

UNIVERSITY OF MUMBAI



New M. E. Programme
Programme: M. E. (Mechanical Engineering)
Energy Systems and Management

(As per Credit Based Semester and Grading System with effect
from the academic year 2014-2015)

Program Structure for ME (Mechanical Engineering): Energy Systems and Management Semester I

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract.	Theory	Pract.	Total
EMC101	Advanced Thermodynamics & Heat Transfer ^{&}	04	--	04	--	04
EMC102	Energy Scenario, Policy and Environment	04	--	04	--	04
EMC103	Conventional Power Plants	04	--	04	--	04
EME101X	Elective I	04	--	04	--	04
EME102X	Elective II	04	--	04	--	04
EML101	Laboratory I – Modeling and Simulation Lab	--	02	--	01	01
EML102	Laboratory II -Renewable Energy Lab [#]	--	02	--	01	01
Total		20	04	20	02	22

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract. /Oral	Total
		Internal Assessment			End Sem.Exam.				
		Test1	Test 2	Avg.					
EMC101	Advanced Thermodynamics & Heat Transfer ^{&}	20	20	20	80	--	--	100	
EMC102	Energy Scenario, Policy and Environment	20	20	20	80	--	--	100	
EMC103	Conventional Power Plants	20	20	20	80	--	--	100	
EME101X	Elective I	20	20	20	80	--	--	100	
EME102X	Elective II	20	20	20	80	--	--	100	
EML101	Laboratory I – Modeling and Simulation Lab	--	--	--	--	25	25	50	
EML102	Laboratory II - Renewable Energy Lab [#]	--	--	--	--	25	25	50	
Total		--	--	100	400	50	50	600	

Course Code	Elective I	Course Code	Elective II
EME1011	Fuels, Combustion and Emission Control	EME1021	Utilization of Solar Energy [#]
EME1012	Uncertainty and Error Analysis [#]	EME1022	Computational Fluid Dynamics [%]
EME1013	Energy Systems, Modeling and Analysis [@]	EME1023	Biomass Energy Engineering
EME1014	Energy Measurement and Control Instruments	EME1024	Environmental Engineering & Pollution Control [#]

[&] Common for Thermal Engineering, Energy Engineering and Energy Systems and Management

[#] Common for Thermal Engineering and Energy Systems and Management

[@] Common for Energy Engineering and Energy Systems and Management

[%] Common for Machine Design, Automobile Engineering, CAD/CAM and Robotics, Energy Engineering and Energy Systems and Management

Semester II

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract.	Theory	Pract.	Total
EMC201	Energy Planning Management and Audit	04	--	04	--	04
EMC202	Cogeneration and Waste Heat Recovery	04	--	04	--	04
EMC203	Non Conventional Power Plants	04	--	04	--	04
EME203X	Elective III	04	--	04	--	04
EME204X	Elective IV	04	--	04	--	04
EML201	Laboratory III – Energy Audit Lab [@]	--	02	--	01	01
EML202	Laboratory IV - Measurement & Virtual Instrumentation Lab [§]	--	02	--	01	01
Total		20	04	20	02	22

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract. /Oral	Total
		Internal Assessment			End Sem. Exam.				
		Test1	Test 2	Avg.					
EMC201	Energy Planning Management and Audit	20	20	20	80	--	--	100	
EMC202	Cogeneration and Waste Heat Recovery	20	20	20	80	--	--	100	
EMC203	Non Conventional Power Plants	20	20	20	80	--	--	100	
EME201X	Elective III	20	20	20	80	--	--	100	
EME202X	Elective IV	20	20	20	80	--	--	100	
EML201	Laboratory III – Energy Audit Lab [@]	--	--	--	--	25	25	50	
EML202	Laboratory IV - Measurement & Virtual Instrumentation Lab [§]	--	--	--	--	25	25	50	
Total		--	--	100	400	50	50	600	

