DEPARTMENT OF MECHANICAL ENGINEERING

Curriculum for M.E. Energy Engineering and Management (Full Time)

First Semester

Sl. No.	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits
1	PC-I	EEMC101	Advanced Numerical Methods	4		-	25	75	100	3
2	PC-II	EEMC102	Advanced Thermodynamics	4		-	25	75	100	3
3	PC-III	EEMC103	Fluid Mechanics and Heat Transfer	4		-	25	75	100	3
4	PC-IV	EEMC104	Waste Management and Energy Generation Techniques	4		-	25	75	100	3
5	PE-I	EEME105	Professional Elective - I	4		-	25	75	100	3
6	PE-II	EEME106	Professional Elective – II	4		-	25	75	100	3
7	PC Lab-I	EEMP107	Energy Laboratory - I		3	-	40	60	100	2
			Total	24	3	**-**	**190**	**510**	**700**	**20**

Second Semester

Sl. No.	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits
1	PC-V	EEMC201	Energy Conservation and Management	4		-	25	75	100	3
2	PC-VI	EEMC202	Energy Modeling, Economics and Project Management	4		-	25	75	100	3
3	PC-VII	EEMC203	Environmental Engineering and Pollution control	4		-	25	75	100	3
4	PC-VIII	EEMC204	Co-Generation and Waste Heat Recovery Systems	4		-	25	75	100	3
5	PE-III	EEME205	Professional Elective – III	4		-	25	75	100	3
6	PE-IV	EEME206	Professional Elective – IV	4		-	25	75	100	3
7	PC Lab-II	EEMP207	Energy Laboratory - II		3	-	40	60	100	2
8	Semin	EEMS208	Seminar		2	-	100	-	100	1
			Total	24	5	**-**	**290**	**510**	**800**	**21**

Third Semester

Sl. No.	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits
1	OE-I	EEME301	Open Elective I	4	-	-	25	75	100	3
2	OE-II	EEME302	Open Elective II	4	-	-	25	75	100	3
3	Thesis	EEMT303	Thesis Phase I and Viva Voce		-	4	40	60	100	4
4	Ind. Train	EEMI304	Industrial Training		-	*	100	-	100	2
			Total	8	**-**	**4**	**190**	**210**	**400**	**12**

Note: * - Four weeks during the summer vacation at the end of IInd Semester.

Fourth Semester

Sl. No.	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits
1	Thesis	EEMT401	Thesis Phase II and Viva Voce	-	-	8	40	60	100	12
			Total	**-**	**-**	**8**	**40**	**60**	**100**	**12**

L- Lecture ; **P-** Practical; **T-** Thesis; **CA-** Continuous Assessment; **FE-** Final Examination

DEPARTMENT OF MECHANICAL ENGINEERING
Curriculum for M.E. Energy Engineering and Management (Part Time)

First Semester

Sl. No.	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits	Equivalent Code
1	PC-I	PEEMC101	Advanced Numerical Methods	4		-	25	75	100	3	EEMC101
2	PC-II	PEEMC102	Advanced Thermodynamics	4		-	25	75	100	3	EEMC102
3	PC-III	PEEMC103	Fluid Mechanics and Heat Transfer	4		-	25	75	100	3	EEMC103
			Total	**12**			**75**	**225**	**300**	**9**	

Second Semester

Sl. No.	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits	Equivalent Code
1	PC-IV	PEEMC201	Waste Management and Energy Generation Techniques	4		-	25	75	100	3	EEMC104
2	PC-V	PEEMC202	Energy Conservation and Management	4		-	25	75	100	3	EEMC201
3	PC-VI	PEEMC203	Energy Modeling, Economics and Project Management	4		-	25	75	100	3	EEMC202
			Total	**12**			**75**	**225**	**300**	**9**	

Third Semester

Sl. No.	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits	Equivalent Code
1	PC-VII	PEEMC301	Environmental Engineering and Pollution control	4		-	25	75	100	3	EEMC203
2	PE-I	PEEME302	Professional Elective - I	4		-	25	75	100	3	EEME105
3	PE-II	PEEME302	Professional Elective – II	4		-	25	75	100	3	EEME106
4	PC Lab-I	PEEMP304	Energy Laboratory - I		3	-	40	60	100	2	EEMP107
			Total	12	3	**-**	**115**	**285**	**400**	**11**	

Fourth Semester:

Sl. No.	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits	Equivalent Code
1	PC-VIII	PEEMC401	Co-Generation and Waste Heat Recovery Systems	4		-	25	75	100	3	EEMC204
2	PE-III	PEEME402	Professional Elective – III	4		-	25	75	100	3	EEME205
3	PE-IV	PEEME403	Professional Elective – IV	4		-	25	75	100	3	EEME206
4	PC Lab-II	PEEMP404	Energy Laboratory - II		3	-	40	60	100	2	EEMP207
5	Semin	PEEMS405	Seminar		-	2	100		100	1	EEMS208
			Total	12	3	**-**	**215**	**285**	**500**	**12**	

Fifth Semester

Sl. No.	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits	Equivalent Code
1	OE-I	PEEME 501	Open Elective I	4	-	-	25	75	100	3	EEME 301
2	OE-II	PEEME502	Open Elective II	4	-	-	25	75	100	3	EEME302
3	Thesis	PEEMT503	Thesis Phase I and Viva Voce		-	4	40	60	100	4	EEMT303
4	Ind. Train	PEEMI504	Industrial Training		*	-	100		100	2	EEMI304
			Total	8	**-**	**4**	**190**	**210**	**400**	**12**	

Note: * - Four weeks during the summer vacation at the end of IVth Semester.

Sixth Semester:

Sl. No.	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits	Equivalent Code
1	Thesis	PEEMT601	Thesis Phase II and Viva Voce	-	-	8	40	60	100	12	EEMT401
			Total	**-**	**-**	**8**	**40**	**60**	**100**	**12**	

L- Lecture ; **P-** Practical; **T-** Thesis; **CA-** Continuous Assessment; **FE-** Final Examination

LIST OF ELECTIVES

PROFESSIONAL ELECTIVES

1. Measurements and Controls in Thermal Engineering
2. Energy Conversion Techniques
3. Solar Energy and Wind Energy
4. Bio Energy Conversion Technologies
5. Boiler Technology
6. Fluidized Bed Systems
7. Design of Heat Exchangers
8. Computational Heat Transfer
9. Energy Storage Technologies
10. Renewable Energy Systems
11. Biomass Energy- Conversion and Conservation Techniques
12. Biomass Gasification -Technology and Utilization

OPEN ELECTIVES

1. Nuclear Engineering
2. Fuels And Combustion
3. Hydropower Systems
4. I.T In Energy Management
5. Computational Fluid Dynamics
6. Numerical Analysis In Engineering
7. Biocomposite Materials
8. Nano Materials Technology
9. Applied Probability and Statistical Inferences
10. Neural Networks and Fuzzy Systems
11. Energy Management In Buildings

EEMC101	ADVANCED NUMERICAL METHODS	L	T	P
		4	0	0

COURSE OBJECTIVES:

- 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.

Algebraic Equations

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, Eigen value problems: power method, inverse power method, Faddeev–Leverrier Method.

Ordinary Differential Equations

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.

Finite Difference Method for Time Dependent Partial Differential Equation

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.

Finite Difference Methods for Elliptic Equations

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.

Finite Element Method

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

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.

COURSE OUTCOMES

Upon completion of this course, the students will be able to
1. Solve engineering problems numerically.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓		✓	✓		✓				

EEMC102	ADVANCED THERMODYNAMICS	L	T	P
		4	0	0

COURSE OBJECTIVES

- To achieve an understanding of basic principle and scope of thermodynamics.
- To predict the availability and irreversibility associated with the thermodynamic processes.
- To analyse the properties of ideal and real gas mixtures. Also to achieve an understanding of Statistical thermodynamics and Irreversible thermodynamics.

Availability Analysis and Thermodynamic Property Relations

Reversible work, Availability, Irreversibility and Second-Law Efficiency for a closed System and Steady-State Control Volume. Availability Analysis of Simple Cycles. Thermodynamic Potentials, Maxwell relations, Generalised relations for changes in Entropy, Internal Energy and Enthalpy, Generalised Relations for C_p and C_v, Clausius Clayperon Equation, Joule-Thomson Coefficient, Bridgman Tables for Thermodynamic relations.

Real Gas Behaviour and Multi-Component Systems

Different Equations of State, Fugacity, Compressibility, Principle of Corresponding States, Use of generlaised charts for enthalpy and entropy departure, fugacity co efficiency, Lee-Kesler generalized three parameter tables.

Fundamental property relations for systems of variable composition, partial molar properties, Real gas mixtures, Ideal solution of real gases and liquids, Activity, Equilibrium in multi phase systems, Gibbs phase rule for non-reactive components.

Statistical Thermodynamics

Microstates and Macrostates, Thermodynamic probability, Degeneracy of energy levels, Maxwell-Boltzman, Fermin-Dirac and Bose-Einstein Statistics, Microscopic Interpretation of heat and work, Evaluation of entropy, Partion function, Calculation of the Macroscopic properties from partition functions, Equilibrium constant statistical thermodynamics approach.

Irreversible Thermodynamics

Conjugate Fluxes and Forces, Entropy Production Onsager's Reciprocity relations, Thermo-electric phenomena, formulations, Power Generation, Refrigeration.

REFERENCES

1. Kenneth Wark Jr., Advanced Thermodynamics for Engineers, McGraw-Hill Inc.,1995.
2. Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Sons, 1988.
3. Holman,J.P., Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1988.
4. Smith, J.M. and Van Ness., H.C., Introduction to Chemical Engineering Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1987.
5. Sonntag, R.E., and Van Wylen, G, Introduction to Thermodynamics, Classical and Statistical, Third Edition, John Wiley and Sons, 1991.
6. Sears, F.W. and Salinger G.I., Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Third Edition, Narosa Publishing House, New Delhi, 1993.
7. DeHotf, R.T., Thermodynamics in Materials Science, McGraw- Hill Inc., 1993.

COURSE OUTCOMES

On successful completion of this course the student will be able to

1. Apply the law of thermodynamics to thermal systems.
2. Calculate the availability of the systems and cycles
3. Analyse the engineering systems to improve and optimize its performance

Mapping with Programme Outcomes										
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓	✓								
CO2	✓	✓								
CO3			✓		✓			✓	✓	✓

EEMC103	FLUID MECHANICS AND HEAT TRANSFER	L	T	P
		4	0	0

COURSE OBJECTIVES

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

Basic Equation, Potential Flow Theory and Boundary Layer Concept

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.

Incompressible and Compressible Flows

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

Conduction and Radiation Heat Transfer

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

Turbulent Forced Convective Heat Transfer

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.

