynolds A.B., “Fast Breeder Reactor”, Pergamon Press, 1981.
7. Lamarsh, J.R., “Introduction to Nuclear Reactor Theory”, Wesley, 1996.
8. Tatjana Tevremovic, “Nuclear Principles in Engineering”, Springer, 2008.
9. Winterton R.H.S., “Thermal Design of Nuclear Reactors”, Pergamon Press, 1981.

EY5004 COMPUTATIONAL FLUID DYNAMICS FOR ENERGY SYSTEMS **L T P C**

3 0 0 3

OBJECTIVES

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

UNIT I INTRODUCTION 8

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

UNIT II CONSERVATION EQUATION 10

Mass, Momentum and Energy Equation three dimensions, Eulerian and Lagrangian Approach, Equation of State, Navier's Strokes equation, Differential and Integral form of general transport equations.

UNIT III CONDUCTION HEAT TRANSFER 9

Steady one-dimensional conduction, Two and three dimensional steady state problems, Transient one-dimensional problem, Two-dimensional Transient Problems - Finite difference and Finite Volume approach.

UNIT IV INCOMPRESSIBLE FLUID FLOW 8

Stream Function – Vorticity methods, Finite volume methods for Convection and diffusion problem – Central difference scheme, Upwind scheme, Hybrid scheme – Assessment of each scheme - Solution algorithm for pressure – velocity – coupling in steady flows - SIMPLE Procedure of Patankar and Spalding, SIMPLER and PISO Algorithm.

UNIT V TURBULENCE MODELS 8

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

TOTAL: 45 PERIODS

OUTCOME

Student will be able to apply the concept of computational fluid dynamics in the Energy systems to predict the actual performance.

REFERENCES

1. Anderson D.A., Tannehill J.I. and Pletcher R.H., "Computational fluid Mechanics and Heat Transfer, "Hemisphere Publishing Corporation, New York, USA,1984.
2. Bose T.X., "Numerical Fluid Dynamics" ,Narosa Publishing House, 1997.
3. Fletcher C.A.J. "Computational Techniques for fluid Dynamics 2" Specific Techniques for Different Flow Categories, Springer – Verlag, 1987.
4. Fletcher C.A.J., "Computational Techniques for Fluid Dynamics 1" Fundamental and General Techniques, Springer – Verlag, 1987.
5. Ghoshdasdidar P.S.,"Computer Simulation of flow and heat transfer" Tata McGraw-Hill Publishing Company Ltd., 1998.
6. Muralidhar K, and Sundararajan T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 1995.
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8. Taylor C and Hughes J.B., "Finite Element Programming of the Navier-Stokes Equation", Pineridge Press Limited, U.K., 1981.

EY5005 ENERGY SYSTEMS MODELING AND ANALYSIS L T P C
3 0 0 3

OBJECTIVES

- To learn to apply mass and energy balances for the systems and to enable to perform with Energy generations.
- Learn to calculate to size performance and cost of energy equipments turns modeling and simulation techniques and to optimize the energy system.

UNIT I INTRODUCTION 9

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

UNIT II MODELING AND SYSTEMS SIMULATION 9

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

UNIT III OPTIMISATION TECHNIQUES 9

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

UNIT IV ENERGY- ECONOMY MODELS 9

Multiplier Analysis - Energy and Environmental Input / Output Analysis - Energy Aggregation – Econometric Energy Demand Modeling - Overview of Econometric Methods - Dynamic programming - Search Techniques - Univariate / Multivariate.

UNIT V APPLICATIONS AND CASE STUDIES 9

Case studies of optimization in Energy systems problems- Dealing with uncertainty- probabilistic techniques – Trade-offs between capital and energy using Pinch analysis.

TOTAL: 45 PERIODS

OUTCOMES

- Simulation and Modeling of typical energy system.
- Able to analysis effect of constraints on the performance of energy systems.
- Has a potential to do design HEN net work and perform Energy-Economic Analysis for typical applications.

REFERENCES

1. B.K.Hodge, “Analysis and Design of Thermal Systems”, Prentice Hall Inc., 1990.
2. Bejan A., Tsatsaronis G. and Moran M., “Thermal Design and Optimization”, John Wiley & Sons 1996.
3. C. Balaji, “Essentials of Thermal System Design and Optimization”, Aue Books, 2011.
4. Kapur J. N., “Mathematical Modelling” , Wiley Eastern Ltd , New York , 1989.
5. Stoecker W.F., “Design of Thermal Systems”, McGraw Hill, 2011.
6. Yogesh Jaluria, “Design and Optimization of Thermal Systems”,CRC Press INC, 2008.