Course Code	Elective III	Course Code	Elective IV
EME2031	Nuclear Power Plants	EME2041	Hydrogen Energy
EME2032	Control System Design	EME2042	Diagnostic Maintenance Techniques*
EME2033	Heat Exchanger Design [§]	EME2043	Boiler Technology
EME2034	Steam and Gas Turbine [§]	EME2044	Emerging Bio Fuel Technologies

[§] Common for Thermal Engineering and Energy Systems and Management

[§] Common for Machine Design, Automobile Engineering, Thermal Engineering and Energy Systems and Management

* Common for Machine Design and Energy Systems and Management

@ Common for Energy Engineering and Energy Systems and Management

Semester III

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned				
		Theory	Pract.		Theory	Pract.	Total		
EMS301	Seminar	--	06		--	03	03		
EMD301	Dissertation I	--	24		--	12	12		
Total		--	30		--	15	15		
Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract. /Oral	Total
		Internal Assessment			End Sem.Exam.				
		Test1	Test 2	Avg.					
EMS301	Seminar	--	--	--	--	50	50	100	
EMD301	Dissertation I	--	--	--	--	100	--	100	
Total		--	--	--	--	150	50	200	

Semester IV

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned				
		Theory	Pract.		Theory	Pract.	Total		
EMD401	Dissertation II	--	30		--	15	15		
Total		--	15		--	15	15		
Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract. /Oral	Total
		Internal Assessment			End Sem.Exam.				
		Test1	Test 2	Avg.					
EEMP401	Dissertation II*	--	--	--	--	100	100	200	
Total		--	--	--	--	100	100	200	

* The Term Work and Oral of Project II of Semester IV should be assessed jointly by the pair of Internal and External Examiners

Note- The Contact Hours for the calculation of load of teacher are as follows

Seminar - 01 Hour / week / student

Project I and II - 02 Hour / week / student

Course Code	Course Name	Credits
EMC101	ADVANCED THERMODYNAMICS & HEAT TRANSFER^{&}	04

Module	Detailed Contents	Hrs.
01	State postulate for Simple System and equation of state, Ideal gas equation, Deviation from ideal gas, Equation of state for real gases, generalized Compressibility chart, Law of corresponding states, Phase change process of pure substances, PVT surface, P-v & P- T diagrams, Use of steam tables and charts in common use	08
02	2nd law Analysis for engineering systems, T-ds relations, entropy generation, thermo electricity, Onsager equation. Exergy analysis of thermal systems, Thermodynamic Property Relations, Partial Differentials, Maxwell relations, Clapeyron equation,	08
03	Statistical Thermodynamics- Fundamentals, equilibrium distribution, Significance of Lagrangian multipliers, Partition function, Calculations of macroscopic properties from partition function, partition function for an ideal monatomic gas, equipartition of energy, Maxwell-Boltzman statistics, Bose Einstein statistics, Fermi-Dirac statistics	08
04	Three dimensional heat conduction equation, conduction with moving boundaries, porous media heat transfer, Analytical solutions for temperature distribution, Numerical methods for fin analysis. Transient Conduction: Lumped capacitance and its validity, General lumped capacitance analysis, spatial effects. Problems related with conventional geometries.	08
05	Radiation in gases and vapour, Principle of Fluid flow and Convective heat transfer, Dimensionless parameters & physical significance, Reynolds analogy, Chilton-Colburn analogy, Heat transfer enhancement, Passive, active and compound Techniques	08
06	Phase change heat transfer and heat exchanger: condensation with shear edge on bank of tubes, Boiling - pool and flow boiling, Heat exchanger, E-NTU approach and design procedure, compact heat exchangers.	08

[&]Common for Thermal Engineering, Energy Engineering and Energy Systems and Management

References:

1. Sonntag, R.E., and Van Wylen, G, Introduction to Thermodynamics, Classical and Statistical, John Wiley and Sons,
2. Cengel Y.A. & Boles M.A., Thermodynamics an Engineering Approach, TMH
3. Rao, Y.V.C., Postulational and Statistical Thermodynamics, Allied Publisher Limited, New Delhi
4. Kalyan Annamalai & Ishwar K Puri, Advanced Thermodynamics Engineering, CRC Press London
5. Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons
6. Patankar. S.V. Numerical heat Transfer and Fluid flow, Hemisphere Publishing Corporation
7. J.P. Holman- Heat transfer, Mc Graw Hill, Int.