Phase Change Heat Transfer and Heat Exchanger

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

REFERENCES

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 Mc Graw Hill, 2002.
6. Ghoshdastidar.P.S., Heat Transfer, Oxford University Press, 2004

COURSE OUTCOMES

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

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓			✓				✓		

EEMC104	**WASTE MANAGEMENT AND ENERGY GENERATION TECHNIQUES**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES

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

Solid Waste

Definitions - Sources, Types, Compositions, Properties of Solid Waste - Municipal Solid Waste - Physical, Chemical and Biological Property - Collection - Transfer Stations - Waste Minimization and Recycling of Municipal Waste

Waste Treatment

Size Reduction - Aerobic Composting - Incineration - Furnace Type & Design, Medical / Pharmaceutical Waste Incineration - Environmental Impacts - Measures to Mitigate Environmental Effects due to Incineration.

Waste Disposal

Land Fill Method of Solid Waste Disposal - Land Fill Classification, Types, Methods & Siting Consideration - Layout & Preliminary Design of Land Fills - Composition, Characteristics, generation, Movement and Control of Landfill Leachate & Gases - Environmental Monitoring System for Land Fill Gases.

Hazardous Waste Management

Definition & Identification of Hazardous Waste - Sources and Nature of Hazardous Waste - Impact on Environment - Hazardous Waste Control - Minimization and Recycling - Assessment of Hazardous Waste Sites - Disposal of Hazardous Waste, Underground Storage Tanks Construction, Installation & Closure Energy Generation from Waste: Types - Biochemical Conversion - Sources of Energy Generation - Industrial Waste, Agro Residues - Anaerobic Digestion - Biogas Production - Types of Biogas Plant.

Thermochemical Conversion

- Sources of Energy Generation - Gasification - Types of Gasifiers - Briquetting - Industrial Applications of Gasifiers - Utilization and Advantages of Briquetting - Environmental Benefits of Biochemical and Thermochemical Conversion

REFERENCES

1. Parker, Colin, & Roberts, Energy from Waste - An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985.
2. Shah, Kanti L., Basics of Solid & Hazardous Waste Management Technology, Prentice Hall, 2000.
3. Manoj Datta, Waste Disposal in Engineered Landfills, Narosa Publishing House, 1997.
4. Rich, Gerald et.al., Hazardous Waste Management Technology, Podvan Publishers, 1987.
5. Bhide AD., Sundaresan BB, Solid Waste Management in Developing Countries, INSDOC New Delhi, 1983.

COURSE OUTCOMES

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

1. Understand the waste characterization, segregation and disposal.
2. Familiarize the technologies that are available for effective waste disposal.
3. Understand the problem in a sensible and realistic manner.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓		✓			✓			✓	
CO2		✓		✓		✓				✓
CO3		✓			✓			✓	✓	

		L	T	P
EEMP107	**ENERGY LABORATORY - I**	**0**	**0**	**3**

COURSE OBJECTIVES

- To conduct the load test, speed test and Heat Balance Test of a single and double cylinder diesel engine.
- To evaluate the performance of steam boiler, turbine and condenser.
- To make the students understand the working principle of various types of governors, balancing systems, Cam analyzer, Torsional vibration of single rotor system, whirling speed concept, action of forces in gyroscope.

List of Experiments

1. Study and Performance test on Kaeser air compressor test rig.
2. Heat balance test and air fuel determination on a Diesel Engine
3. Effect of injection pressure on the performance and emission of Diesel Engine.
4. Determination of damping coefficient in damping torsional oscillation.
5. Experimentation of pressure processes station by PID control.

6. Demonstrate the gyroscopic effects and determination of gyroscopic couple.
7. Performance evaluation of loco type boiler.
8. Performance evaluation of Greenbat turbine with condenser.
9. Performance evaluation of reader vertical steam engine.

COURSE OUTCOMES

Upon completing this course, students should be able to:

1. Gain knowledge about the combustion principles.
2. Analyze the performance of steam boiler, turbine and condenser.
3. Supplement the principles learnt in kinematics and Dynamics of Machinery.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓	✓	✓				✓			
CO2	✓	✓					✓			✓
CO3	✓	✓					✓		✓	✓

		L	T	P
EEMC201	**ENERGY CONSERVATION AND MANAGEMENT**	**4**	**0**	**0**

COURSE OBJECTIVES

- Familiarizing with management, especially with management in energy sector engineering.
- Fundamentals of product strategy management. Studying methods of energy accounting and energy auditing in energy sector, industry and final consumption.
- Finding opportunities to increase the rational use of energy.

Introduction

Energy Scenario - Principles and Imperatives of Energy Conservation - Energy Consumption Pattern - Resource Availability - Role of Energy Managers in Industries Thermal Energy Auditing: Energy Audit - Purpose, Methodology with respect to Process Industries - Power Plants, Boilers etc. - Characteristic Method Employed in Certain Energy Intensive Industries - Various Energy Conservation Measures in Steam System - Losses in Boiler, Methodology of Upgrading Boiler Performance.

Energy Conservation in Pumps, Fans & Compressors, Air conditioning and refrigeration systems, Steam Traps - Types, Function, Necessity.

Role of Instrumentation in Energy Conservation

Total Energy Systems - Concept of Total Energy - Advantages & Limitations - Total Energy System & Application - Various Possible Schemes Employing Steam Turbines Movers Used in Total Energy Systems - Potential & Economics of Total Energy Systems.

Electrical Energy Auditing

Potential areas for Electrical Energy Conservation in Various Industries - Energy Management Opportunities in Electrical Heating, Lighting System, Cable Selection - Energy Efficient Motors - Factors Involved in Determination of Motor Efficiency- Adjustable AC Drives, Application & its use Variable Speed Drives Belt Drives.

Energy Management

Importance of Energy Management, Energy Economics - Discount Rate, Payback Period, Internal Rate of Return, Life Cycle Costing.

REFERENCES

1. CB Smith, Energy Management Principles, Pergamon Press, New York, 1981
2. Hamies, Energy Auditing and Conservation ; Methods, Measurements, Management & Case Study, Hemisphere, Washington, 1980.
3. Trivedi, PR, Jolka KR, Energy Management, Commonwealth Publication, New Delhi, 1997.
4. Witte, Larry C, Industrial Energy Management & Utilization, Hemisphere Publishers, Washington, 1988.
5. Diamant, RME, Total Energy, Pergamon, Oxford, 1970

COURSE OUTCOMES

The theory should be taught in such a manner that students are able to acquire different learning out comes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

1. Identify the demand supply gap of energy in Indian scenario.
2. Carry out energy audit of an industry/Organization.
3. Draw the energy flow diagram of an industry and identify the energy wasted or a waste stream.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1		✓							✓	✓
CO2		✓	✓		✓	✓				
CO3		✓		✓			✓	✓		✓

EEMC202	**ENERGY MODELLING, ECONOMICS AND PROJECT MANAGEMENT**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES

- To impart greater understanding of energy modeling in renewable energy technology.
- To throw light on the economic aspects involved in renewable energy technology.
- To enlighten the students on the various techniques involved in project management.

Models and Modeling Approaches

Macroeconomic Concepts - Measurement of National Output - Investment Planning and Pricing - Economics of Energy Sources - Reserves and Cost Estimation.

Input-Output Analysis

Multiplier Analysis - Energy and Environmental Input / Output Analysis - Energy Aggregation –Econometric Energy Demand Modeling - Overview of Econometric Methods.

Energy Demand Analysis and Forecasting

Methodology of Energy Demand Analysis - Methodology for Energy Technology Forecasting -Methodology for Energy Forecasting - Sectoral Energy Demand Forecasting.

Economics of Stand-alone Power Systems

Solar Energy - Biomass Energy - Wind Energy and other Renewable Sources of Energy - Economics of Waste Heat Recovery and Cogeneration - Energy Conservation Economics.

Project Management – Financial Accounting

Cost Analysis - Budgetary Control - Financial Management - Techniques for Project Evaluation.

REFERENCES

1. Munasinghe M., Meier P., “Energy Policy Analysis and Modeling”, Cambridge University Press, New York, 2008.
2. Spyros Makridakis, Steven C. Wheelwright, Rob J. Hyndman, “Forecasting Methods and Applications”, Wiley, Singapore, 2008.
3. James Stock, Mark Watson, “Introduction to Econometrics”, 2nd ed., Pearson Education, New Delhi, 2006.
4. Kurt Campbell, Jonathon Price, “The Global Politics of Energy”, The Aspen University, Washington, 2008.
5. Bob Shivley, John Ferrare, “Understanding Today's Electricity Business”, Enerdynamics, Laporte, 2010.
6. S.Makridakis, “ Forecasting method and applications”, Wiley,1983

COURSE OUTCOMES

At the end of this course, the students will be able to
1. Gain clear perspective on energy economy.
2. Forecast the energy demand and plan wisely.
3. Become excellent managers of the energy resources.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓	✓			✓				✓	
CO2		✓	✓					✓		✓
CO3			✓	✓	✓					✓

EEMC203	**ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES

To provide the engineering graduates with technical expertise in Environmental Engineering which enable to have a career and professional accomplishment in the public or private sector to

- Address the complexities of real life environmental engineering problems related to water supply, sewerage, sewage treatment, waste management, environmental impact assessment, industrial pollution prevention and control.
- Identify, formulate, analyze, and develop processes and technologies to meet desired environmental protection needs of society and formulate solutions that are technically sound, economically feasible, and socially acceptable.
- To impart knowledge on the principles and design of control of indoor/particulate/gaseous air pollutant and its emerging trends and also application of Industrial pollution prevention, cleaner technologies, industrial wastewater treatment and residue management.

Air Pollution

Sources and Effect - Acid Rain - Air Sampling and Measurement - Analysis of Air Pollutants -Air Pollution Control Methods and Equipments - Issues in Air Pollution Control.

Solid Waste Management

Sources and Classification - Characteristics of Solid Waste - Potential Methods of Solid Waste Disposal - Process and Equipments for Energy Recovery from Municipal Solid Waste and Industrial Solid Waste.

Water Pollution

Sources and Classification of Water Pollutants - Characteristics - Waste Water Sampling Analysis - Waste Water Treatment - Monitoring Compliance with Standards - Treatment, Utilization and Disposal of Sludge.

Other Types of Pollution

Noise Pollution and its Impact - Oil Pollution - Pesticides - Radioactivity Pollution - Prevention and Control.

Pollution from Thermal Power Plants and Control Methods

Instrumentation for Pollution Control - Water Pollution from Tanneries and Other Industries and their Control.

REFERENCES

1. Environmental Considerations in Energy Development, Asian Development Bank (ADB), Manila (1991)
2. G.Masters (2003): Introduction to Environmental Engineering and Science Prentice Hall of India Pvt Ltd, New Delhi.
3. H.S.Peavy, D.R.Rowe, G.Tchobanoglous (1985): Environmental Engineering-McGraw-Hill Book Company, New York.
4. H.Ludwig, W.Evans (1991): Manual of Environmental Technology in Developing Countries, .International Book Company, Absecon Highlands, N.J.

