ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

REGULATIONS – 2015

CHOICE BASED CREDIT SYSTEM

M.E. ENERGY ENGINEERING

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

I. To specialize students in the filed of Energy Engineering to meet the national, and global needs.

II. To equip the students with a necessary foundation in mathematical, scientific and engineering concepts required to solve energy engineering problems

III. To provide students with required scientific and engineering training required to analyze, design, and create novel products and solutions suitable for the demands of the present and future.

IV. To inculcate professional aptitude, ethical attitude, effective communication skills, sprit of teamwork and ability to conduct energy analysis of various systems in the minds of the students.

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

PROGRAMME OUTCOMES (POs):

On successful completion of the programme,

1. Graduates will demonstrate knowledge of mathematics, science and engineering.
2. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
3. Graduate will demonstrate an ability to design and conduct experiments, analyze and interpret data.
4. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.
5. Graduates will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.
6. Graduate 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 have excellent verbal and written communication.
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.

Mapping of PEOs with POs

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

			PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
YEAR 1	**SEM 1**	Advanced Numerical Methods	✓	✓				✓				
		Thermodynamic Analysis of Energy Systems	✓	✓		✓						✓
		Fluid Mechanics and Heat Transfer	✓	✓		✓		✓				
		Energy Resources and Conversion Techniques			✓	✓			✓		✓	
		Energy Auditing and Management			✓	✓	✓	✓				
		Elective I										
		Energy Laboratory			✓	✓	✓	✓				
	SEM 2	Energy Efficient Buildings Design			✓	✓	✓	✓				✓
		Energy Conservation in Industrial Utilities			✓	✓	✓	✓				
		Instrumentation for Thermal Systems				✓			✓		✓	
		Elective II										
		Elective III										
		Elective IV										
		Seminar							✓	✓		✓
		Analysis and Simulation Lab for Energy Engineering		✓	✓	✓	✓	✓				
YEAR 2	**SEM 1**	Elective V										
		Elective VI										
		Elective VII										
		Project Work Phase I	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	SEM 2	Project Work Phase II	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Attested

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ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

REGULATIONS – 2015

CHOICE BASED CREDIT SYSTEM

CURRICULA AND SYLLABI

M.E. ENERGY ENGINEERING

SEMESTER I

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	EY7101	Energy Auditing and Management	PC	3	3	0	0	3
2.	EY7151	Energy Resources and Conversion Techniques	FC	3	3	0	0	3
3.	EY7152	Fluid Mechanics and Heat Transfer	FC	4	4	0	0	4
4.	EY7153	Thermodynamic Analysis of Energy Systems	FC	4	4	0	0	4
5.	MA7154	Advanced Numerical Methods	FC	4	4	0	0	4
6.		Elective I	PE	3	3	0	0	3
PRACTICALS								
7	EY7111	Energy Laboratory	PC	4	0	0	4	2
			TOTAL	**25**	**21**	**0**	**4**	**23**

SEMESTER II

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	EY7201	Energy Conservation in Industrial Utilities	PC	3	3	0	0	3
2.	EY7251	Energy Efficient Buildings Design	PC	3	3	0	0	3
3.	IC7251	Instrumentation for Thermal Systems	PC	3	3	0	0	3
4.		Elective II	PE	3	3	0	0	3
5.		Elective III	PE	3	3	0	0	3
6.		Elective IV	PE	3	3	0	0	3
PRACTICALS								
7.	EY7211	Analysis and Simulation Lab for Energy Engineering	PC	4	0	0	4	2
8.	EY7212	Seminar	EEC	2	0	0	2	1
			TOTAL	**24**	**18**	**0**	**6**	**21**

SEMESTER III

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Elective V	PE	3	3	0	0	3
2.		Elective VI	PE	3	3	0	0	3
3.		Elective VII	PE	3	3	0	0	3
PRACTICALS								
5.	EY7311	Project Work Phase I	EEC	12	0	0	12	6
			TOTAL	**21**	**9**	**0**	**12**	**15**

SEMESTER IV

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	EY7411	Project Work Phase II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