TE5072 **DESIGN OF HEAT EXCHANGERS** **L T P C**
3 0 0 3

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

UNIT I FUNDAMENTALS OF HEAT EXCHANGER 9
Temperature distribution and its implications types – shell and tube heat exchangers – regenerators and recuperators – analysis of heat exchangers – LMTD and effectiveness method.

UNIT II FLOW AND STRESS ANALYSIS 9
Effect of turbulence – friction factor – pressure loss – stress in tubes – header sheets and pressure vessels – thermal stresses, shear stresses - types of failures.

UNIT III DESIGN ASPECTS 9
Heat transfer and pressure loss – flow configuration – effect of baffles – effect of deviations from ideality – design of double pipe - finned tube - shell and tube heat exchangers - simulation of heat exchangers.

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

UNIT V CONDENSERS AND COOLING TOWERS 9
Design of surface and evaporative condensers – cooling tower – performance characteristics

TOTAL :45 PERIODS

OUTCOME
After completion of the syllabus student able to:
- Design the heat exchanger based on the information provided for a particular application and do the cost economic analysis.

REFERENCES

1. Arthur P. Frass, “Heat Exchanger Design”, John Wiley & Sons, 1988.
2. Hewitt G.F., Shires G.L. and Bott T.R., “Process Heat Transfer”, CRC Press, 1994.
3. Nicholas Cheremisioff, “Cooling Tower”, Ann Arbor Science Pub 1981.
4. SadikKakac and Hongtan Liu, “Heat Exchangers Selection, Rating and Thermal Design”, CRC Press, 2002.
5. Sekulic D.P., “Fundamentals of Heat Exchanger Design”, John Wiley, 2003 .
6. TaborekT., Hewitt.G.F. and Afgan N., “Heat Exchangers, Theory and Practice”, McGraw-Hill Book Co. 1980.
7. Walker, “Industrial Heat Exchangers - A Basic Guide”, McGraw Hill Book Co., 1980

EY5006 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 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. Austin Hughes, “Electric Motor & Drives”, Newnes, 2006.
2. D.Singh and K.B.Khanchandani, “Power Electronics”, Tata McGraw-Hill Education Ltd, 2006.
3. Partab. H., “Art and Science and Utilisation of Electrical Energy”, Dhanpat Rai and Sons, 1994.
4. Pillai.S.K., “A First Course on Electric Drives”, Wiley Eastern Limited, 1998.
5. Rene Husson, “Modelling and Control of Electrical machines”, Elsevier Science Ltd, 2009.
6. Robert A. Huggins, “Energy Storage” , Springer 2010.
7. Subrahmanyam, Electric Drives : ‘Concepts & Applications” 2/E, Tata McGraw-Hill Education, 2011.

EY5007 POWER GENERATION, TRANSMISSION AND UTILIZATION L T P C
3 0 0 3

OBJECTIVES

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

UNIT I CONVENTIONAL POWER GENERATION 12

Steam power plant - Selection of site - Generated layout - Coal and ash handling - Steam Generating Plants - Feed Make Circuit - Cooling Towers - Turbine Governing -Hydro Power Plant- Selection of Site - Classification Layout Governing of Turbines -Nuclear Power Plants - Selection of Site - Classification Layout Governing of Turbines - Nuclear Power Plants - Gas Turbine Plants.

UNIT II NON CONVENTIONAL POWER GENERATION 9

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

UNIT III ELECTRICAL POWER TRANSMISSION 9

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

UNIT IV UTILISATION OF ELECTRICAL ENERGY 9

Selection of Electrical Drives - Electrical characteristics and mechanical considerations -size, rating and cost, Transformer characteristics – illumination - laws of illumination-polar curve – incandescent -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

OUTCOMES

- The Operation of Conventional Power Plants (Steam, Hydro, Nuclear and Gas Turbine plants) and concepts of Renewable Energy Power generation.
- The Economics of Power generation and Utilization of Electrical Energy for Various applications.