COURSE OUTCOMES

By the time of their graduation, the students are expected to be able to:

1. Have basic knowledge about environmental protection and operation of pollution control devices – design and conduct experiments, as well as interpreted data and communicate effectively.
2. Identify, formulate, and solve environmental engineering problems using the techniques, skills, and modern engineering tools necessary for environmental engineering practice.
3. Design systems, processes, and equipment for the control and remediation of water, air, and soil quality environment within realistic constraints of economic affordability and social acceptability.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓	✓								
CO2			✓		✓					✓
CO3							✓	✓		✓

EEME204	COGENERATION AND WASTE HEAT RECOVERY SYSTEMS	L	T	P
		4	0	0

COURSE OBJECTIVES

- To gain fundamental knowledge in energy generation, heat transfer in thermal engineering.
- To reduce the impact global warming for betterment of living things to serve healthy life.

Cogeneration

Introduction - Principles of Thermodynamics - Combined Cycles - Topping - Bottoming - Organic Rankine Cycles - Advantages of Cogeneration Technology

Application & Techno Economics of Cogeneration

Cogeneration Application in various Industries like Cement, Sugar Mill, Paper Mill etc. Sizing of Waste Heat Boilers - Performance Calculations - Part Load Characteristics. Selection of Cogeneration Technologies - Financial Considerations-Operating and Investments - Costs of Cogeneration.

Waste Heat Recovery

Introduction - Principles of Thermodynamics and Second Law - Sources of Waste Heat Recovery - Diesel Engines and Power Plant etc.

Waste Heat Recovery Systems, Applications & Techno Economics

Recuperators - Regenerators - Economizers - Plate Heat Exchangers - Waste Heat Boilers - Classification, Location, Service Conditions, Design Considerations, Unfired Combined Cycle - Supplementary Fired Combined Cycle - Fired Combined Cycle.Applications in Industries - Fluidized Bed Heat Exchangers - Heat Pipe Exchangers - Heat Pumps - Thermic Fluid Heaters Selection of Waste Heat Recovery Technologies - Financial Considerations - Operations and Investment Costs of Waste Heat Recovery.

Environmental Considerations

Environmental considerations for Cogeneration and Waste Heat Recovery - Pollution

REFERENCES

1. Charles H Butler, Cogeneration, McGraw Hill Book Co., 1984.
2. Horlock JH, Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford, 1987.
3. Institute of Fuel, London, Waste Heat Recovery, Chapman & Hall Publishers, London, 1963.
4. Sengupta Subrata, Lee SS EDS, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.
5. De Nevers, Noel., Air Pollution Control Engineering, Mcgraw Hill, New York, 1995.

COURSE OUTCOMES

1. The students will acquire fundamental knowledge in energy generation, heat transfer in thermal engineering.
2. Students will get the ability solve problems using mathematical concepts and to use modern engineering tools, software and equipment to analyze and solve complex engineering problems.
3. The students will be able to solve real world problems and reduce the impact global warming for betterment of living things to serve healthy life.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓		✓							
CO2			✓			✓	✓			
CO3	✓			✓					✓	

		L	T	P
EEMP207	**ENERGY LABORATORY - II**	**0**	**0**	**3**

COURSE OBJECTIVES

- To make the students understand the modes of heat transfer and to conduct the trails on various experiments to analyze the heat transfer parameters.
- To understand the working of refrigeration trainer and air conditioners.
- To study the basics of solar energy.

List of Experiments

1. Natural convection from vertical cylinder
2. Experiments on finned tube heat exchanger
3. Experiments on unsteady state heat transfer apparatus.
4. Determination of thermal conductivity of metal rod.
5. Experiments on composite wall apparatus
6. Performance test on central A/C plant
7. Performance test on vapor absorption refrigeration system
8. Performance test on Solar still
9. Performance test on Solar concentrator test rig.
10. Performance test on Solar cooker.

COURSE OUTCOMES

Upon completing this course, students should be able to:

1. Understand the behavior of a system at different operating conditions
2. Understand the usage of different refrigeration tools.
3. Learn the basics of solar energy, how to determine solar intensity, and how to estimate daily and annual solar energy potential at each location.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓	✓					✓			
CO2	✓					✓	✓			✓
CO3	✓	✓					✓		✓	✓

EEMT303	THESIS PHASE I AND VIVA VOCE	L	T	P
		0	4	0

COURSE OBJECTIVES

- To enhance the research and development activities of the students

COURSE OUTCOMES

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

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓	✓	✓	✓		✓		✓	✓	✓

EEMI304	INDUSTRIAL TRAINING	L	T	P
		0	*	0

COURSE OBJECTIVES:

- To train the students in the field work related the Mechanical Engineering and to have a practical knowledge in carrying out Structural field related works.
- To train and develop skills in solving problems during execution of certain works related to Manufacturing Engineering.

The students individually undergo a training program in reputed concerns in the field of Manufacturing Engineering during the summer vacation (at the end of second semester for full – time / fourth semester for part – time) for a minimum stipulated period of four weeks. At the end of the training, the student has to submit a detailed report on the training he had, within ten days from the commencement of the third semester for Full-time / fifth semester for part-time. The students will be evaluated by a team of staff members nominated by head of the department through a viva-voce examination.

COURSE OUTCOMES:

1. The students can face the challenges in the practice with confidence.

2. The student will be benefited by the training with managing the situation arises during the execution of works related to Manufacturing Engineering.

EEMT401	THESIS PHASE II AND VIVA VOCE	L	T	P
		0	8	0

COURSE OBJECTIVES

- To improve the student research and development activities.
- To improve presentation and report preparation skills.

COURSE OUTCOMES:

1. The students would apply the knowledge in solving problems, so as to give confidence to be creative, well planned, organized, coordinated project outcome of the aimed work.

Mapping with Programme Outcomes										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓	✓	✓	✓		✓		✓	✓	✓

PROFESSIONAL ELECTIVES

EEMEX0X	MEASUREMENTS AND CONTROLS IN THERMAL ENGINEERING	L	T	P
		4	0	0

COURSE OBJECTIVES

- To equip the students with necessary foundation for effectively analyzing and solving the problems associated in thermal engineering field.
- To deliver comprehensive education in thermal Engineering to ensure that the students have core competency to be successful in industry/ research laboratory and motivate them to pursue higher studies and research in interrelated areas.
- To encourage the students to take up real life and/or research related problems and to create innovative solutions of these problems through comprehensive analysis and designing.

Measurement Characteristics

Measuring instruments-static and dynamic characteristics - experimental error analysis- systematic and random errors- statistical analysis – Uncertainty- experimental planning and selection of measuring instruments.

Concepts of Instrumentation

Basic instruments for the measurement of temperature- torque-strain gauges- pressure- velocity-current-flow and level.

Measurements of Surface Temperature

Measurements of conductivity remote sensing of temperature- coefficient of conduction- insulating materials –convection and radiation - measurements of conduction in porus insulating material- measurement of pH value- Oxygen Concentration.

Gas Analysis

Measurements of Co_2, No_2, Co and hydrocarbons and So_2, Use of gas Chromatography - fuel analysis- Measurements of Smoke- Dust and Moisture.

Microprocessor Based Instrumentation and Data Logging System

Controllers and displays in power plants- pneumatic and electronic controls- typical control system in power plant control- loop interaction- nuclear reactor control systems.

REFERENCES

1. C.S.Rangan, G.R.Sharma, V.S.V.Mani, Instrumentation Devices and systems, Tata McGraw-Hill, New Delhi (1983).
2. J.P.Holman - Experimental methods for Engineers, McGraw-Hill (1988).
3. Doeblin, Measurment System Application and Design-McGraw-Hill(1978)
4. Barnery, Intelligent Instrumentation, Prentice Hall of India (1988)
5. http://www.eets.com
6. http://www.thermomax.com

COURSE OUTCOMES

1. Ability to acquire, apply and share in-depth knowledge in the area of thermal engineering.
2. Graduates will demonstrate skills to use modern engineering tools, software and equipment to analyze and solve complex engineering problems.
3. Graduate will acquire knowledge about current issues/advances in engineering practices.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓	✓				✓			✓	
CO2								✓		
CO3	✓				✓				✓	

		L	T	P
EEMEX0X	**ENERGY CONVERSION TECHNIQUES**	**4**	**0**	**0**

COURSE OBJECTIVES

- To analyze the pros and cons of conventional energy and direct energy conversion techniques for converting one form of energy to another.
- To study the various forms of energy conversion techniques and production of electrical energy.
- To understand the necessity of energy storage systems and the thermodynamic and kinetic principles of fuel cells.

Introduction

Energy - Classification – Sources – Utilization – Principle of energy conversion – Biomass - Solar energy.

Production of Thermal Energy and Mechanical Energy

Conversion of mechanical, electrical, electromagnetic and chemical energy-conversion of thermal energy – turbines – Electromechanical conversion.

Production of Electrical Energy

Conversion of Thermal energy into electricity - Chemical energy into Electricity – Electromagnetic energy into Electricity – Mechanical energy into Electricity.

Energy Storage Systems

Introduction - Storage of Mechanical energy, Electrical energy, Chemical energy, Thermal energy. Fuel Cells: Thermodynamic and kinetics of fuel cell processes – Fuel cell performance – Types of fuel cells – Advantages – Fuel cell applications.

Thermal Biomass Conversion

Combustion, pyrolysis, Gasification and Liquefaction-Biological Conversion-Methanol, Ethanol Production -Fermentation-Anaerobic Digestion Biodegradation and Biodegradability of Substrate.

REFERENCES

1. Archie.W.Culp, Principles of Energy Conversion, McGraw-Hill Inc., New York, (1991).
2. Kordesch. K and Simader. G, Fuel Cell and Their Applications, Wiley-Vch., Germany (1996).
3. Kettari. M.A, Direct Energy Conversion, Addison-Wesley Pub. Co, (1997).
4. Hart. A.B and Womack G.J, Fuel Cells: Theory and Application, Prentice Hall New York Ltd., London (1989).
5. http ://www.ovonic.com
6. http ://www.iiec.org
7. www.alternativepower.com

COURSE OUTCOMES

1. Awareness on the existence of various mechanisms for conversion of energy from one form to another and their merits, constraints.
2. Understand the production of electrical energy from different conversion methods.
3. Understand the working of various fuel cells, their relative advantages/disadvantages.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓								✓	
CO2			✓			✓				✓
CO3	✓						✓		✓	

EEMEX0X	**SOLAR ENERGY AND WIND ENERGY**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To understand and analyze the present and future energy demand of world and nation and techniques to exploit the available renewable energy resources such as solar, bio-fuels, wind power, tidal and geothermal effectively

Solar Radiation

Availability - Measurement and Estimation - Isotropic and an Isotropic Models - Introduction to Solar Collectors (Liquid Flat - Plate Collector, Air Heater and Concentrating Collector) and Thermal Storage - Steady State and Transient Analysis - Solar Pond - Solar Refrigeration.