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

ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

REGULATIONS – 2015

CHOICE BASED CREDIT SYSTEM

CURRICULA AND SYLLABI

M.E. ENERGY ENGINEERING (PART TIME)

SEMESTER I

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MA7154	Advanced Numerical Methods	FC	4	4	0	0	4
2.	EY7153	Thermodynamic Analysis of Energy Systems	FC	4	4	0	0	4
3.	EY7152	Fluid Mechanics and Heat Transfer	FC	4	4	0	0	4
			TOTAL	**12**	**12**	**0**	**0**	**12**

SEMESTER II

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	EY7251	Energy Efficient Buildings Design	PC	3	3	0	0	3
2.	EY7201	Energy Conservation in Industrial Utilities	PC	3	3	0	0	3
3.	IC7251	Instrumentation for Thermal Systems	PC	3	3	0	0	3
			TOTAL	**9**	**9**	**0**	**0**	**9**

SEMESTER III

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	EY7151	Energy Resources and Conversion Techniques	FC	3	3	0	0	3
2.	EY7101	Energy Auditing and Management	PC	3	3	0	0	3
3.		Elective I	PE	3	3	0	0	3
PRACTICALS								
5.	EY7111	Energy Laboratory	PC	4	0	0	4	2
			TOTAL	**13**	**9**	**0**	**4**	**11**

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SEMESTER IV

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Elective II	PE	3	3	0	0	3
2.		Elective III	PE	3	3	0	0	3
3.		Elective IV	PE	3	3	0	0	3
PRACTICALS								
4.	EY7211	Analysis and Simulation Lab for Energy Engineering	PC	4	0	0	4	2
5.	EY7212	Seminar	EEC	2	0	0	2	1
			TOTAL	**15**	**9**	**0**	**6**	**12**

SEMESTER V

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Elective V	PE	3	3	0	0	3
2.		Elective VI	PE	3	3	0	0	3
3.		Elective VII	PE	3	3	0	0	3
PRACTICALS								
4.	EY7311	Project Work Phase I	EEC	12	0	0	12	6
			TOTAL	**21**	**9**	**0**	**12**	**15**

SEMESTER VI

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICALS								
1.	EY7411	Project Work Phase II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

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

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FOUNDATION COURSES (FC)

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

PROFESSIONAL CORE (PC)

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Energy Auditing and Management	PC	3	3	0	0	3
2.		Energy Conservation in Industrial Utilities	PC	3	3	0	0	3
3.		Energy Efficient Buildings Design	PC	3	3	0	0	3
4.		Instrumentation for Thermal Systems	PC	3	3	0	0	3
5.		Energy Laboratory	PC	4	0	0	4	2
6.		Analysis and Simulation Lab for Energy Engineering	PC	4	0	0	4	2

PROFESSIONAL ELECTIVES (PE)

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	EY7001	Advanced Power Plant Engineering	PE	3	3	0	0	3
2.	EY7002	Bio Energy Technologies	PE	3	3	0	0	3
3.	EY7003	Design of Heat Exchangers	PE	3	3	0	0	3
4.	EY7004	Fluidized Bed Systems	PE	3	3	0	0	3
5.	EY7005	Hydrogen and Fuel Cell	PE	3	3	0	0	3
6.	EY7006	Modeling and Analysis of Energy Systems	PE	3	3	0	0	3
7.	EY7007	Nuclear Engineering	PE	3	3	0	0	3

8.	EY7008	Solar Energy Technologies	PE	3	3	0	0	3
9.	EY7009	Steam Generator Technology	PE	3	3	0	0	3
10.	EY7010	Waste Management and Energy Recovery Techniques	PE	3	3	0	0	3
11.	EY7011	Wind Energy Systems	PE	3	3	0	0	3
12.	EY7071	Advanced Energy Storage Technologies	PE	3	3	0	0	3
13.	EY7072	Design and Analysis of Turbo Machines	PE	3	3	0	0	3
14.	EY7073	Electrical Drives and Controls	PE	3	3	0	0	3
15.	EY7074	Energy Forecasting, Modeling and Project Management	PE	3	3	0	0	3
16.	EY7075	Environmental Engineering and Pollution Control	PE	3	3	0	0	3
17.	EY7076	Power Electronics for Renewable Energy Systems	PE	3	3	0	0	3
18.	EY7077	Power Generation, Transmission and Distribution	PE	3	3	0	0	3
19.	IC7071	Computational Fluid Dynamics	PE	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

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

EY7101 ENERGY AUDITING AND MANAGEMENT

	L	T	P	C
	3	0	0	3

OBJECTIVES:

- To understand the various methods of energy management.
- To understand the various techniques of energy auditing.