REFERENCES

1. Krishnan.R, “Electric Motor Drives”, Prentice hall, 2001.
2. Mohammed E. Hawary, “Introduction to Electrical Power Systems”, John Wiley & Sons, 2008.
3. Rai G.D., "Non Conventional Energy Sources", Khanna Publishers, 1993.
4. Rakosh Das Begamudre, "Energy Conversion Systems", New Age International, 2007.
5. Singh.S.N, “Electrical Power generation, Transmission and Distribution”, 2nd Edition, PHI Learning Private Limited, 2010.
6. Soni M.L., Gupta P.V., Bhatnagar U.S. amd Chakrabarti S., "A Text Book on Power System Engineering", Dhanpatrai and Co, New Delhi, 2008
7. Twidell J.W and Weir A.D, “Renewable Energy Sources”, Taylor and Francis, 2006.
8. Wadhwa C.L, “Generation Distribution and utilization of Electrical Energy”, New Age International, 2012.

EY5008 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS L T P C
3 0 0 3

OBJECTIVES

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

UNIT I INTRODUCTION 9

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

UNIT II ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION 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 : 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-PV- Maximum Power Point Tracking (MPPT).

TOTAL = 45 PERIODS

OUTCOMES

- After completion of syllabus student able to develop maximum power point tracking algorithms.
- Knowledge in power converters namely AC to DC, DC to DC and AC to AC converters for renewable energy systems.

REFERENCES

1. Bhadra.S.N, Kastha.D , and Banerjee.S, “Wind Electrical Systems”, Oxford University Press, 2009.
2. Gray L. Johnson, “Wind energy system”, Prentice hall linc, 1995.
3. Khan.B.H, “Non-conventional Energy sources”, Tata McGraw-hill Publishing Company, New Delhi.
4. Mukund.R.Patel," Wind and Solar Power Systems", 2nd Edition, Taylor and Francies, 2001.
5. Rashid M. H “Power electronics Hand book”, Academic press, 2001.
6. Rai G.D., “Non conventional energy sources”, Khanna publishers, 1993.
7. Rai G.D., “Solar energy utilization”, Khanna publishers, 1993.
8. Roger A. Messenger, Jerry Ventre," Photovoltaic System Engineering", CRC Press, 2004.

EY5092 DESIGN AND ANALYSIS OF TURBOMACHINES L T P C
3 0 0 3

OBJECTIVES:

- To design and analyse the performance of Turbo machines for engineering applications
- To understand the energy transfer process in Turbomachines and governing equations of various forms.
- To understand the structural and functional aspects of major components of Turbomachines.
- To design various Turbomachines for power plant and aircraft applications

UNIT I INTRODUCTION 12

Basics of isentropic flow – static and stagnation properties – diffuser and nozzle configurations - area ratio – mass flow rate – critical properties. Energy transfer between fluid and rotor velocity triangles for a generalized turbomachines - velocity diagrams. Euler's equation for turbomachines and its different forms. Degree of reaction in turbo-machines – various efficiencies – isentropic, mechanical, thermal, overall and polytropic

UNIT II CENTRIFUGAL AND AXIAL FLOW COMPRESSORS 9

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

UNIT III COMBUSTION CHAMBER 9

Basics of combustion. Structure and working of combustion chamber – combustion chamber arrangements - flame stability – fuel injection nozzles. Flame stabilization - cooling of combustion chamber

UNIT IV AXIAL AND RADIAL FLOW TURBINES 9

Elementary theory of axial flow turbines - stage parameters- multi-staging - stage loading and flow coefficients. Degree of reaction - stage temperature and pressure ratios – single and twin spool arrangements – performance. Matching of components. Blade Cooling. Radial flow turbines.

UNIT V GAS TURBINE AND JET ENGINE CYCLES 9

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

TOTAL: 45 PERIODS

OUTCOME:

When a student completes this subject, he / she can

- Understand the design principles of the turbomachines
- Analyse the turbomachines to improve and optimize its performance

REFERENCES:

1. Austin H. Chruch, Centrifugal pumps and blowers, John wiley and Sons, 1980.
2. Cohen H., Rogers, G F C. and Saravanmotto H I H., Gas Turbine Theory-5th Edition, John Wiely, 2001.
3. Csanady G.T., Theory of Turbo machines, McGraw Hill, 1964.
4. Ganesan V., Gas Turbines, Tata McGrawHill, 2011.
5. Hill P G. and Peterson C R., Mechanics and Thermodynamics of Propulsion, Addition-Wesley, 1970.
6. Khajuria P.R. and Dubey S.P., Gas Turbines and Propulsive Systems, Dhanpat Rai Publications, 2003.
7. Mattingly J D., Elements of Gas turbine Propulsion-1st Edition, McGraw Hill, 1997.