8. S.P. Sukhatme, Heat transfer, University Press
9. Bejan A & Kraus A, Heat Transfer Handbook, John Wiley & Sons
10. Moran and Shapiro -- Fundamentals of Engineering Thermodynamics, John Wiley & Sons
11. Bejan A, Advanced engineering thermodynamics, John Wiley and Sons

Assessment:

Internal Assessment: Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Course Code	Course Name	Credits
EMC102	ENERGY SCENARIO, POLICY AND ENVIRONMENT	04

Module	Detailed Contents	Hrs.
01	<p>Global Energy Scenario : Role of energy in economic development and social transformation, Energy &GDP, GNP and its dynamics. Energy sources and overall energy demand and availability, Energy Consumption in various sectors and its changing pattern, Exponential increase in energy consumption and projected future demands. Non Conventional and Conventional Energy Resources: Coal, Oil, Natural Gas, Nuclear Power and Hydroelectricity, Solar, wind and other renewable etc. Depletion of energy sources and impact on exponential rise in energy consumption on economies of countries and on international relations. Energy Security, Energy Consumption and its impact on environmental climatic change</p>	11
02	<p>Indian Energy Scenario Energy resources & Consumption, Commercial and noncommercial forms of energy, Fossil fuels, Renewable sources including Bio-fuels in India and their utilization pattern in the past, present and future projections of consumption pattern, Sector wise energy consumption. Impact of Energy on Economy, Development and Environment, Energy for Sustainable Development, Energy and Environmental policies, Need for use of new and renewable energy sources, present status and future of nuclear and renewable energy, Energy Policy Issues related Fossil Fuels, Renewable Energy, Power sector reforms, restructuring of energy supply sector, energy strategy for future.</p>	10
03	<p>International Energy Policies of G-8 Countries, G-20 Countries, OPEC Countries, EU Countries. International Energy Treaties (Rio, Montreal, Kyoto), INDO-US Nuclear Deal. Future Energy Options, Sustainable Development, Energy Crisis.</p>	08
04	<p>Energy Conservation Act-2001 & its features, Electricity Act-2003 & its features. Frame work of Central Electricity Authority (CEA), Central & States Electricity Regulatory Commissions (CERC & ERCs)</p>	
05	<p>Energy Policy Global energy issues, National & State level energy issues, National & State energy policy, Industrial energy policy, Energy security, Energy vision. Energy pricing & Impact of global variations. Energy productivity (National & Sector wise productivity).</p>	10
06	<p>Environment Concept of environment and ecology, various natural cycles in environment and ecology, effect of human activities on environment and ecology. Environmental Impact Assessment, Methodologies for environmental pollution prevention. Rules, regulations, laws etc. regarding environmental protection, pollution prevention and control, waste disposal etc. Role of government, semi/quasi govt. and voluntary organizations.</p>	09

References:

1. Jose Goldemberg, A K N Reddy, Thomas Johnsson, Energy for a sustainable world, Princeton University
2. B V Desai, Energy policy, Wiley Eastern
3. J K Parikh, Modeling approach to long term demand and energy implication, IASA Professional Paper
4. TEDDY Year Book Published by Tata Energy Research Institute (TERI),
5. S Rao, Energy Technology, Khanna Publishers
6. International Energy Outlook -EIA annual Publication
7. A.W. Culp, Principles of Energy Conversion, McGraw Hill International edition
8. BEE Reference book: no.1/2/3/4
9. Frank P Lees, Loss Prevention in Process Industries Volume 1, 2 & 3, ELSEVIER BUTTERWORTH HEINEMANN