Modeling of Solar Thermal Systems and Simulations in Process Design

Design of Active Systems by f-chart and Utilizability Methods - Water Heating Systems - Active and Passive - Passive Heating and Cooling of Buildings - Solar Distillation - Solar Drying.

Photovoltaic Solar Cell

P:N Junction - Metal - Schottky Junction, Electrolyte - Semiconductor Junction, Types of Solar Cells - their Applications - Experimental Techniques to determine the Characteristics of Solar Cells - Photovoltaic Hybrid Systems Photovoltaic Thermal Systems - Storage Battery - Solar Array and their Characteristics Evaluation - Solar Chargeable Battery.

Wind

Structure - Statistics - Measurements and Data Presentation - Wind Turbine Aerodynamics - Momentum Theories - Basic Aerodynamics - Airfoils and their Characteristics - HAWT-Blade Element Theory - Prandtl's Lifting Line Theory (prescribed wake analysis) - VAWT Aerodynamics - Wind Turbine Loads - Aerodynamic Loads in Steady Operation - Wind Turbulence - Yawed Operation and Tower Shadow.

Wind Energy Conversion System (WECS)

Siting - Rotor Selection - Annual Energy Output - Horizontal Axis Wind Turbine (HAWT) - Vertical Axis Wind Turbine - Rotor Design Considerations - Number of Blades - Blade Profile - 2/3 Blades and Teetering - Coning - Upwind/Downwind - Power Regulation - Yaw System - Tower - Synchronous and Asynchronous Generators and Loads - Integration of Wind Energy Converters to Electrical Networks - Inverters - Testing of WECS - WECS Control System - Requirements and Strategies - Miscellaneous Topics - Noise etc - Other Applications.

REFERENCES

1. L.L.Freris, Wind Energy Conversion Systems, Prentice Hall, 1990.
2. D.A.Spera, Wind Turbine Technology: Fundanental concepts of Wind Turbine Engineering, ASME Press.
3. S.P.Sukhatme-Solar Energy: principles of Thermal Collection and Storage, Tata McGraw-Hill (1984).
4. J.A.Duffie and W.A.Beckman-Solar Engineering of Thermal Processes-John Wiley (1991).
5. J.F.Kreider and F.Kreith-Solar Energy Handbook McGraw-Hill (1981).
6. http ://www.ises.ors
7. http :/www.windpower-monthly.com
8. www.solarpv.com

COURSE OUTCOMES

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

1. Know about the exploration of nonconventional energy resources and their effective tapping technologies.

2. Effective utilization of available renewable energy resources.
3. To acquire the knowledge of modern energy conversion technologies.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓	✓			✓	✓		✓		✓
CO2		✓				✓			✓	
CO3	✓			✓		✓		✓		

		L	T	P
EEMEX0X	**BIO ENERGY CONVERSION TECHNOLOGIES**	**4**	**0**	**0**

COURSE OBJECTIVES

- To pursue the various technologies for utilizing the bio-energy and its availability and conversion of bio-energy in the useful forms.
- Analyze elaborately the technologies available for conversion of biomass to energy in the technical update.
- Analyze the bio-energy conversion with respect to economical aspect and also in the environmental aspect.

Introduction of Biomass

Availability merits and demerits-Indian scenario-conversion mechanism- utilization of photo synthesis comparison with other energy.

Thermal Biomass Conversion

Combustion, pyrolysis, Gasification and Liquefaction-Biological Conversion-Methanol, Ethanol Production -Fermentation-Anaerobic Digestion Biodegradation and Biodegradability of Substrate.

Combustion

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.

Power Generation Techniques

Through Fermentation and Gasification-Biomass Production from different Organic Wastes-Effect of Additives on Biogas Yield-Biogas production from Dry Dung Cakes-Industrial Application-Viability of Energy Production-Wood Gasifier System, Operation of Spark Ignition and Compression Ignition with Wood Gas Operation and Wood Gas Operation and Maintenance.

Economics and Environmental Aspects

Energy Effectives and Cost Effectiveness-History of Energy Consumption and Cost – Environmental Aspects of Bio-energy Conversion.

REFERENCES

1. David Boyles, Bio Energy Technologies Thermodynamics and Costs, Ellis Hoknood,Chichester,1984.
2. Khandelwal KC, Mahdi SS, Biogas Technology-A Practical Handbook, Tata McGraw Hil,1986.
3. R.C. Maheswari, Bio Energy for Rural Energisation ,Concept Publication,1987.
4. Anthony San Pietro, Biochemical and Photosynthetic aspects of Energy Production, Academic Press, New York,1980.
5. EL-Halwagi MM, Biogas Technology: Transfer & Diffusion, Elsevier Applied SC, London 1986.
6. Tom B Reed ,Biomass Gasification-Principles and Technology, Noyce Data Corporation,1981.
7. Iyer PVR et al, Thermochemical Characterization of Biomass, M N E S.

COURSE OUTCOMES

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

1. Gain vast idea of the various form of biomass availability in the earth.
2. Get complete understanding of the various biomass energy conversion technologies, and its importance of these energies in the economical and environmental aspect towards and environmental aspect towards the present energy crisis.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓								✓	✓
CO2			✓			✓				

EEMEX0X	**BOILER TECHNOLOGY**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES

The course content should be taught with the aim to develop different types of skills so that students are able to acquire following competency:

- To apply basic concepts, laws and principles of Boiler design.
- To impart greater understanding of heat balance in Boiler for modern power plant.
- To throw light on the heat transfer aspects involved in boiler technology.
- To enlighten the students on the various techniques involved in the boiler code.

Introduction

Parameter of a Steam Generator - Thermal Calculations of a Modern Steam Generator - Tube Metal Temperature Calculation and Choice of Materials - Steam Purity Calculations and Water Treatment Heat balance: Heat transfer in Furnace - Furnace Heat Balance - Calculation of Heating Surfaces - Features of Firing Systems for Solid - Liquid and Gaseous Fuels - Design of Burners

Boiler Design

Design of Boiler Drum - Steam Generator Configurations for Industrial Power and Recovery Boilers - Pressure Loss and Circulation in Boilers

Design of Accessories

Design of Air Preheaters - Economisers and Superheater for High Pressure Steam Generators - Design Features of Fuel Firing Systems and Ash Removing Systems

Emission Aspects

Emission Control – Low NOx 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

Boiler code

IBR and International Regulations - ISI Code's Testing and Inspection of Steam Generator - Safety Methods in Boilers - Factor of Safety in the Design of Boiler Drums and Pressure Parts - Safety of Fuel Storage and Handling - Safety Methods for Automatic Operation of Steam Boilers

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, NewYork, 1983.
6. Richard Dolezal, Large Boiler Furnaces, Elsevier Publishing Company, 1980 .
7. Power Plant Familiarization NPTI Manual, Govt. of India New Delhi.

COURSE OUTCOMES

At the end of this course, the students will be able to

1. Gain the ability of engineering design calculations in boiler technology.

2. Attain knowledge of modern technology in boiler accessories design and heat balance calculation.
3. Become excellent managers of the boiler code.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓	✓				✓		✓		✓
CO2	✓			✓					✓	
CO3	✓	✓		✓	✓		✓			

EEMEX0X	**FLUIDIZED BED SYSTEMS**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES

- To understand the design principles and applications of fluidized bed systems.
- To introduce the concepts of fluidization and heat transfer in fluidized beds.

Fluidized Bed Behaviour

Fluidization Phenomena - Regimes of Fluidized Bed Behaviour - Characterization of Fluidized Particles - Two Phase and Well Mixed Theory of Fluidization - Solids Mixing - Particle Entrainment and Carryover.

Heat Transfer

Different Modes of Heat Transfer in Fluidized Bed - Use of Immersed Tubes - Finned Tubes - Heat Recovery Systems.

Combustion and Gasification

Fluidized Bed Combustion and Gasification, Pressurized Systems, Sizing of Combustion and Gasification Systems, Start-up Methods, Fast Fluidized Beds, Different Modes of Heat Transfer in Fluidized Beds.

System Design

Design of Distributors, Fluidized Bed Furnaces for Fossil and Agricultural Fuels, Fluidized Bed Heat Recovery Systems, Fluid Bed Dryers.

Industrial Applications

Sulpher Retention - Nitrogen Emission Control - Furnaces, Dryers, Heat Treatment, etc. Pollution Control and Environmental Effects - Cost Analysis

REFERENCES

1. Howard, J.R., Fluidized Bed Technology: Principles and Applications, Adam Hilger, New York, 1983.
2. Geldart, D, Gas Fluidization Technology, John Wiley & Sons, New York, 1986.
3. Howard, J.R. (Ed), Fluidized Beds : Combustion and Applications, Applied Science Publishers, New York 1983.
4. Yates, J.G. Fundamentals of Fluidized bed Chemical Processes, Butterworths, 1983.
5. Reed, T.B., Biomass Gasification : Principles and Technology, Noyes Data Corporation, New Jersey, 1981.

COURSE OUTCOMES

Upon completion of the course, the students will be able to
1. Understand the working principles, merits and limitations of fluidized bed systems.
2. Apply fluidized bed systems for a specific engineering application.
3. Analyze the fluidized bed system to improve and optimize its performance.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓	✓							✓	
CO2		✓				✓				✓
CO3	✓			✓		✓		✓		

EEMEX0X	**DESIGN OF HEAT EXCHANGERS**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES

- To expose the student to perform the energy transfer analysis on the all types of heat exchangers.
- To impart the knowledge about phase changes-Special application to Condensers and Evaporators.
- To understand and solve the real life industrial problems for heat exchanger design and optimization.

Constructional Details and Heat Transfer

Types - Shell and Tube Heat Exchangers - Regenerators and Recuperators - Industrial Applications Temperature Distribution and its Implications - LMTD - Effectiveness

Flow Distribution and Stress Analysis

Effect of Turbulence - Friction Factor - Pressure Loss - Channel Divergence Stresses in Tubes - Heater Sheets and Pressure Vessels - Thermal Stresses - Shear Stresses - Types of Failures

Design Aspects

Heat Transfer and Pressure Loss - Flow Configuration - Effect of Baffles - Effect of Deviations from Ideality - Design of Typical Liquid - Gas-Gas-Liquid Heat Exchangers

Condensors and Evaporators Design

Design of Surface and Evaporative Condensors - Design of Shell and Tube - Plate Type Evaporators

Cooling Towers

Packings - Spray Design - Selection of Pumps - Fans and Pipes - Testing and Maintenance - Experimental Methods

REFERENCES

1. T. Taborek, G.F. Hewitt and N.Afgan, Heat Exchangers, Theory and Practice, McGraw Hill Book Co., 1980.
2. Walker, Industrial Heat Exchangers - A Basic Guide, McGraw Hill Book Co., 1980.
3. Nicholas Cheremisioff, Cooling Tower, Ann Arbor Science Pub 1981.
4. Arthur P.Fraas, Heat Exchanger Design, John Wiley & Sons, 1988
5. Donald Q Kern, Process Heat Transfer, Tata McGraw Hill, 2008.
6. http ://www.thermomax.com
7. http ://www.tata.com
8. http ://www.altalevel.com

COURSE OUTCOMES

1. The student will be able to perform the energy transfer in the all types of heat exchangers.
2. The student with engineering equation solver and its use in heat exchanger design.
3. The student to do energy transfer analysis for research and develop energy effective systems.