EY5009 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 9

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 9

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 9

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 9

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 9

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

OUTCOMES

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

EY5010 **ENERGY EFFICIENT BUILDINGS** **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; Sol-air temperature; Decrement factor; Phase lag. Design of day lighting; 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

OUTCOMES:

After completion of the syllabus student able to:

- Perform energy audits in any type of building and suggest the conservation measures.
- 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”, Mc Graw 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)

EY5011 NANOMATERIALS FOR ENERGY APPLICATIONS L T P C
3 0 0 3

OBJECTIVES

Upon successful completion of the course the students will be familiar with

- To explain the nanostructures and nanomaterials and their properties.
- To study the use of nanostructures and nanomaterials in solar energy conversion devices and systems.
- To explain the use of nanomaterials in energy storage and conversion.
- To explain the use of nanomaterials in the fuel cell, hydrogen and biofuel production technologies.

UNIT I NANOMATERIALS 9

Classification and Properties of Nanomaterials. Characteristics of Nanomaterials- Bottom-Up Synthesis- Top-Down Synthesis. Nanocharacterization- Electron Microscopic Analysis-Atomic Force Microscopic Analysis-X-ray Diffraction Analysis-Spectroscopic Analysis.

UNIT II NANOMATERIALS APPLIED IN SOLAR CELLS 9

Nano, micro, and poly crystalline and amorphous Si for solar cells, Nano-micro Si-composite structure, various techniques of Si deposition. Nanostructured Materials for High Efficiency Perovskite Solar Cells, Dielectric Nanomaterials for Silicon Solar Cells, Nanostructured Cathode Buffer Layers for Inverted Polymer Solar Cells - Discotic Liquid Crystals for Self-organizing Photovoltaics.

UNIT III NANOMATERIALS FOR ENERGY STORAGE AND CONVERSION DEVICES 9

Carbon Materials- Carbon Nanotubes, Graphene, CNT/Graphene Hybrid, Carbon Fiber, Carbon Grease- Conjugated Polymer- Metal Oxides- Lithium Metal Oxides- Elemental and Compound Semiconductors- Metals. Piezoelectric Nanomaterials- Properties and Synthesis of Piezoelectric Nanomaterials- Energy Harvesting with Piezoelectric Nanomaterials. Nanomaterials for Rechargeable Lithium Batteries- Positive Electrode Materials- Negative Electrode Materials.

UNIT IV MICRO FUEL CELL TECHNOLOGY 9

Micro-fuel cell technologies, integration and performance for micro-fuel cell systems -thin film and microfabrication methods - design methodologies - micro-fuel cell power sources. Incorporating Graphene into Fuel Cell Design, Mesoporous Materials for Fuel Cells. Nanomaterials for Hydrogen Generation from Solar Water Splitting.

UNIT V BIOFUEL PRODUCTION, CARBON CAPTURE, STORAGE AND NANOSAFETY 9

Nanomaterials for the Production of Biofuels-Levulinic Acid-Based Fuels-Fuels from Sugar Alcohols-Lignin-Based Fuels. Carbon Cycle- Emissions are Partitioned between the Atmosphere, Land, and Ocean- Methods of CO_2 Capture- Material Used for CO_2 Capture. Introduction to Nanosafety-Measurement- Toxicology.

TOTAL : 45 PERIODS

OUTCOMES

After completion of the syllabus student able to :

- Know the nanostructures and nanomaterials and their properties.
- Understand usage of nanomaterials in energy storage and conversion.
- Use the nanomaterials in the fuel cell, hydrogen and biofuel production technologies.