UNIT I INTRODUCTION 7

Types & Forms of Energy - Primary / Secondary Energy Sources –EC Act 2003 - Energy Auditing: Types, classifications, deliverables, barriers – Benchmarking - Roles & Responsibility of Energy Managers

UNIT II ENERGY COSTING, MONITORING & TARGETING 11

Data & Information Analysis – Cost / Energy Share Diagram – Data Graphing – 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 – Wheeling and Banking - Demand Side Management – comparison on unit cost of power cost from various sources – steam cost from different sources

UNIT III METERING FOR ENERGY MANAGEMENT & POWER QUALITY ANALYSES 9

Instruments Used in Energy systems: Load and power factor measuring equipment, Wattmeter, flue gas analysis, Temperature and thermal loss measurements, air quality analysis etc. Relationships between parameters-Units of measure-Typical cost factors- Utility meters – Timing of meter disc for kilowatt measurement - Demand meters - Paralleling of current transformers - Instrument transformer burdens-Multitasking solid-state meters - Metering location vs. requirements – Net metering - Metering techniques and practical examples.

UNIT IV LIGHTING SYSTEMS & COGENERATION 9

Concept of lighting systems - The task and the working space - Light sources - Ballasts - Luminaries - Lighting controls - Optimizing lighting energy - Power factor and effect of harmonics on power quality - Cost analysis techniques - Lighting and energy standards Cogeneration: Forms of cogeneration - feasibility of cogeneration- Electrical interconnection.

UNIT V ECONOMICS 9

Energy Economics – Depreciation - Financial Analysis Techniques – Discount Rate, Payback Period, Internal Rate of Return, Net Present Value, Life Cycle Costing – ESCO concept - CUSUM Technique – ESCO Concept – ESCO Contracts

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of this course, the students can able to analyse the energy data of industries.

- Can carry out energy accounting and balancing
- Can suggest methodologies for energy savings

TEXT BOOK:

1. Energy Manager Training Manual (4Volumes) available at www.energymanagertraining.com, a website administered by Bureau of Energy Efficiency (BEE), a statutory body under Ministry of Power, Government of India.2004.
2. Barney L. Capehart, Wayne C. Turner, and William J. Kennedy, Guide to Energy Management, Fifth Edition, The Fairmont Press, Inc., 2006

REFERENCES:

1. L.C. Witte, P.S. Schmidt, D.R. Brown, “Industrial Energy Management and Utilisation” Hemisphere Publ, Washington, 1988.
2. Callaghn, P.W. “Design and Management for Energy Conservation”, Pergamon Press, Oxford, 1981.
3. I.G.C. Dryden, “The Efficient Use of Energy” Butterworths, London, 1982
4. W.C. turner, “Energy Management Hand book” Wiley, New York, 1982

5. W.R. Murphy and G. McKay "Energy Management" Butterworths, London 1987
6. Ursala Eicker, "Solar Technologies for buildings", Wiley publications, 2003
7. Eastop T.D & Croft D.R, Energy Efficiency for Engineers and Technologists,. Logman Scientific & Technical, ISBN-0-582-03184, 1990.