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Course Code	Course Name	Credits
EMC103	CONVENTIONAL POWER PLANTS	04

Module	Detailed Contents	Hrs.
01	Introduction Energy and Power, Principal types of power plants, Power plant cycles and their classification. Power Plant Cycles	06
02	Steam Power Plants Classification, Layout, Essential requirements of Power Station Design, Site Selection, Capacity, Plant arrangement, Useful life of SPP components, SPP pumps, Advantages and Disadvantages, Cost and Economics of SPP	08
03	Gas Turbine Power Plants General aspects, Advantages and Disadvantages of GTPP over SPP, Site selection, Classification of GTPP, GTPP fuels, Operation of GTPP, GTPP layout, Effect of operating variables on thermal efficiency, Combined GT and SPP	10
04	Hydro-Electric Power Plants, HePP Advantages and disadvantages, Site selection, Essential features/elements of HePP, Classification, Plant layout, Average life of HePP components, Electrical and Mechanical components, Comparison of HePP and SPP, Underground HePP, Advanced HePP, Safety measures and preventive maintenance, Cost of HePP and hydroelectric power	08
05	Nuclear Power Plant General aspects, Nuclear power systems, Main components of NPP, Advantages of NPP, Site selection, Applications, Economics of NPP, Safety measures for NPP, Future of NPP, Nuclear Power Plants in India, Useful byproducts of Nuclear power generator and their uses	08
06	Combined Operation of Plants General aspects, Advantages of COP, Load division and power stations, Coordination of different power plants, Cost comparison and cost analysis of SPP, GTPP, HePP and NPP	08

References:

1. El-Walkil M M, Power Plant Engineering, McGraw Hill, New York, 1985
2. Power Plant Familiarization, Manual of Central Training Resources Unit of NTPC India, 1991
3. P K Nag, Power Plant Engineering, TMH, New Delhi, 1998
4. A K Raja, Amit Praksh Shrivastava, Manish Dwivedi, Power Plant Engineering, New Age International Publishers
5. M G Jog, Hydro-Electric and Pumped Storage Plants, New Age International Publishers

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Course Code	Course Name	Credits
EME1011	FUELS, COMBUSTION AND EMISSION CONTROL	04

Module	Detailed Contents	Hrs.
01	Introduction to fuels, types of fuels, commercial and non commercial fuels. Solid Fuels: Different types of solid fuels, Family of coal, origin of coal, composition of coal, analysis and properties of coal, action of heat on coal, oxidation of coal, hydrogenation of coal, classification of Indian coal, Storage of coal, carbonization, gasification and liquefaction and pulverization of solid fuels.	09
02	Liquid Fuels: Introduction to Petroleum, origin of petroleum, petroleum production, composition and classification, processing of petroleum, Important petroleum products, properties of petroleum products, liquid fuels from sources other than petroleum, storage and handling of liquid fuels, gasification of liquid fuels, petroleum refining in India.	08
03	Gaseous Fuels: Classification of gaseous fuels based on mode of occurrence and method of production, cleaning and purification of gaseous fuels. Hydrogen as energy carrier	08
04	COMBUSTION Combustion stoichiometry, Nature of combustion process, types of combustion process, Mechanism of combustion reaction, Spontaneous ignition temperature, velocity of flame propagation, limits of inflammability, flame structure, stability and diffusion of flames.	09
05	Kinetics of liquid and solid fuel combustion. Combustion appliances: Oil and gas burners, coal burning equipments.	09
06	EMISSION CONTROL Introduction, atmosphere, Emission control methods. Quantification of emissions	05

References:

1. D P Mishra, Fundamentals of Combustion, PHI Publications.
2. S P Sharma, Fuels and combustion, Tata McGraw Hill Publications, 1984.
3. Samir Sarkar, Fuels and combustion, Universities Press (India) Pvt Ltd, Third Edition 2009.
4. Stephen Turns, An Introduction to Combustion: Concepts and Applications, McGraw Hill Publications.
5. K K Kuo, Principles of combustion 2nd Edition, John Wiley & Sons, New Jersey, 2005
6. Gupta R B, Boca Raton, Hydrogen fuel: Production, transport and storage, CRC Press, 2008.