Mapping with Programme Outcomes										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓						✓		✓	
CO2				✓		✓				✓
CO3			✓		✓			✓		✓

EEMEX0X	COMPUTATIONAL HEAT TRANSFER	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To impart fundamental mathematical concepts related to computational heat transfer.
- To impart fundamental mathematical concepts about fluid flow and heat transfer.
- To train students in the usage of computational codes and develop new ones.

Mathematical Description of Physical Phenomena

Governing Differential Equation - Energy Equation - Momentum Equation - Nature of Co-ordinates - Discretization Methods

Finite Difference Methods in Partial Differential Equations

Parabolic Equations - Explicit, Implicit and Crank Nicholson Methods. Finite Differences in Cartesian and Polar Co-ordinates. Local Truncation Error - Consistency Convergence - Stability - ADI Methods. Elliptic Equations - Laplace's Equation. Laplace's Equation in a Square - Non-rectangular Regions - Mixed Boundary Condition - Jacobi - Gauss-siedel and SOR Methods. Necessary and Sufficient Conditions for Iterative Methods Finite Difference

Applications in Heat Condition and Convection

Control Volume Approach - Steady and Unsteady One Dimensional Conduction - Two and Three Dimensional Situations - Solution Methodology. Convection and Diffusion: Upwind Scheme - Exponential Scheme. Hybrid Scheme - Power Law Scheme : Calculation of the Flow Field - Simpler Algorithm.

Finite Element Method Concept

General Applicability of the Method using one dimensional heat transfer equation - Approximate Analytical Solution - Raleigh's Method. Galerikin Method, Solution Methods

Finite Element Method Packages

General Procedure - Discretisation of the domain - Interpolation Polynomials - Formulation of Element Characteristic Matrices and Vectors - Direct, Variational and Weighted - Residual Approach - Higher Order Isoparametric Element Formulations Conduction and Diffusion Equations - Heat Transfer Packages - Heat 2, HEATAX, RADIAT, ANSYS

REFERENCES

1. Suhas V.Patnakar, Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corporation, 1980.
2. Jaluria and Torrance, Computational Heat Transfer - Faluria and Torrance, Hemisphere Publishing Corporation, 1986.
3. A.R.Mitchell and D.F.Grifths, Finite Difference Method in Partial Differential Equations, John Wiley & Sons, 1980
4. S.S.Rao, The Finite Element Methode in Engineering, Pergamon Press - 1989
5. O.C. Zienkiewicz & R.L.Taylor, The Finite Element Method IV Edition - Vol. I & II, McGraw Hill International Edition, 1991
6. www.fluent.com
7. http ://chtol.mech.unsw.edu.au

COURSE OUTCOMES

1. The students will acquire fundamental knowledge in mathematical related to computational heat transfer in thermal engineering.
2. Students will get the ability solve problems using mathematical concepts.
3. The students will be able to solve real world problems using numerical methods.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓		✓							✓
CO2			✓				✓		✓	
CO3	✓			✓						✓

EEMEX0X	**ENERGY STORAGE TECHNOLOGIES**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES

- Student will be able to demonstrate and apply in depth technical knowledge of engineering in design and operation of various thermal systems.
- Develop the students to enrich their wise through their cognitive skill.
- Student will be able to understand the need for, and an ability to engage in life-long learning and continual updating of professional skills.

Energy Storage Need of energy storage

Different modes of Energy Storage. Potential energy: Pumped hydro storage; KE and Compressed gas system: Flywheel storage, compressed air energy storage; Electrical and magnetic energy storage: Capacitors, electromagnets; Chemical Energy storage: Thermo-chemical, photo-chemical, bio-chemical, electro-chemical, fossil fuels and synthetic fuels. Hydrogen for energy storage.

Electrochemical Energy Storage Systems Batteries

Primary, Secondary, Lithium, Solid-state and molten solvent batteries; Lead Lead acid batteries; Nickel Cadmium Batteries; Advanced Batteries. Role of carbon nano-tubes in electrodes.

Magnetic and Electric Energy Storage Systems

Superconducting Magnet Energy Storage(SMES) systems; Capacitor and Batteries: Comparison and application; Super capacitor: Electrochemical Double Layer Capacitor (EDLC), principle of working, structure, performance and application, role of activated carbon and carbon nano-tube.

Sensible Heat Storage

SHS mediums; Stratified storage systems; Rock-bed storage systems; Thermal storage in buildings; Earth storage; Energy storage in aquifers; Heat storage in SHS systems; Aquifers storage. Solar Ponds for energy storage. Green house heating.

Latent Heat Thermal Energy Storage

Phase Change Materials (PCMs); Selection criteria of PCMs; Stefan problem; Solar thermal LHTES systems; Energy conservation through LHTES systems; LHTES systems in central air-conditioning systems; Energy Storage Food preservation; Waste heat recovery; Solar energy storage;

REFERENCES

1. H.P.Garg et al, D Reidel (1885) “Solar Thermal Energy Storage”, Publishing Co.
2. V Alexiades & A.D.Solomon(1993) “Mathematical Modeling of Melting and Freezing Proces” , Hemisphere Publishing Corporation,
3. WashingtonNarayan R, Viswanath B(1998), Chemical and Electro Chemical Energy System, Universities Press
4. A.Ter-Gazarian(1994), “Energy Storage for Power Systems”, Peter Peregrinus Ltd.London
5. B.Kilkis and S.Kakac (1989),”Energy Storage Systems”,(Ed),KAP,London,1989
6. http ://www.arcon.dk
7. http ://www.tata.com

COURSE OUTCOMES

1. Able to understanding of principles and technologies for thermal storage system, application and utilization.
2. Able to identify, formulate and solve simple to complex troubles of thermal storage systems, conversion and storage.
3. Able to identify and understand components and their function.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓					✓		✓		
CO2		✓		✓			✓		✓	
CO3	✓		✓			✓				✓

EEMEX0X	RENEWABLE ENERGY SYSTEMS	L	T	P
		4	0	0

COURSE OBJECTIVES

- To acquire knowledge of technical competency combined with research to generate innovative solutions in Energy engineering.
- To be acquainted with a variety of options in energy sources.
- To prepare the students to exhibit a high level of professionalism, integrity, environmental and social responsibility, and life-long independent learning ability.

Introduction

World energy use-reserves of energy resources-energy cycle of the earth-environmental aspects of energy utilisation-renewable energy resources and their importance.

Solar Energy

Introduction -extraterrestrial solar radiation -radiation at ground level-collectors-solar cells-applications of solar energy- Biomass Energy-Introduction-Biomass Conversion-Biogas Production- Ethanol Production-Pyrolysis and Gasification-Direct Combustion-

Applications

Wind, Geo thermal and Hydro Energy Sources: Introduction-basic theory-types of turbines-applications-Geothermal Energy-Introduction-geothermal resource types-resource base-applications for heating and electricity generation- Hydropower-introduction-basic concepts-site selection-types of turbines-small scale hydropower.

Tidal Energy

Introduction-origin of tides-power generation schemes-Wave Energy-Introduction-basic theory-wave power devices.

Other Renewable Energy Sources: Introduction-Open and Closed OTEC cycles-biophotolysis-Ocean Currents-Salinity Gradient Devices-Environmental Aspects-Potential impacts of harnessing the different renewable energy resources.

REFERENCES

1. A. Duffie and W.A. Beckmann, Solar Engineering of Thermal Processes-John Wiley (1980).
2. F.Kreith and J.F. Kreider, Principles of Solar Engineering, McGraw-Hill (1978).
3. T.N.Veziroglu, Alternative Energy Sources,Vol 5 and 6,McGraw- Hil (1978).
4. http ://www.solstice.crest.orgl
5. http ://www.res-.ltd-com
6. www.mnes.mic.in
7. www.ireada.org
8. http://sundancepower.com

COURSE OUTCOMES

1. An ability to acquire, apply and share in depth knowledge in the area of Energy Engineering and Management.
2. An ability to conduct independent research and generate knowledge for the benefit of mankind.
3. An ability to apply engineering and scientific principles for the effective management of energy systems.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓				✓				✓	
CO2		✓	✓		✓			✓		✓
CO3		✓			✓	✓				

EEMEX0X	**BIOMASS ENERGY- CONVERSION AND CONSERVATION TECHNIQUES**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES

- To learn the present biomass energy scenario and the importance of energy conversion.
- To learn the biomass, biomethanation, gasification, pyrolysis and carbonization.
- To analysis different routes of biomass conversion and methods of characterization.

Origin of Biomass

Generation and utilization- Properties of biomass-Agriculture Crop & Forestry residues used as fuels. Biomass: Types – Advantages and drawbacks, Biochemical, Thermo-chemicalConversion- Combustion and Gasification. Biomass gasifiers and types. Applications of Gasifiers to thermal power and Engines.Biomass as a decentralized power generation source for villages Concept of Bio-energy. Characterization of biomass (Proximate analysis and Ultimate analysis) - Indian scenario – Characteristics – Carbon neutrality – Conversion mechanisms – Fuel assessment studies.

Biomass Production and Conversion

Biomass Production: Introduction- Wastelands- Classification and their use through energy plantation- Selection of species-Methods of field preparation and transplanting. Harvesting of biomass. Biomass Conversion: Different routes of conversion of biomass such as Physical: cutting-Sizing, drying and storage of wood- Twigs and other biomass. Biochemical-Conversion of biomass-Sugar- starch and cellulose into alcohol- Biodiesel. Thermo chemical- Direct combustion- improved cookstoves- Briquetting of biomass- pyrolysis- gasification. Biomass Characterizations: Physio-chemical characteristics of biomass- Calorific values of solid- Liquid and Gaseous fuels.

Biomethanation and Combustion

Bio-Chemical Conversion: Aerobic and Anaerobic conversion phases in biomass production- Fermentation etc. Bio-fuels: Importance- Production and applications. Bio-fuels: Types of Bio-fuels, Production processes and technologies - Bio fuel applications- Ethanol as a fuel for I.C. engines. Combustion : Perfect- Complete and incomplete – Equivalence ratio – Fixed Bed, Fluid Bed – Fuel and Ash handling – Steam cost comparison with conventional fuels. Briquetting: Types of Briquetting – Merits and demerits – Feed requirements and preprocessing – Advantages – Drawbacks.