REFERENCES

1. Garcia-Martinez J., ed. “Nanotechnology for Energy Challenge”, Wiley-VCH, Weinheim, 2010.
2. Hari Singh Nalwa, “Nanomaterials for Energy Storage Applications”, Nanomax Technologies, USA , 2009.
3. Hoogers , “Fuel cell technology handbook”, CRC Press, 2003.
4. Li Quan (Ed.), “Nanomaterials for Sustainable Energy”, ISBN 978-3-319-32023-6, Springer Publications, 2016.
5. Martin A Green, “Solar cells: Operating principles, technology and system applications”, Prentice Hall Inc, Englewood Cliffs, NJ, USA, 1981.
6. Tsakalakos L., “Nanotechnology for Photovoltaics”, CRC, 2010.
7. Twidell.J and T. Weir, “Renewable Energy Resources”, E & F N Spon Ltd, London, 1986.
8. Vayssieres L., “On Solar Hydrogen and Nanotechnology’, Wiley, 2009.

TE5074 ADVANCED POWER PLANT ENGINEERING L T P C
3 0 0 3

OBJECTIVES

- To make the students to understand the energy scenario and the environmental issues related to the power plants.
- To create awareness to the students on the various utilities in the power plants and the avenues for optimizing them.

UNIT I INTRODUCTION 5

Overview of Indian power sector – load curves for various applications – types of power plants – merits and demerits – criteria for comparison and selection - Economics of power plants.

UNIT II STEAM POWER PLANTS 9

Basics of typical power plant utilities - Boilers, Nozzles, Turbines, Condensers, Cooling Towers, Water Treatment and Piping system - Rankine Cycle – thermodynamic analysis. Cycle improvements – Superheat, Reheat, Regeneration

UNIT III DIESEL AND GAS TURBINE POWER PLANTS 9

I.C Engine Cycles - Otto, Diesel & Dual –Theoretical vis-à-vis actual – Typical diesel power plant – Types – Components - Layout - Performance analysis and improvement - Combustion in CI engines - E.C cycles – Gas turbine & Stirling - Gas turbine cycles – thermodynamic analysis – cycle improvements - Intercoolers, Re heaters, regenerators.

UNIT IV ADVANCED POWER CYCLES 12

Cogeneration systems – topping & bottoming cycles - Performance indices of cogeneration systems – Heat to power ratio - Thermodynamic performance of steam turbine cogeneration systems – gas turbine cogeneration systems – reciprocating IC engines cogeneration systems- Binary Cycle - Combined cycle – IGCC – AFBC / PFBC cycles – Thermionic steam power plant. MHD – Open cycle and closed cycle- Hybrid MHD & steam power plants

UNIT V HYDROELECTRIC & NUCLEAR POWER PLANTS 10

Hydroelectric Power plants – classifications - essential elements – pumped storage systems – micro and mini hydel power plants. General aspects of Nuclear Engineering – Components of nuclear power plants - Nuclear reactors & types – PWR, BWR, CANDU, Gas Cooled, Liquid Metal Cooled and Breeder reactor - nuclear safety – Environmental issues.

TOTAL = 45 PERIODS

OUTCOMES

- Understanding the concept of various power plant cycles.
- Possible mitigation of anthropogenic emissions by optimizing the power plant cycles/utilities.

REFERENCES

1. Arora and Domkundwar, A course in power Plant Engineering, Dhanpat Rai and CO, 2004.
2. Gill A.B., Power Plant Performance, Butterworths, 1984.
3. Haywood R.W., Analysis of Engineering Cycles, 4th Edition, Pergamon Press, Oxford, 1991.
4. Horlock J.H., Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford,1987.
5. Lamarsh J.R., Introduction to Nuclear Engineering - 2nd edition, Addison-Wesley, 1983.
6. Nag P.K., Power Plant Engineering, Tata Mcgraw Hill Publishing Co Ltd, New Delhi, 1998.
7. Wood A.J., Wollenberg B.F., Power Generation, operation and control, John Wiley, New York,1984.

EY5072 STEAM GENERATOR TECHNOLOGY L T P C
3 0 0 3

OBJECTIVES

- To educate the students on the types of boilers with their constructional and functional significance.
- To understand the working and design of fuel preparation units and boilers.
- To introduce the concept of boiler design, emission aspects.

UNIT I BASICS 8

Steam Cycle for Power Generation – Fuel Stoichiometry - Boiler Classification & Components – Specifications - Boiler Heat Balance – Efficiency Estimation (Direct & Indirect) – Sankey Diagram

UNIT II FUELS AND BOILER TYPES 8

Solid Fuel : Coal Preparation – Pulverization – Fuel feeding arrangements , Fuel Oil : Design of oil firing system – components – Air regulators , Types of Boiler – Merits & Limitations – Specialty of Fluid Bed Boilers – Basic design principles (Stoker, Travelling Grate etc).