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

OBJECTIVES:

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

UNIT I SOLAR ENERGY 9

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

UNIT II WIND ENERGY 9

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

UNIT III BIO-ENERGY 9

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

UNIT IV OTHER TYPES OF ENERGY 9

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

UNIT V DIRECT CONVERSION OF THERMAL TO ELECTRICAL ENERGY 9

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

TOTAL: 45 PERIODS

OUTCOMES:

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

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

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

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

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

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

UNIT II INCOMPRESSIBLE AND COMPRESSIBLE FLOWS 12

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

UNIT III CONDUCTION AND RADIATION HEAT TRANSFER 15

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

UNIT IV TURBULENT FORCED CONVECTIVE HEAT TRANSFER 11

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

UNIT V PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGER 10

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

TOTAL: 60 PERIODS

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

TEXT BOOKS

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

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

OBJECTIVES

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

UNIT I AVAILABILITY ANALYSIS AND THERMODYNAMIC PROPERTY RELATION 13

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 13

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 13

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 11

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

UNIT V COMBUSTION PROCESS AND COMBUSTION CHAMBERS 10

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

TOTAL : 60 PERIODS

OUTCOMES

Students will able to

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

REFERENCES:
1. Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Cons, 1988.
2. Kuo, K.K., Principles of Combustion, John Wiley and Sons, 2005
3. Kenneth Wark Jr., Advanced Thermodynamics for Engineers, McGrew – Hill Inc., 1995.
4. Winterbone D E, Advanced Thermodynamics for Engineers, Arnold, 1997.
5. Ganesan, V., Gas Turbines, Tata McGraw Hill, 2011.
6. Ganesan,V., Internal Combustion Engines, Tata McGraw Hill, 2006.
7. Natarajan, E., Engineering Thermodynamics – Fundamentals and Applications, Anuragam Publications, 2014.
8. Cohen, H., Rogers, G F C and Saravanmotto, H I H, Gas Turbine Theory, John Wiley, 2001.

MA7154 ADVANCED NUMERICAL METHODS

L	T	P	C
4	0	0	4

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

UNIT I ALGEBRAIC EQUATIONS 12

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

UNIT II ORDINARY DIFFERENTIAL EQUATIONS 12

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

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

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

UNIT IV FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS 12

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

UNIT V FINITE ELEMENT METHOD 12

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

TOTAL : 60 PERIODS

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

REFERENCES:

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

EY7111	ENERGY LABORATORY	L T P C
		0 0 4 2

OBJECTIVES

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

Session 1 RENEWABLE ENERGY 24

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

Session 2 ENERGY CONSERVATION 24

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

Session 3 ALTERNATE ENERGY SYSTEMS 12

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

TOTAL : 60 PERIODS

OUTCOME

Students will be knowledgeable on the

- Procedure to be adopted for performance analysis and optimization of energy utilities
- Methodology to be adopted for the quantification of performance governing parameters

EQUIPMENTS REQUIRED

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

EY7201	ENERGY CONSERVATION IN INDUSTRIAL UTILITIES	L T P C
		3 0 0 3

OBJECTIVES

- To understand the principles of energy conservation and their importance.
- To apply the principles of energy conservation in industrial utilities.

UNIT I STEAM GENERATION AND UTILISATION 9

Boiler – Stoichiometry – Combustion Principles – Heat Loss Estimation – Steam Traps – Steam - Piping & Distribution – Thermic Fluid Heaters – Furnaces – Insulation & Refractories

UNIT II WASTE HEAT RECOVERY 9

Cogeneration – Principles & Operation – Power Ratio - Economics of Cogeneration Scheme – Case Study on Cogeneration – WHR – Sources & Grades – Types (Heat Wheel, Recuperators, Regenerators ,Heat Pipe) – Economics of WHR Systems – Thermal Energy Storage

UNIT III REFRIGERATION AND AIR CONDITIONING SYSTEMS 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.

UNIT IV 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 - Soft Starters / Auto Star – Delta – Star Starters / APFC / Variable Speed & Frequency Drives

UNIT V FANS, PUMPS, COMPRESSORS AND ILLUMINATION 11

Basics – Types - Selection – Performance Evaluation – Cause for inefficient operation – scopes for energy conservation

TOTAL: 45 PERIODS

OUTCOME:

- Students will be familiar with Energy Conservation scenario in general and will be mastering the thermal and electrical energy conversation technologies / procedures

TEXT BOOK:

1. Energy Manager Training Manual(4 Volumes) available at www.energymanagertraining. com, a website administered by Bureau of Energy Efficiency (BEE), a statutory body under Ministry of Power, Government of India.2004.