Gasification

Types – Comparison – Application – Performance evaluation – Economics – Dual fuel engines –100 % Gas Engines – Engine characteristics on gas mode – Gas cooling and cleaning train. Gas producer – Types - Operating principle. Gasifier fuels- Properties-preparation-Conditioning of producer gas. Application-Shaft power generation- Thermal application-economics.

Pyrolysis and Carbonization

Plant operation- Product recovery- Incineration and Plant lay out. Types – Process governing parameters – Thermo gravimetric analysis – Differential thermal analysis – Differential scanning calorimetry – Typical yield rates.

REFERENCES

1. Biomass Renewable Energy – D.O.hall and R.P. Overeed (John Wiley and Sons, New york, 1987).
2. Biomass Gasification Principles and Technology, Energy technology review No. 67, - T.B. Read (Noyes Data Corp. 1981).
3. G.D. Rai. Non-Conventional Energy Sources, Kh Publishers, New Delhi.
4. Rathore N. S., Panwar N. L, Kothari S., Biomass Production and Utilization Technology. Himanshu Production, 2007.
5. Vimal, O. P. and Bhatt, M.S., Wood Energy System, Agricole, Pub. New Delhi.
6. Best Practises Manual for Biomass Briquetting, I R E D A, 1997.
7. David Boyles, Bio Energy Technology Thermodynamics and costs, Ellis Hoknood Chichester, 1984. Khandelwal KC, Mahdi SS, Biogas Technology – A Practical Handbook, Tata McGraw Hill, 1986.

COURSE OUTCOMES

After successful completion of this course, the students should be able to
1. To understand the generation and utilization of various biomass.
2. To gain knowledge in the concept of biomass – proximate and ultimate analysis.
3. To study the various biomass conversion - biomethanation, gasification and pyrolysis.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓		✓			✓		✓		
CO2	✓	✓				✓				✓
CO3	✓				✓	✓		✓	✓	

EEMEX0X	BIOMASS GASIFICATION -TECHNOLOGY AND UTILIZATION	L	T	P
		4	0	0

COURSE OBJECTIVES

- To learn about the different types biomass technology.
- To study the origin and developments of gasification system.
- To learn the various types of gasifier, purification, cooling system and impact on environment.
- To learn the properties of gaseous fuel from woody biomass and application as engine fuel.

Introduction

Overview of gasification technology-Biomass as gasification fuel- Gasification for energy supply- Gasification history and development- Gasification process-Producer gas and its constituents-Hazards with producer gas. Suitability of Bio mass fuels: Charcoal-Wood-Sawdust-Peat-Agricultural residues.

Biomass Technology

Biological Conversion- Bioconversion mechanism, sources of wastes undergoing biotreatment, biogas. Energetics and rate processes of major biological significance. Bioconversion of substrates into alcohols, organic acids, solvents, amino acids, antibiotics etc. Thermochemical Conversion: - Conversion to solid, liquid and gaseous fuels. Pyrolysis, gasification, energy balance and the economics.

Gasifiers, Gas Cleaning and Cooling

Gasifiers- Up draught Gasifiers -Down draught Gasifiers -Twin-fire Gasifiers - Cross draft Gasifiers -Fluidized bed gasifiers & Other Gasifiers. Theory of Gasification: Prediction of the gas composition, Gasifier Efficiency. Gas Cleaning and Cooling: Cleaning dust from the gas- Gas cooling. Health and Environmental hazards associated with the use of producer gas: Toxic hazards-Fire hazards- Explosion hazards- Environmental hazards.

Impact of Fuel Properties on Gasification and Drive Engines

Gasification fuels-Need for selection of the right gasifier for each fuel-Energy content of the fuel- Moisture content of the fuel- Voltaile matter content of the fuel-ash content and ash chemical composition-Reactivity of the fuel-Particle size and distribution-Bulk density of the fuel- Charring properties of the fuel- Assessment of the suitability of various types of biomass as gasifier fuel.
Producer gas drive engines- Performance of gasifier- engine system- Operational difference between diesel and gasoline engine- Conversion of gasoline engine to produce gas-Conversion of diesel engine to producer gas- Conditions of producer gas- Engine power output using producer gas- Gas quality requirements for trouble free operation.

Technologies for Biomass Utilisation

Biomass utilisation strategy - Applications to be serviced - Biomass classification and - properties Gasification- Combustion vs Gasification - Woody biomass gasifier (thermal and electric)-Pulverised fuel gasifier (thermal and electric) - Engine operation - Technologies available-Production of fuel gas-production of mechanical or Electrical power in stationary installations.-Mobile applications.

REFERENCES

1. P.F. Stan Bury and A. Witalker, 'Principles of Fermentation Technology, Pergamo Press,1984.
2. H. D. Kumar Biotechnology, 1991.
3. Tom B Reed, Biomass Gasification – Principles and Technology, Noyce Data Corporation, 1981.
4. D.O. Hall, G.N. Barnard, and P.A. Moss, Biomass for Energy in the Developing Countries, Current Roles, Potential, Problems, Prospects, Pergamon, Press Ltd. 1990
5. L.P. White, L.G. Claskett, Biomass as Fuel, Academic Press, 1981
6. T.B. Real, Biomass Gasification Principles and Technology, Energy Technology Review,No.67, Hoyes Data Corporation, U.S.A.1981.
7. Microbial Technology, Fermentation Technology, Edited by Peppler and Perlman, Vol. I and II, Academic Press.

COURSE OUTCOMES

Upon completion of the course, students will be able to

1. Understand biomass gasification technology.
2. Learn different types of gasifier and purification systems.
3. Gain knowledge on different fuel properties and their impact on gasification.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓		✓			✓			✓	
CO2		✓	✓			✓		✓		✓
CO3	✓					✓			✓	

OPEN ELECTIVES

EEMEX0X	NUCLEAR ENGINEERING	L	T	P
		4	0	0

COURSE OBJECTIVES

- To acquire knowledge of technical competency combined with research to generate innovative solutions in Energy engineering
- To be acquainted with a variety of options in energy sources.
- To prepare the students to exhibit a high level of professionalism, integrity, environmental and social responsibility, and life-long independent learning ability

Review of nuclear physics

Nuclear equations – Energy from nuclear reactions and fission – Thermal neutrons – Nuclear cross-sections. Nuclear Reactions: Mechanism of Nuclear Fission and Fusion - Nuclides – Radioactivity - Decay chains-Neutron flux distribution is cores – slowing down – Neutron life cycle.

Reactor Materials

Nuclear Fuel cycles - Characteristics of Nuclear Fuels - Uranium -Production and Purification of Uranium - Conversion to UF4 and UF6 - Other Fuels like Zirconium, Thorium - Berylium- Reactor heat generation and removal – Heat flow in and out of solid fuel elements – Axial temperature distribution of coolant and fuel element – Hot spot factors – Absorption of core radiation._Heat removal in slabs subjected to radiation – Thermal shields – Quality and void fractions in non-flow and flow systems – Boiling reactor hydraulics.

Boiling water reactor

Controlled Recirculation fluidized bed reactor – Gas cooled reactors – Radioactivity of gas coolants – Analysis of gas – steam cycle – simple and dual pressure cycle – Pebble bed reactors.

Liquid metal cooled reactors

Compatibility with materials – Types of Fast Breeding Reactors - Design and Construction of Nuclear reactors_– Fluid fueled reactors – types – corrosion and erosion characteristics – Safety aspects. Separation of Reactor Products - Nuclear reprocessing – PUREX-UREX – TRUEX – FLOUREX .

Waste Disposal and Radiation Protection

Types of Nuclear Wastes - Safety Control and Pollution Control

REFERENCES

1. El-Wakil M.M., Nuclear Power Engineering, McGraw-Hill Book Co., New York, 1985.
2. Loftness, Nuclear Power Plants.
3. P.K.Nag, Power Plant Engineering, Tata McGraw Hill Book Co., New Delhi, 2001.

4. S. Glasstone and A. Sesonske, Nuclear Reactor Engineering (3rd Edition), Von Nostrand, 1981.
5. J.R. Lamarsh, Introduction to Nuclear Reactor Theory, Wesley, 1966

COURSE OUTCOMES

1. Able to acquire, apply and share in depth knowledge in the area of Nuclear physics and reactor materials.
2. Gain knowledge about different types of reactors and ore materials of uranium and thorium.
3. An ability to apply knowledge about nuclear reprocessing, Waste Disposal and Radiation Protection methods.

EEMEX0X	FUELS AND COMBUSTION	L	T	P
		4	0	0

COURSE OBJECTIVES

- To learn different type of conventional and non conventional fuel with their properties, methods to analysis of fuel, Energy conversion techniques in detail.
- To learn the combustion process of conventional and non conventional fuels, able to calculate the necessary air requirement for combustion process.
- To acquire knowledge in the areas of ignition, Flame study and details of burners to develop combustion process.

Introduction

General, Conventional Energy Sources, Solar Energy, Nuclear Power, Energy from Biomass, Wind Power, Tidal Power, Geothermal Energy, Energy Survey of India, Rocket Fuels,

Solid & Liquid Fuels

General, Family of Coal, Origin of Coal, Gasification of Coal, Analysis and Properties of Coal, Classification of Coal, Oxidation of Coal, Hydrogenation of Coal, Efficient use of Solid Fuel. Renewable Solid (biomass) Fuel, Solid Fuel Handling and Storage. Origin and Classification of Petroleum, Refining and Other Conversion Processes, Composition of Petroleum with respect to Combustion, Property & Testing of Petroleum Products, Various Petroleum Products, Liquid Fuels from Other Sources, Storage and Handling of Liquid Fuels, Liquid Fuels Combustion Equipment

Gaseous Fuels

Types of Gaseous Fuels, Natural Gases, Methane from Coal Mines, Manufactured Gases, Producer Gas, Water Gas, Carburetted Water Gas, Blast Furnace Gas, Biogas, Refinery Gas, LPG, Cleaning and Purification of Gaseous Fuels.

Theory of Combustion Process and Stoichiometry

Combustion Thermodynamics, Stoichiometry Relations, Rapid Methods of Combustion Stoichiometry, Theoretical Air Required for Complete Combustion, Mass Basis and Volume Basis

Calculation of Minimum Amount of Air Required for a Fuel of known Composition, Calculation of Dry Flue Gases if Fuel Composition is Known, Calculation of the Composition of Fuel, Excess Air Supplied and Amount of Exhaust gases.

Burner Design

Ignition, Concept of Ignition, Auto Ignition, Ignition Temperature, Flame, Flame Propagation, Flame Front, Various Methods of Flame Stabilization, Concepts of Burner, Basic Features and Types of Solid, Liquid and Gaseous Fuel Burners - Different Types of Coal - Oil and Gas Burners, Recuperative & Regenerative Burners.