UNIT III COMPONENTS DESIGN 12

Furnace– Water Wall – Steam Drum – Attemperator - Superheaters – Reheaters – Air Preheaters – Economisers - Steam Turbines : Design Aspects of all these.

UNIT IV AUXILIARY EQUIPMENTS – DESIGN & SIZING 10

Forced Draft & Induced Draft Fans – PA / SA Fans – Water Pumps (Low Pressure & High Pressure) – Cooling Towers – Softener – DM Plant.

UNIT V EMISSION ASPECTS 7

Emission Control – Low NO_x Burners– Boiler Blow Down - Control & Disposal : Feed Water Deaeration & Deoxygenation – Reverse Osmosis - Ash Handling Systems Design – Ash Disposal– Chimney Design to meet Pollution std – Cooling Water Treatment & Disposal.

TOTAL = 45 PERIODS

OUTCOMES

- Familiarization with Boiler cycles, components and will have specialized knowledge in steam boiler performance evaluation.
- Emission related aspects in terms of CO_2 NOx emission, mitigation etc will make them to realize the impact of Coal / fuel burning in the society.

REFERENCES
1. Blokh A.G.,Heat Transfer in Steam Boiler Furnace, Hemisphere Publishing Corporation, 1988.
2. Carl Schields, Boilers: Type, Characteristics and Functions, McGraw Hill Publishers, 1982.
3. David Gunn and Robert Horton, Industrial Boilers, Longman Scientific and Technical Publication, 1986.
4. Ganapathy V., Industrial Boilers and Heat Recovery Steam Generators, Marcel Dekker Ink, 2003.
5. Howard J.R., Fluidized Bed Technology: Principles and Applications, Adam Hilger, NewYork, 1983.
6. Mosoon Kwauk, Fluidization Idealized and Bubbleless, with Applications, Science Press, 1992.
7. PrabirBasu, Cen Kefa and Louis Jestin, Boilers and Burners: Design and Theory, Springer, 2000.

EY5073 FLUIDIZED BED SYSTEMS L T P C
3 0 0 3

OBJECTIVES
- To introduce the concepts of fluidization and heat transfer in fluidized beds.
- To understand the design principles and apply the same for industrial applications.

UNIT I FLUIDIZED BED BEHAVIOUR 12

Characterization of bed particles - comparison of different methods of gas - solid contacts. Fluidization phenomena - regimes of fluidization – bed pressure drop curve. Two phase and well-mixed theory of fluidization. Particle entrainment and elutriation – unique features of circulating fluidized beds.

UNIT II HEAT TRANSFER 6

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

UNIT III COMBUSTION AND GASIFICATION 6

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

UNIT IV DESIGN CONSIDERATIONS 9

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

UNIT V INDUSTRIAL APPLICATIONS 12

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

TOTAL: 45 PERIODS

OUTCOMES

After completion of the syllabus student able to :
- Understand the working principles, merits and limitations of fluidized bed systems.
- Apply fluidized bed systems for a specific engineering applications.
- Analyse the fluidized bed systems to improve and optimize its performance.

REFERENCES
1. Botteril J.S.M., Fluid Bed Heat Transfer, Academic Press, London, 1975.
2. Geldart D., Gas Fluidization Technology, John Willey and Sons, 1986.
3. Howard J.R. , Fluidized Beds: Combustion and Applications, Applied Science Publishers, New York, 1983.
4. Howard J.R., Fluidized Bed Technology: Principles and Applications, Adam Hilger, NewYork, 1983.
5. Kunii D. and Levespiel O., Fluidization Engineering, John Wiley and Son Inc, New York,1969.
6. Liang-Shih Fan, Gas-Liquid-Solid Fluidization Engineering, Butterworths Publishers,1989.
7. O. Levenspiel and D. Kunii, Fluidization Engineering, John Wiley, 1972.

EY5012 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 9
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 Transys

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 FUEL CELL 9
Fuel Cell – History of Fuel cell, Principles of Electrochemical storage – Types – Hydrogen oxygen cells, Hydrogen air cell, Hydrocarbon air cell, alkaline fuel cell, detailed analysis – advantage and drawback of each type.