REFERENCES

1. Smith, CB Energy Management Principles, Pergamon Press, NewYork, 1981
2. Hamies, Energy Auditing and Conservation; Methods Measurements, Management and Case study, Hemisphere, Washington, 1980
3. Trivedi, PR, Jolka KR, Energy Management, Commonwealth Publication, New Delhi, 1997
4. Write, Larry C, Industrial Energy Management and Utilization, Hemisphere Publishers, Washington, 1988
5. Handbook on Energy Efficiency, TERI, New Delhi, 2001

EY7251 ENERGY EFFICIENT BUILDINGS DESIGN

L	T	P	C
3	0	0	3

OBJECTIVES

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

UNIT I INTRODUCTION 9

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

UNIT II LANDSCAPE AND BUILDING ENVELOPES 9

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

UNIT III HEATING, VENTILATION AND AIR-CONDITIONING 9

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

UNIT IV HEAT TRANSMISSION IN BUILDINGS 9

Surface co-efficient: air cavity, internal and external surfaces, overall thermal transmittance, wall and windows; Heat transfer due to ventilation/infiltration, internal heat transfer; Solar temperature; Decrement factor; Phase lag. Design of daylighting; Estimation of building loads: Steady state method, network method, numerical method, correlations; Computer packages for carrying out thermal design of buildings and predicting performance.

UNIT V PASSIVE COOLING & RENEWABLE ENERGY IN BUILDINGS 9

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

TOTAL: 45 PERIODS

OUTCOME

Student will be able to

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

(b) Acquaint students with the principle theories materials, construction techniques and to create energy efficient buildings

(b) Integrate the renewable energy systems in the buildings and passive cooling in buildings

REFERENCES

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

IC7251 INSTRUMENTATION FOR THERMAL SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES

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

UNIT I MEASUREMENT CHARACTERISTICS 8

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

UNIT II MEASUREMENTS IN THERMAL SYSTEMS 10

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

UNIT III MESAURMENT OF FUEL PROPERTIES AND POLLUTANTS 10

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

UNIT IV CONTROL SYSTEMS, COMPONENTS AND CONTROLLERS 10

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

UNIT V DESIGN OF MEASUREMENT AND CONTROL SYSTEMS **7**

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

TOTAL:45 PERIODS

OUTCOME

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

REFERENCES

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

EY7211	ANALYSIS AND SIMULATION LAB FOR ENERGY ENGINEERING	L T P C 0 0 4 2

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

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

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

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

SIMULATION LAB – REQUIREMENT:

1. Software - Modelling software like ProE, Gambit, ANSYS etc
   Analysis software like ANSYS, Fluent, CFX, etc
   Equation solving software like MATLAB, Engg equation solver
2. Every student in a batch must be provided with a terminal
3. Hardware should be compatible with the requirement of the above software.

TOTAL: 60 PERIODS

EY7212 SEMINAR **L T P C**
0 0 2 1

OBJECTIVES

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

TOTAL: 30 PERIODS

EY7311 PROJECT WORK PHASE I **L T P C**
0 0 12 6

OBJECTIVES

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

EVALUATION

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

TOTAL : 90 PERIODS

OUTCOME

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

EY7411 PROJECT WORK PHASE II **L T P C**
0 0 24 12

OBJECTIVES

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

EVALUATION

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

TOTAL = 180 PERIODS

OUTCOME

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

EY7001 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
- Creating 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 issue