REFERENCES

1. Samir Sarkar, Fuels & Combustion, 2nd Edition, Orient Longman, 1990
2. Bhatt ,vora Stoichiometry, 2nd Edition, Tata Mcgraw Hill, 1984
3. Blokh AG, Heat Transfer in Steam Boiler Furnace, Hemisphere Publishing Corpn, 1988
4. Civil Davies, Calculations in Furnace Technology, Pergamon Press, Oxford, 1966
5. Sharma SP, Mohan Chander, Fuels & Combustion, Tata Mcgraw Hill, 1984 EIA

COURSE OUTCOMES

Upon completion of the course, students will be able to

1. Evaluate the properties of conventional and non conventional fuel, and to describe, compare, cost, availability, various advantages and disadvantages for further continued usage of each fuel.
2. Understand the complete combustion process of each fuel, ability to calculate the stoichiometry, theoretical and actual air requirement for the combustion process.
3. Understand the concepts of ignition characteristics, Flame, Flame propagation and Flame front in detail.

<table>
<tr><td rowspan="2">EEMEX0X</td><td rowspan="2">HYDROPOWER SYSTEMS</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td>4</td><td>0</td><td>0</td></tr>
</table>

COURSE OBJECTIVES

- To learn and understand the various hydropower systems and its concepts.
- To Prepare energy audit and cost analysis of hydropower systems and to Design, Develop and construction of hydropower systems.
- Maintenance of power station and its reservoirs.
- Development of Software for Hydropower System Analysis.

Overview of Hydropower Systems - List of Major Hydro Power Stations in India and other countries-Preliminary Investigation - Determination of Requirements - Basic Factors - Project Feasibility - Load Prediction and Planned Development -Preparation of hydropower energy audit reports- Cost analysis of Hydroelectric Power.

Layout of Hydroelectric Power Plants- Essential components of the power house-Development of Prototype Systems: Advances in Planning, Design and Construction of Hydro Electric Power Stations.

Trends in Development of Generating Plant and Machinery - Plant Equipment for Pumped Storage Schemes - Some aspects of Management and Operation –uprating and refurbishing of turbines

Power Station Operation and Maintenance: Governing of Water Turbines - Function of Turbine Governor - Condition for Governor Stability - Surge Tank Oscillation and Speed Regulative Problem of Turbine Governing in Future.

Reservoir maintenance-Civil Engineering works - Mechanical maintenance of reservoirs-Maintenance of Electrical and instrumentation Works.
Development of Software: Computer Aided Hydropower System Analysis - Design - Execution - Testing - Operation and Control and Monitoring of Hydropower Services.

REFERENCES

1. L.Monition, M.Lenir and J.Roux, Micro Hydro Electric Power Station (1984).
2. AlenR.Inversin, Micro Hydro Power Source Book (1986)
3. Tyler G.Hicks (1988), Power Plant Evaluation and Design.
4. www.tva.gov/power
5. indianpowersector.com/power-station/hydro-power-plant
6. mnre.gov.in/schemes/grid-connected/small-hydro

COURSE OUTCOMES

The students graduates will
1. Acquire the knowledge of various hydropower systems and its concepts.
2. Enable to prepare energy audit reports and cost analysis of hydropower systems.
3. Able to Design, Develop and construction of hydropower systems.
4. Basic knowledge of maintenance in power station and its reservoirs.
5. Attain motivation to develop new software for hydropower system analysis.

		L	T	P
EEMEX0X	**I.T IN ENERGY MANAGEMENT**	**4**	**0**	**0**

COURSE OBJECTIVES

- To introduce various programming languages.
- To learn the principle of data base management system.

Introduction to Computer Application

Programming languages-Introduction to Visual C++, C-Programming Design-Computer Organization.

Introduction to Computer Based Information System

Types of CBIS-Relationship among CBIS systems concepts and CBIS- general systems theory-Energy Management concepts and CBIS.

Data Base Management System

Intelligence based systems - energy data bases-networking -time sharing concepts.

Software Engineering

The need for and scope of software engineering -survey of software life cycle models-Transform theory of software performance-network model of structured programs.

Computer based Monitoring and Online Control Systems

Data acquisition systems-expert based systems for energy management-Parallel Processing Concepts-Typical applications in energy management area.

REFERENCES

1. Herbert Schildt-C/C++ Programmer's reference (2000), McGraw- Hill, New York.
2. David McMahon, Rapid Application Development With Visual C++(1999), McGraw-Hill, New York.
3. Gerrit Blaauw, Frederick Brooks, (1997), Computer Architecture: Concepts and Evolution, Addison Wesley.
4. Ian Sommerville, Software Engineering, 5/e, University of Lancaster, England (1996), Addison Wesley.
5. Peter Jackson, Introduction to Expert Systems, 3/e, Addison Wesley (1998).
6. Peter Rob, Databases: Design, Development and Deployment with student CD (Pkg), McGraw-Hill, New York (1999).
7. http://www.emd.dk
8. http://www.esd.uk
9. www.energymanagementsys.com

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:
1. Acquire the knowledge of need and scope of software engineering.
2. Understand the programming languages.
3. Learn the principle of data base management system.

<table>
<tr><td rowspan="2">EEMEX0X</td><td rowspan="2">COMPUTATIONAL FLUID DYNAMICS</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td>4</td><td>0</td><td>0</td></tr>
</table>

COURSE OBJECTIVES

Graduates are able to:
- Learn the physical significance of computational fluid dynamics as a design and research tool through derivation of governing equations.
- Understand to linearization of given mathematical behavior of flow field by finite difference method and obtain solution by numerical methods.
- Learn the implementation of FDM and numerical techniques in simple field behavior problems.

Philosophy of computational fluid dynamics

CFD as a research tool, CFD as a design tool, applications. Governing equations, their derivation, physical meaning and presentation of forms suitable to CFD.

Models of flow, continuity, momentum and energy equations, Navier- Stokes equation, Euler equation, physical boundary conditions. Mathematical behavior of partial differential equations, discrimination, finite differences, explicit and implicit approaches.

Grids with appropriate transformation

Transformation of equations, stretched grids, adaptive grids, mesh generation.

Simple CFD techniques

The Lax-Wendroff Technique, MacCormack's technique, relaxation technique, the alternating direction implicit technique, pressure correction method Leap frog and Crank Nicolsan method, upwind schemes

Some applications

Numerical solution of Quasi one-dimensional nozzle flows, incompressible coutte flow.

REFERENCE BOOKS

1. Computational Fluid Dynamics, J.D.Anderson, Jr., McGraw-Hill, International Edition, 1995.
2. Numerical method for Scientific & Engineering, Joe D HoffMan, McGraw-Hill 2001.
3. Numerical method for Scientific & Engineering, Peter A.Stark, McGraw-Hill 1992.
4. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 1995.
5. Ghoshdasdidar, P.S., "Computer Simulation of flow and heat transfer" Tata McGraw Hill Publishing Company Ltd., 1998.
6. Bose, T.X., "Numerical Fluid Dynamics" Narosa Publishing House, 1997.

COURSE OUTCOMES

At the end of course, the graduates have ability to:

1. Describe the signification of flow field in energy engineering which imparts the knowledge of design and research as tool.
2. Formulate the linear equation of complex field behavior of mathematical governing equations through finite difference method solved by numerical techniques.
3. Handle multidisciplinary task of work and used as modern engineering tools by the application of software which continues the updating of professional skills.

EEMEX0X	NUMERICAL ANALYSIS IN ENGINEERING	L	T	P
		4	0	0

COURSE OBJECTIVES

- To understand the significance of numerical analysis in solving engineering problems.
- To understand the basic concepts of mathematical modeling.

Functional Approximation

Interpolation - divided difference, finite difference, Lagrangian, Chebychev, Hermite, Spline interpolations. Least squares methods - Orthogonal polynomial approximations, fourier approximations, fast fourier transforms. Types of errors - introduction to error analysis.

Numerical Calculus

Numerical differentiation. Numerical integration - Newton Cote's formulas, Gaussian quadrature formulas, adaptive quadrature. Solution of a system of linear equations - Gaussian elimination, Crout's method, Cholesky's method, Potter's, iterative methods.

Eigen value problems

Power and inverse power methods, Householder method, simultaneous iteration method, Lanczo's method.

Solution of Differential Equations

Initial Value problems - Euler's method, Runge-Kutta methods, Variable step methods. Boundary value problems - shooting method.

Unconstrained optimisation

Single variable minimization, multivariate minimization - direct search methods, gradient Introduction to constrained optimisation.

REFERENCES

1. Ralston and Rabinouitz.P, "A first course in Numerical Analysis", McGraw Hill, 1978.
2. Hildebrand F.B., "Introduction to Numerical Analysis", Tata McGraw Hill, 1974.
3. Mathews, "Numerical Methods in Engineering and Science", PHI, 1995.
4. Rao S.S., "Optimization Techniques", Wiley Eastern 1984.
5. Buchanan & Turner, "Numerical Methods and Analysis", McGraw Hill, 1992.
6. Ramamurthy. V., "Computer Aided Mechanical Design and Analysis", Tata McGraw Hill, 1992.

COURSE OUTCOMES

Upon completion of the course, the students will be able to
1. Understand the common numerical methods used in engineering analysis
2. Estimate the amount of error inherent in different numerical methods.
3. Assess the efficiency of a selected numerical method when more than one option is available to solve a certain class of problem.

EEMEX0X	BIOCOMPOSITE MATERIALS	L	T	P
		4	0	0

COURSE OBJECTIVES

- To impart an in-depth knowledge on Biocomposite materials, types, production processing and the structural development in Biocomposite materials.

Introduction to Composite Materials – Definition – Types of composites - Conventional materials and their limitations – Strong fibres – Types – Styles of reinforcement – Scope for reinforcement of conventional materials – Applications of composites.

Fibers – Types – Glass fibers, Carbon fibers, Aramid fibers, Extended chain polyethylene fibers, Natural fibers, Boron fibers, Ceramic fibers. Matrix – Types – Polymer matrix, Thermoplastic and Thermoset polymers – Selection of matrix – Metal matrix – Ceramic matrix. Thermoset matrix – Epoxy, Polyester, Vinyl Ester, Bismaleimides, Polyimides, Cyanate ester. Thermoplastic matrix – Polyether ether ketone, Polyphenylene sulfide, Polysulfone, Thermoplastic polyimide's. Fiber surface treatments – Fillers and other additives. Incorporation of fibers into matrix – Fiber content, density and void content - Fiber architecture.

Manufacturing of fiber reinforced composites – fundamentals – Bag molding process, Compression molding, Pultrusion, Liquid composite molding processes and other manufacturing processes. Manufacturing processes for thermoplastic matrix composites – Cured composite part.

Mechanical properties of composites – Basic mechanical properties – Effect of damage on the mechanical properties – Brittle vs Ductile materials – Strengthening. Durability and Degradation of Materials – Corrosion resistance – Elevated temperature resistance – Fatigue resistance – Mechanical fatigue and thermal fatigue – Durability.