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Course Code	Course Name	Credits
EME1012	UNCERTAINTY AND ERROR ANALYSIS[#]	04

Module	Detailed Contents	Hrs.
01	Basics on Uncertainties General Characteristics of Uncertainties, Definitions, Uncertainty of Data Depending on One Variable, Multiple Uncertainty Components (Quadratic Sum), Uncertainty Evaluations (Error Analysis), Experimental Uncertainty	09
02	Frequency and Probability Distributions, Frequency Distribution (Spectrum), Probability Distributions, Statistical Confidence, Dealing with Probabilities, Inductive Approach to Uncertainty, Deductive Approach to Uncertainty,	08
03	Correlation, Introduction, Correlated (Systematic) Uncertainties, Differentiation from “Systematic Errors” , Correlation in Cases of Linear Regression, Consistency among Data Sets, Target Shooting as a Model for Uncertainties	08
04	Dealing with Internal Uncertainties, Calculations with Both Types of Uncertainties, Total Uncertainty, Using Internal Uncertainties for Diagnosis	06
05	Presentation and Estimation of Uncertainties, Graphic Presentation of Uncertainties, Correct Presentation of Uncertainties, Finding the Size of Internal Uncertainties, Estimating the Size of Uncertainties	08
06	Feedback of Uncertainties on Experiment Design, Optimizing Experiments, Optimizing Background Measurements, Optimizing with Respect to Dead Time, Optimizing in View of the Mathematical Presentation, Achieving the Smallest Overall Uncertainty	09

[#] Common for Thermal Engineering and Energy Systems and Management

Students have to apply concepts/ carry out error analysis to a real life thermal engineering problem

References:

1. Manfred Drogs, Dealing with Uncertainties A Guide to Error Analysis, Springer, 2007
2. Stephanie Bell, A Beginner’s Guide to Uncertainty of Measurement, National Physical Laboratory, UK, 1999
3. Taylor J R, Introduction to Error Analysis, University Press, Oxford, 1982

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End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Course Code	Course Name	Credits
EME1013	ENERGY SYSTEMS MODELING AND ANALYSIS[@]	04

Module	Detailed Contents	Hrs.
01	MODELING OVERVIEW: levels of analysis, steps in model development, examples of models.	06
02	QUANTITATIVE TECHNIQUES: Interpolation-polynomial, Lagrangian, Curve fitting, regression analysis, solution of transcendental equations.	08
03	SYSTEMS SIMULATION: information flow diagram, solution of set of nonlinear algebraic equations, successive substitution, Newton Raphson. Examples of energy systems simulation. Numerical solution of Differential equations- Overview, Convergence, Accuracy. Transient analysis- application example	12
04	OPTIMISATION : Objectives/constraints, problem formulation. Unconstrained problems- Necessary & Sufficiency conditions. Constrained Optimisation- Lagrange multipliers, constrained variations, Kuhn-Tucker conditions Linear Programming - Simplex tableau, pivoting, sensitivity analysis. Dynamic Programming. Search Techniques- Univariate / Multivariate	12
05	Case studies of optimisation in Energy systems problems. Dealing with uncertainty-probabilistic techniques. Trade-offs between capital & energy using Pinch Analysis	06
06	Energy- Economy Models: Scenario Generation, Input Output Model	04

[@] Common for Energy Engineering and Energy Systems and Management

References:

1. Yogesh Jaluria, Design and Optimization of Thermal Systems, McGraw-Hill international editions, 1998
2. Stoecker W F, Design of Thermal Systems, Mcgraw Hill, 1981
3. S.S.Rao, Optimisation Theory and Applications, Wiley Eastern, 1990
4. S.S. Sastry, Introductory Methods of Numerical Analysis, Prentice Hall, 1988
5. P. Meier, Energy Systems Analysis for Developing Countries, Springer Verlag, 1984
6. R.de Neufville, Applied Systems Analysis, Mcgraw Hill, International Edition, 1990
7. Beveridge and Schechter, Optimisation Theory and Practice, Mcgraw Hill, 1970

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End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Course Code	Course Name	Credits
EME1014	ENERGY MEASUREMENT AND CONTROL INSTRUMENTS	04

Module	Detailed Contents	Hrs.
01	Measurement Concepts Introduction to measurements for scientific and engineering application need and goal. Broad category of methods for measuring field and derived quantities. Principles of measurement, parameter estimation, regression analysis, correlations, error estimation and data presentation, analysis of data	08
02	Process Parameter Measurement Measurement of field quantities, measurement of force, pressure, temperature, flow rate, velocity, humidity, noise, vibration, measurement by probe and non instructive techniques.	08
03	Measurement of derived quantities, torque, power, thermo physical properties, radiation and surface properties.	08
04	Automatic Control Systems Control Room Equipments, PLCs and other logic devices, Analytical instrumentation,	10
05	Instrument Selection and Commissioning General considerations, Control valve selection and sizing, Regulators and final control elements	10
06	Limits, Margins and their Relevance to Instrumentation and control, Control Centers, Fire and Safety Instruments	04

References:

1. Bela G Liptak, Instrument Engineers' Handbook, Vol I, II, III, 4th Edition, CRC Press
2. Doebelin E.O: Measurement Systems-Application and Design, McGraw Hill Publication Co.
3. Bolton W, Mechatronics-Electronics Control Systems in Mechanical and Electrical Engg.
4. Helfrick A.D. and Cooper W.D. Modern Electronic Instrumentation and Measurement Technique
5. Johnson C.D., Process Control Instrumentation
6. J.P.Holman: Experimental Methods For Engineers, McGraw Hill International Edition, Seventh Edition

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End Semester Examination:

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Course Code	Course Name	Credits
EME1021	UTILIZATION OF SOLAR ENERGY[#]	04

Module	Detailed Contents	Hrs.
01	Description Solar Radiation, availability, measurement and estimation; Isotropic and anisotropic models; empirical relations	08
02	flat plate collector, concentrating collector, thermal energy storage: steady state and dynamic analysis, process economics	08
03	Solar water heating: active and passive, building heating and cooling, solar drying, solar distillation	09
04	Industrial process heating, solar ponds: evaporative processes	07
05	Simulation in solar process design, limitations of simulation, design of active systems by f-chart, utilizability method	06
06	Solar photovoltaic systems, PV generators: characteristics and models, load characteristics and direct coupled systems, maximum power point trackers, applications, design procedure , applications of nano materials/technology in solar energy	10

[#] Common for Thermal Engineering and Energy Systems and Management

References:

1. S. P. Sukhatme, Solar Energy - Principles of thermal collection and storage, third edition, Tata McGraw-Hill, New Delhi.
2. J. A. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, second edition, John Wiley, New York, 1991.
3. D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor and Francis, Philadelphia, 2000.
4. M. S. Sodha, N. K. Bansal, P. K. Bansal, A. Kumar and M. A. S. Malik, Solar Passive Building: science and design, Pergamon Press, New York, 1986.
5. M. A. S. Malik, G. N. Tiwari, A. Kumar and M.S. Sodha, Solar Distillation. Pergamon Press, New York, 1982.