UNIT V ALTERNATE ENERGY STORAGE TECHNOLOGIES 8
Flywheel , Super capacitors, Principles & Methods – Applications, Compressed air Energy storage, Concept of Hybrid Storage – Applications

TOTAL: 45 PERIODS

OUTCOME
After completion of the syllabus student able to:
- Anlayse various types of energy storage devices and perform the selection based on techno-economic view point.

REFERENCES

1. Ibrahim Dincer and Mark A. Rosen, “Thermal Energy Storage Systems and Applications”, John Wiley & Sons 2002.
2. James Larminie and Andrew Dicks, ”Fuel cell systems Explained”, Wiley publications, 2003.
3. Lunardini.V.J, Heat Transfer in Cold Climates, John Wiley and Sons 1981.
4. Ru-shiliu, Leizhang and Xueliang sun, “Electrochemical technologies for energy storage and conversion”, Wiley publications, 2012.
5. Schmidt.F.W and Willmott.A.J, Thermal Storage and Regeneration, Hemisphere Publishing Corporation, 1981.

EY5013 WASTE MANAGEMENT AND ENERGY RECOVERY L T P C
3 0 0 3

OBJECTIVES

- To provide information on various methods of waste management.
- To familiarize students with recent energy generation techniques.
- To detail on the recent technologies of waste disposal
- To make student realize on the importance of healthy environment

UNIT I CHARACTERISTICS AND PERSPECTIVES 9

Sources – Types – Composition – Generation – Estimation Techniques – Characterization – Types of Collection System – Transfer Stations – Transfer Operations – Material Recycle / Recovery Facilities.

UNIT II UNIT OPERATIONS & TRANSFORMATION TECHNOLOGIES 8

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

UNIT III WASTE DISPOSAL 9

Landfill Classification – Types – Siting Considerations – Landfill Gas (Generation, Extraction, Gas Usage Techniques) – Leachates Formation, Movement, Control Techniques – Environmental Quality Monitoring – Layout, Closure & Post Closure Operation – Reclamation.

UNIT IV TRANSFORMATION TECHNOLOGIES AND VALUE ADDITION 10

Physical Transformation : Component Separation & Volume Reduction : Chemical Transformation – Combustion/Gasification/ Pyrolysis : Energy Recovery - Biological Transformation – Aerobic Composting – Anaerobic Digestion.

UNIT V HAZARDOUS WASTE MANAGEMENT & WASTE RECYCLING 9

Definition – Sources – Classification – Incineration Technology - Incineration vs Combustion Technology – RDF / Mass Firing – Material Recycling : Paper / Glass / Plastics etc., - Disposal of White Goods & E-Wastes.

TOTAL: 45 PERIODS

OUTCOMES

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

REFERENCES

1. Energy Cogeneration Hand book, George Polimveros, Industrial Press Inc, New York 1982.
2. Howard S. Peavy etal, "Environmental Engineering", McGraw Hill International Edition, 1985.
3. LaGrega, M., et al., "Hazardous Waste Management", McGraw-Hill, c. 1200 pp., 2nd ed.,2001.
4. Manoj Datta, "Waste Disposal in Engineered Landfills", Narosa Publishing House, 1997.
5. Parker Colin and Roberts, "Energy from Waste – An Evaluation of Conversion Technologies", Elsevier Applied Science, London, 1985.
6. Stanley E. Manahan, "Hazardous Waste Chemistry, Toxicology and Treatment", Lewis Publishers, Chelsea, Michigan, 1990.
7. Tchobanoglous, Theisen and Vigil, "Integrated Solid Waste Management", 2d Ed. McGraw-Hill, New York, 1993.

TE5291	**ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL**	**L T P C**
		3 0 0 3

OBJECTIVES

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

UNIT I INTRODUCTION 9

Global atmospheric change – green house effect – Ozone depletion - natural cycles - mass and energy transfer – material balance – environmental chemistry and biology – impacts – environmental. Legislations.

UNIT II AIR POLLUTION 9

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

UNIT III WATER POLLUTION 9

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

UNIT IV WASTE MANAGEMENT 9

Sources and Classification – Solid waste – Hazardous waste - Characteristics – Collection and Transportation - Disposal – Processing and Energy Recovery – Waste minimization

UNIT V OTHER TYPES OF POLLUTION FROM INDUSTRIES 9

Noise pollution and its impact - oil pollution - pesticides - instrumentation for pollution control - water pollution from tanneries and other industries and their control – environment impact assessment for various projects – case studies. Radiation pollution: types, sources, effects, control of radiation pollution.