TOTAL: 45 PERIODS

OUTCOME

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

REFERENCES

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

EY7002 BIO ENERGY TECHNOLOGIES

	L	T	P	C
	3	0	0	3

OBJECTIVES

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

UNIT I INTRODUCTION 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

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

REFERENCES

1. Tom B Reed, Biomass Gasification – Principles and Technology, Noyce Data Corporation, 1981
2. David Boyles, Bio Energy Technology Thermodynamics and costs, Ellis Hoknood Chichester, 1984.
3. Khandelwal KC, Mahdi SS, Biogas Technology – A Practical Handbook, Tata McGraw Hill, 1986
4. Mahaeswari, R.C. Bio Energy for Rural Energisation, Concepts Publication,1997
5. Best Practises Manual for Biomass Briquetting, I R E D A, 1997
6. Eriksson S. and M. Prior, The briquetting of Agricultural wastes for fuel, FAO Energy and Environment paper, 1990
7. Iyer PVR et al, Thermochemical Characterization of Biomass, M N E S

EY7003 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

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

REFERENCES

1. Sadik Kakac and Hongtan Liu, Heat Exchangers Selection, Rating and Thermal Design, CRC Press, 2002
2. Arthur. P Frass, Heat Exchanger Design, John Wiley & Sons, 1988.
3. Taborek.T, Hewitt.G.F and Afgan.N, Heat Exchangers, Theory and Practice, McGraw Hill Book Co. 1980.
4. Hewitt.G.F, Shires.G.L and Bott.T.R, Process Heat Transfer, CRC Press, 1994.

EY7004 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

OUTCOME

When a student completes this subject, he / she can

- Understand the working principles, merits and limitations of fluidized bed systems
- Apply fluidized bed systems for specific engineering applications
- Analyse the fluidized bed systems to improve and optimize its performance

REFERENCES

1. Howard,J.R., Fluidized Bed Technology: Principles and Applications, Adam Hilger, NewYork, 1983.
2. Geldart, D., Gas Fluidization Technology, John Willey and Sons, 1986.
3. Kunii, D and Levespiel, O., Fluidization Engineering, John Wiley and Son Inc, New York,1969.
4. Howard, J.R. (Ed), Fluidized Beds: Combustion and Applications, Applied Science Publishers, New York, 1983.
5. Botteril, J.S.M., Fluid Bed Heat Transfer, Academic Press, London, 1975.

EY7005 HYDROGEN AND FUEL CELL L T P C
3 0 0 3

OBJECTIVES

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

UNIT I HYDROGEN – BASICS AND PRODUCTION TECHNIQUES 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 – Metal Hydrides – 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. Selection and use of Materials.

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

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

REFERENCES

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

EY7006 MODELLING AND ANALYSIS OF ENERGY SYSTEMS

L	T	P	C
3	0	0	3

OBJECTIVES

- To learn to apply mass and energy balances for the systems enable to perform enthalpy
- Learn to calculate size, performance and cost of energy equipment turns modelling 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 - modelling overview - levels and steps in model development - Examples of models – curve fitting and regression analysis

UNIT II MODELLING AND SYSTEMS SIMULATION 9

Modelling 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 Modelling - 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

- Student will be able do to Simulation and Modelling of typical energy system
- Able to analysis effect of constraints on the performance of energy systems
- Has a potential to do design HEN network and perform Energy-Economic Analysis for a typical applications

REFERENCES

1. Bejan, A, Tsatsaronis, G and Moran, M., Thermal Design and Optimization, John Wiley & Sons 1996
2. Stoecker, W.F., Design of Thermal Systems, McGraw Hill, 2011.
3. Yogesh Jaluria, Design and Optimization of Thermal Systems, CRC Press INC, 2008
4. C. Balaji, Essentials of Thermal System Design and Optimization, Ane Books, 2011

EY7007	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 – Beryllium

UNIT III REPROCESSING 9

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

UNIT IV SEPARATION OF REACTOR PRODUCTS 9

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

UNIT V WASTE DISPOSAL AND RADIATION PROTECTION 9

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

TOTAL: 45 PERIODS

OUTCOMES:

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

REFERENCES

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

EY7008 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 learn about PV technology principles and techniques of various solar cells / materials for lister energy conversion
- To learn economic 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:

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

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, J K Nayak, 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.

EY7009 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 & 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). Indian Boiler Regulations.