Thermal Properties of Composites – Thermal expansion – Specific heat – Phase transformations – Thermal conductivity – Thermal conductance of an Interface – Evaluating the thermal conduction – Uses.

REFERENCES

1. Engineering Composite Materials, Bryan Harris, The Institute of Materials, London, 1999.
2. Fiber Reinforced Composites Materials, Manufacturing and Design, P.K. Mallick, CRC Press, Taylor & Francis Group, Boca Raton, FL, Third Edition, 2008.
3. Composite Materials Science and Applications, Deborah D. L. Chung, Springer-Verlag London Limited, Second Edition, 2010.

4. Principles of the Manufacturing of Composite Materials, Suong V. Hoa, DEStech Publications, Inc. U.S.A. 2009.
5. Composites, Volume 21 of ASM Handbook, ASM International, 2001.

COURSE OUTCOMES

Upon completion of the course, the student will be able to

1. Gain knowledge about Bio-composites.
2. Understand the various methods of producing bio composites.
3. Able to engage in lifelong learning.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓		✓						✓	
CO2	✓	✓			✓	✓				✓
CO3								✓	✓	✓

		L	T	P
EEMEX0X	**NANO MATERIALS TECHNOLOGY**	**4**	**0**	**0**

COURSE OBJECTIVES

- This course has been designed in such a way that to provide in depth knowledge on nano materials fabrication methods, characterization techniques and application of nano materials.

Introduction to nano technology

Scientific revolutions - Types of nanotechnology and nanomachines - The periodic table - Atomic structure - Molecules and phases - Energy - Molecular and Atomic Size, Surfaces and Dimensional space - Atoms by inference - Scanning probe microscopy: atomic force microscope - Scanning tunneling microscope – Nanomanipulator, Nanotweezers - Atom Manipulation - Nanodots - Self assembly - Dip pen nanolithography.

Nanopowders and Nanomaterials

Classification of nano materials - Properties of nano materials - characteristics of nano particulate materials; Production Methods: Top down approach - mechanical milling, Chemical Etching, Electro explosion, Sputtering, Laser ablation; Bottom up approach Plasma spraying, Chemical vapour deposition, Sol Gels, Laser pyrolosis, Atomic or molecular condensation.

Characterisation and Detection Techniques

Atomic structure and chemical composition: spectroscopic methods, vibrational spectroscopies, Nuclear magnetic resonance, X-ray and UV spectroscopies, X-ray and neutron diffraction. Determination of size, shape and surface area: Electron microscopes, BET and pycnometry, Ephiphaniometer, Laser granulometries and Zeta potential, Elliptically polarised light scattering; Determination of nanoparticles in aerosols and in biological tissues

Applications of Nanomaterials

New forms of carbon - Types of Nanotubes - Formation of Nanotubes - Assemblies Purification of carbon nanotubes - Properties of Nanotubes - Uses of Nanotubes : electronics, hydrogen storage, materials, mechanical machines - Space elevators. Application of Nanomaterials : insulation materials, machine tools, batteries, high power magnets, motor vehicles and aircraft, medical implants and other medical uses, Nanocomposites and Nanowires.

Applications of Nanotechnology

Nanotechnology in industries - Nanotechnology in computing: quantum computing and molecular computation - Nanotechnology in electronics: computational nanotechnology and optoelectronics, mechanical nanocomputers, super computing systems Nanotechnology in health and life sciences: drug delivery, drug encapsulation, tissue repair and implantation, biorestorable materials - Nanotechnology in smart materials: sensors and smart instruments, ageless materials, nanoparticle coatings.

REFERENCES

1. Nanotechnology: Basic Science and Emerging Technologies, Michael Wilson and Geoff Smith, Chapman and Hall, London, 2002.
2. Industrial application of nanomaterials - chances and risks, Wulfgang Luther, Future Technologies Division, Germany, 2004.
3. Nanotechnology: Applications and Trends, J.Schulte, John Wiley and Sons, 2005.
4. Nanotechnology, G.L.Timp, Springer-Verlog, New York, 1999.
5. Handbook of Nanotechnology, Editor: B.Bhushan,Springer Verlog, New York, 2004.

COURSE OUTCOMES

Upon completion of the course, the student will be able to

1. Gain knowledge about Nano Materials`
2. Understand the various methods of fabricating Nano Materials
3. Able to engage in lifelong learning.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓		✓						✓	
CO2	✓	✓			✓	✓				✓
CO3								✓	✓	✓

EEMEX0X	APPLIED PROBABILITY AND STATISTICAL INFERENCES	L	T	P
		4	0	0

COURSE OBJECTIVES

- To introduce the different techniques in applied probability and statistics, that have engineering and technological applications.

Introduction to probability theory – Random variable – Probability density and distribution functions – Standard distributions: Geometric, Hypergeometric, Binomial, Poisson, Normal, Log-Normal, Exponential, Gamma, Beta and Weibull distributions – Applications – Baye's Theorem – Chebysev's Theorem.

Sampling distributions of statistical parameters – Standard error – central limit theorem – t, F and Chi-square distributions - Estimation – Point estimation - Interval estimation for population means, standard deviation, proportion, difference in mean, ratio of standard deviations, proportions - Maximum likelihood estimation, least square estimation and bayesian estimation.

Testing of Hypothesis - Parametric test – small samples – Tests concerning proportion, means, standard deviations – Test based on Chi-square, goodness of fit and test of independence.

Non-parametric test – run test, sign test, U-test, H-test and kolmogorov-Smirnov (k-s) test – spearman rank correlation coefficient test.

Experimental designs – completely randomised blocks– Latin square – Analysis of variance – Methods for one, two factor models, concepts of factorial design, fractional factorial design, response surface methods and central composite designs.

REFERENCES

1. Probability and Statistics for Engineers, Irwin Miller & John Freund. E, PHI, 1987.
2. Applied Statistics and Probability for Engineers, Montgomery D.C & Runger G.C., John Wiley and Sons, USA, 1994.
3. Engineering Statistics, Bowker and Libermann, PHI, 1990.
4. Statistics for Management, Richard Levin.I. PHI, 1988.
5. Introduction to Statistics, Ronald E. Walpole, Macmillan Inc., New York, 1982.
6. Introduction to Probability and Statistics for Engineers and Scientists, Walter Rosenkorantz. A, McGraw Hill, 1997.

COURSE OUTCOMES

1. Acquire basic knowledge in statistics.
2. The student will able to acquire the basic concepts of Probability and Statistical techniques for solving real life problems and Engineering problems.

Mapping with Programme Outcomes										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	✓	✓				✓				✓
CO2		✓		✓		✓			✓	

<table>
<tr><td rowspan="2">EEMEX0X</td><td rowspan="2">NEURAL NETWORKS AND FUZZY SYSTEMS</td><td>L</td><td>T</td><td>P</td></tr>
<tr><td>4</td><td>0</td><td>0</td></tr>
</table>

COURSE OBJECTIVES

- The objective is to increase machine IQ by overlapping the dynamic system, adaptive control, Statistics with probability and mathematical logic.

Introduction to Fuzzy Logic Principles

Basic concepts of Fuzzy Set theory - Operations of Fuzzy sets - Properties of Fuzzy sets - Crisp relations - Fuzzy relational equations - operations on Fuzzy Relations Fuzzy systems - Propositional Logic - Inference Predicate Logic - Inference in Predicate Logic - Fuzzy Logic Principles - Fuzzy Quantifiers - Fuzzy Inference – Fuzzy rule based systems – Fuzzification and Defuzzification – types.

Advanced Fuzzy Logic Applications

Fuzzy Logic Controllers - principles - Review of Control systems theory -Various industrial applications of FLC - Adaptive Fuzzy systems - Fuzzy Decision making Multi objective Decision making - Fuzzy Classification – c Means Clustering -Fuzzy pattern Recognition - Image processing applications - Syntactic Recognition - Fuzzy optimization - Various Fuzzy measures.

Introduction to Artificial Neural Networks

Fundamentals of Neural Networks - Model of an Artificial Neuron - Neural network Architectures – Learning methods - Taxonomy of Neural network Architectures Standard Back propagation Algorithms - Selection of various-parameters - Variations - Applications of Back Propagation Algorithms.

Other JANN Architectures

Associative Memory - Exponential BAM - Associative Memory for Real Coded Pattern Pairs - Applications Adaptive Resonance Theory - Introduction - ART 1 - ART2 - Applications - Neural Networks based on Competition - Kohenen Self Organizing Maps - Learning vector Quantization - Counter Propagation Networks Industrial Applications.

Recent Advances

Fundamentals of Genetic Algorithms - Genetic Modeling - Hybrid systems - Integration of Fuzzy Logic, Neural Networks and Genetic Algorithms - Non Traditional Optimization Techniques like Ant Colony Optimization, Particle -Swam Optimization and Artificial, Immune Systems - Applications in Design and Manufacturing.

REFERENCES

1. S. Rajasekaran, G.A. Vijayalakshimi, " Pai Neural Networks, Fuzzy Logic and Genetic Algorithms", Prentice Hall of India Private limited, 2003.
2. Klir.G, Yuan.B.B, "Fuzzy sets and Fuzzy Logic", Prentice Hall of India Private limited, 1997.
3. Timothy J.Ross,"Fuzzy Logic with Engineering Applications". McGraw Hill, 1995.

4. ZuradaJ .M, "Introduction to Artificial of Neural Systems", Jaico Publishing House, 1994.
5. Laurence Fausett, "Fundamentals of Neural Networks", Prentice Hall. 1992.
6. Gen, M. and R.Cheng," Genetic Algorithm and I I Engineering Design", John Wiley, 1997.

COURSE OUTCOMES

Upon completion of the course, the student will be able to
1. Comprehend the concepts of feed forward neural networks.
2. Analyze the various feedback networks.
3. Understand the concept of fuzziness involved in various systems and fuzzy set theory.

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	✓					✓			✓	
CO2		✓						✓		✓
CO3								✓		✓

EEMEX0X	ENERGY MANAGEMENT IN BUILDINGS	L	T	P
		4	0	0

COURSE 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.

Introduction

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

Landscape and Building Envelopes

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.

Heat Transmission in Buildings

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.

Passive Cooling

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 airtunnel. Hybrid methods.

Renewable Energy in Buildings

Introduction of renewable sources in buildings, Solar water heating, small wind turbines, stand-alone PV systems, Hybrid system – Economics.

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
4. Smith, CB Energy Management Principles, Pergamon Press, NewYork, 1981.

COURSE OUTCOMES

Upon completion of the course, the student will be able to

1. Perform energy audit in any type for buildings and suggest the conservation measures.
2. Provide the renewable energy systems for the buildings

Mapping with Programme Outcomes										
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1				✓		✓			✓	
CO2		✓		✓	✓	✓				✓