TOTAL: 45 PERIODS

OUTCOME

- On successful Completion of this course the student will be understand Emission standards, waste management power generation and pollution from various industries.

REFERENCES

1. Arcadio P Sincero and G.A. Sincero, Environmental Engineering – A Design Apporach, Prentice Hall of India Pvt Ltd, New Delhi, 2002.
2. Bishop P., Pollution Prevention: Fundamentals and Practice, McGraw-Hill International Edition, McGraw-Hill book Co, Singapore, 2000.
3. G.Masters, Introduction to Environmental Engineering and Science Prentice Hall of India Pvt Ltd, New Delhi, 2003.
4. Gilbert M. Masters, Introduction to Environmental Engineering and Science, 2nd Edition, Prentice Hall, 1998.
5. H.Ludwig, W.Evans, Manual of Environmental Technology in Developing Countries, International Book Company, Absecon Highlands N.J. (1991).
6. H.S.Peavy, D.R.Rowe and G.Tchobanoglous, Environmental Engineering McGraw- Hill Book Company, NewYork, (1985).
7. Rao C.S., Environmental Pollution Control Engineering, 2nd Edition, New Age International Publishers, 2006.

MF5072 RESEARCH METHODOLOGY L T P C

3 0 0 3

OBJECTIVES

To impart scientific, statistical and analytical knowledge for carrying out research work effectively.

UNIT I INTRODUCTION TO RESEARCH 9

The hallmarks of scientific research – Building blocks of science in research – Concept of Applied and Basic research – Quantitative and Qualitative Research Techniques – Need for theoretical frame work – Hypothesis development – Hypothesis testing with quantitative data. Research design – Purpose of the study: Exploratory, Descriptive, Hypothesis Testing.

UNIT II EXPERIMENTAL DESIGN 9

Laboratory and the Field Experiment – Internal and External Validity – Factors affecting Internal validity. Measurement of variables – Scales and measurements of variables. Developing scales – Rating scale and attitudinal scales – Validity testing of scales – Reliability concept in scales being developed – Stability Measures.

UNIT III DATA COLLECTION METHODS 9

Interviewing, Questionnaires, etc. Secondary sources of data collection. Guidelines for Questionnaire Design – Electronic Questionnaire Design and Surveys. Special Data Sources: Focus Groups, Static and Dynamic panels. Review of Advantages and Disadvantages of various Data-Collection Methods and their utility. Sampling Techniques – Probabilistic and non-probabilistic samples. Issues of Precision and Confidence in determining Sample Size. Hypothesis testing, Determination of Optimal sample size.

UNIT IV MULTIVARIATE STATISTICAL TECHNIQUES 9

Data Analysis – Factor Analysis – Culster Analysis -Discriminant Analysis – Multiple Regression and Correlation – Canonical Correlation – Application of Statistical (SPSS) Software Package in Research.

UNIT V RESEARCH REPORT 9

Purpose of the written report – Concept of audience – Basics of written reports. Integral parts of a report – Title of a report, Table of contents, Abstract, Synopsis, Introduction, Body of a report – Experimental, Results and Discussion – Recommendations and Implementation section – Conclusions and Scope for future work.

TOTAL = 45 PERIODS

OUTCOME

After completion of the syllabus student able:

- To get knowledge about the different research techniques and research report.

REFERENCES

1. C.R.Kothari, Research Methodology, WishvaPrakashan, New Delhi, 2001.
2. Donald H.McBurney, Research Methods, Thomson Asia Pvt. Ltd. Singapore, 2002.
3. Donald R. Cooper and Ramela S. Schindler, Business Research Methods, Tata McGraw- Hill Publishing Company Limited, New Delhi, 2000
4. Ranjit Kumar, Research Methodology, Sage Publications, London, New Delhi, 1999.
5. Raymond-Alain Thie tart, *et.al.,* Doing Management Research, Sage Publications, London, 1999
6. Ticehurst.G.W and Veal.A.J, Business Research Methods, Longman, 1999.
7. Uma Sekaran, Research Methods for Business, John Wiley and Sons Inc., New York, 2000.