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 standard – Cooling Water Treatment & Disposal

TOTAL: 45 PERIODS

OUTCOME

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

REFERENCES

1. Prabir Basu, Cen Kefa and Louis Jestin, Boilers and Burners: Design and Theory, Springer, 2000.
2. Ganapathy, V., Industrial Boilers and Heat Recovery Steam Generators, Marcel Dekker Ink, 2003
3. David Gunn and Robert Horton, Industrial Boilers, Longman Scientific and Technical Publication, 1986
4. Carl Schields, Boilers: Type, Characteristics and Functions, McGraw Hill Publishers, 1982
5. Howard, J.R., Fluidized Bed Technology: Principles and Applications, Adam Hilger, New York, 1983

EY7010 WASTE MANAGEMENT AND ENERGY RECOVERY TECHNIQUES

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 and
- 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

OUTCOME

1. Waste characterization, Segregation, Disposal will be made known
2. Technologies that are available for effective waste disposal along with pros / cons will become cleaner to students
3. 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. Tchobanoglous, Theisen and Vigil, Integrated Solid Waste Management, 2d Ed. McGraw Hill, New York, 1993.
2. Howard S. Peavy et al, Environmental Engineering, McGraw Hill International Edition, 1985
3. La Grega, M., et al., Hazardous Waste Management, McGraw Hill, c. 1200 pp., 2nd ed., 2001.
4. Stanley E. Manahan. Hazardous Waste Chemistry, Toxicology and Treatment, Lewis Publishers, Chelsea, Michigan, 1990
5. Parker, Colin and Roberts, Energy from Waste – An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985.
6. Manoj Datta, Waste Disposal in Engineered Landfills, Narosa Publishing House, 1997.

EY7011 WIND ENERGY SYSTEMS

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 Synchronisation 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

- Knowledge in conversion techniques of wind energy
- Learning of wind turbine components and their construction
- Understating of modern wind turbine control & monitoring

REFERENCES

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

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

OBJECTIVES

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

UNIT I INTRODUCTION 6

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

UNIT II THERMAL STORAGE SYSTEM 9

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

UNIT III ELECTRICAL ENERGY STORAGE SYSTEM 9

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

UNIT IV HYDROGEN AND BIOGAS STORAGE 9

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

UNIT V ALTERNATE ENERGY STORAGE TECHNOLOGIES 12

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

TOTAL: 45 PERIODS

OUTCOME

- Able to 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, JohnWiley & Sons 2002
2. Fuel cell systems Explained, James Larminie and Andrew Dicks, Wiley publications, 2003.
3. Electrochemical technologies for energy storage and conversion, Ru-shiliu, Leizhang, Xueliang sun, Wiley publications, 2012

EY7072 DESIGN AND ANALYSIS OF TURBOMACHINES

L	T	P	C
3	0	0	3

OBJECTIVES

- To understand the energy transfer process in Turbo machines and governing equations of various forms.
- To understand the structural and functional aspects of major components of turbo machines.
- To design various turbo machines 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 turbo machines - velocity diagrams. Euler's equation for turbo machines 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

Attested

working – velocity diagrams – ideal and actual work – stage pressure ratio - free vortex theory – performance curves and losses

UNIT III COMBUSTION CHAMBER 6

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, Scramjet and Pulsejet Engines and cycle analysis – thrust, specific impulse, specific fuel consumption, thermal and propulsive efficiencies.

TOTAL: 45 PERIODS

OUTCOMES

When a student completes this subject, he / she can

- Understand the design principles of the turbo machines
- Analyze the turbo machines to improve and optimize their performance

REFERENCES

1. Ganesan, V., Gas Turbines, Tata McGraw Hill, 2011.
2. Khajuria P.R and Dubey S.P., Gas Turbines and Propulsive Systems, Dhanpat Rai Publications, 2003
3. Cohen, H., Rogers, G F C and Saravanmotto, H I H, Gas Turbine Theory, John Wiley, 5th Edition 2001.
4. Hill P G and Peterson C R, Mechanics and Thermodynamics of Propulsion, Addition-Wesley, 1970.
5. Mattingly J D, Elements of Gas turbine Propulsion, McGraw Hill, 1st Edition. 1997

EY7073 ELECTRICAL DRIVES AND CONTROLS

L	T	P	C
3	0	0	3

OBJECTIVES

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

UNIT I CONVENTIONAL MOTOR DRIVES 9

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

UNIT II PHYSICAL PHENOMENA IN ELECTRICAL MACHINES 9

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

UNIT III SOLID STATE POWER CONTROLLERS **9**

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

UNIT IV SUPERCONDUCTIVITY **9**

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

UNIT V SOLID STATE MOTOR CONTROLLERS **9**

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

TOTAL: 45 PERIODS

OUTCOME

The student will be able to understand

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

REFERENCES

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

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

OBJECTIVES

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

UNIT I ENERGY SCENARIO **10**

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

UNIT II FORECASTING MODEL **10**

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

UNIT III OPTIMIZATION MODEL **10**

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

UNIT IV PROJECT MANAGEMENT 10

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

UNIT V ENERGY POLICY 5

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

TOTAL: 45 PERIODS

OUTCOME

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

REFERENCES

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

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

OBJECTIVES

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

UNIT I INTRODUCTION 8

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

UNIT II WATER POLLUTION 9

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

UNIT III AIR POLLUTION 10

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

UNIT IV SOLID & HAZARDOUS WASTE MANAGEMENT 11

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

UNIT V GLOBAL WARMING & CLIMATE CHANGE 7

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

TOTAL: 45 PERIODS

OUTCOME

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

REFERENCES

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

EY7076 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS L T P C
3 0 0 3

OBJECTIVES

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

UNIT I INTRODUCTION 9

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

UNIT II ELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION 9

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

UNIT III POWER CONVERTERS 9

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

uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-matrix converters. Power Quality Measurements.

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:

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

REFERENCES

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

EY7077 POWER GENERATION, TRANSMISSION AND DISTRIBUTION

L	T	P	C
3	0	0	3

OBJECTIVES

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

UNIT I CONVENTIONAL POWER GENERATION 12

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

UNIT II NON CONVENTIONAL POWER GENERATION 9

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

UNIT III ELECTRICAL POWER TRANSMISSION 9

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

UNIT IV UTILISATION OF ELECTRICAL ENERGY 9

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

UNIT V ECONOMICS OF POWER GENERATION & TRANSMISSION 6

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

TOTAL: 45 PERIODS

OUTCOME

The student will be able to understand

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

IC7071 COMPUTATIONAL FLUID DYNAMICS

L	T	P	C
3	0	0	3

OBJECTIVES

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

UNIT I GOVERNING DIFFERENTIAL EQUATIONS AND DISCRETISATION TECHNIQUES 8

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

UNIT II DIFFUSION PROCESSES : FINITE VOLUME METHOD 10

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

UNIT III CONVECTION - DIFFUSION PROCESSES : FINITE VOLUME METHOD 9

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

UNIT IV FLOW PROCESSES : FINITE VOLUME METHOD 8

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

UNIT V MODELLING OF COMBUSTION AND TURBULENCE 10

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

TOTAL: 45 PERIODS

OUTCOME:

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

REFERENCES:

1.Versteeg and Malalasekera, N, “An Introduction to computational Fluid Dynamics The Finite Volume Method,” Pearson Education, Ltd., Second Edition, 2014.

2.Ghoshdastidar, P.S., “Computer Simulation of Flow and Heat Transfer”, Tata McGraw Hill Publishing Company Limited, New Delhi, 1998.

3. Muralidhar, K., and Sundararajan, T., “Computational Fluid Flow and Heat Transfer”, Narosa Publishing House, New Delhi, 2003.

4. Subas and V. Patankar “Numerical heat transfer fluid flow”, Hemisphere Publishing Corporation,1980.

5. Jiyuan Tu, Guan Heng Yeoh, Chaogun Liu, “Computational Fluid Dynamics A Practical Approach” Butterworth – Heinemann An Imprint of Elsevier, Madison, U.S.A., 2008

6. John D. Anderson . JR. “Computational Fluid Dynamics The Basics with Applications” McGraw Hill International Editions, 1995

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