Assessment:

Internal Assessment:

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination:

Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Subject Code	Subject Name	Credits
EME 1022	Computational Fluid Dynamics[%]	04

Module	Detailed Contents	Hrs.
01	Definition and overview of CFD, Advantages and applications, CFD methodology	06
02	Governing Differential Equations Governing equations for mass, momentum and energy; Navier-Stokes equations; Mathematical behavior of PDE's viz. parabolic, elliptic and hyperbolic, Initial and boundary conditions, Initial and Boundary value problems.	10
03	Discretization Techniques Introduction to Finite difference Method, Finite Volume method and Finite Element method Finite difference methods; Finite difference representation of PDE's; Solutions to Finite Difference Equations; Implicit, semi-implicit and explicit methods; Errors and stability criteria	13
04	Finite Volume Methods FVM solutions to steady one, two and three dimensional diffusion problems and unsteady one and two dimensional diffusion problems, FVM solutions to convection-diffusion problems - one and two dimensional, steady and unsteady; Advection schemes; Pressure velocity coupling; SIMPLE family of algorithms	14
05	Grid Generation Structured and Unstructured Grids; General transformations of the equations; body fitted coordinate systems; Algebraic and Elliptic Methods; multi block structured grids; adaptive grids	08
06	Turbulence Modeling Effect of turbulence on governing equations; RANS, LES and DNS Models	09

[%] Common for Machine Design, Automobile Engineering, CAD/CAM and Robotics, Energy Engineering and Energy Systems and Management

References:

1. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi 1995.
2. Ghoshdasdar, P.S., "Computer Simulation of flow and heat transfer" Tata McGraw-Hill Publishing Company Ltd., 1998.
3. Subas, V. Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation
4. Taylor, C and Hughes J.B., Finite Element Programming of the Navier Stock Equation, Pineridge Press Ltd., U.K. 1981.
5. Anderson, D.A., Tannehill, I.I., and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, Hemisphere Publishing Corporation, New York, USA, 1984.

6. Fletcher, C.A.J., "Computational Techniques for Fluid Dynamics 1" Fundamental and
7. General Techniques, Springer-Verlag, 1987. Date A. W., "Introduction to Computational Fluid Dynamics", Cambridge Uni. Press, 2005.

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Course Code	Course Name	Credits
EME1023	BIOMASS ENERGY ENGINEERING	04

Module	Detailed Contents	Hrs.
01	Origin of Biomass: Resources: Classification and characteristics; Techniques for biomass assessment; Application of remote sensing in forest assessment; Biomass estimation.	07
02	Thermochemical Conversion: Different processes: Direct combustion, incineration, pyrolysis, gasification and liquefaction; Economics of thermochemical conversion.	09
03	Biological Conversion: Biodegradation and biodegradability of substrate; Biochemistry and process parameters of biomethanation; Biogas digester types; Digester design and biogas utilisation;	08
04	Biomethanation Process, Economics of biogas plant with their environmental and social impacts, Bioconversion of substrates into alcohol, Methanol & ethanol Production, organic acids, solvents, amino acids, antibiotics etc.	08
05	Chemical Conversion: Hydrolysis & hydrogenation; Solvent extraction of hydrocarbons; Solvolysis of wood; Biocrude and biodiesel; Chemicals from biomass	07
06	Power Generation: Utilisation of gasifier for electricity generation; Operation of spark ignition and compression ignition engine with wood gas, methanol, ethanol & biogas; Biomass integrated gasification/combined cycles systems. Sustainable cofiring of biomass with coal. Biomass productivity: Energy plantation and power programme.	09

References:

1. Sergio Capareda, Introduction to Biomass Energy Conversions, CRC Press, 2013
2. Osamu Kitani, Thomas Jungbluth, Robert M Peart, Abdellah Ramdani, CIGR Handbook of Agricultural Engineering Vol V Energy and Biomass Engineering, Published by American Society of Agricultural Engineering
3. H S Mukunda, Understanding Clean Energy and Fuels from Biomass, Wiley India
4. Biomass Combustion Science, Technology and Engineering Edited by Lasse Rosendahl, Woodhead Publishing Series in Energy No 40
5. Venkata Ramana P and Srinivas S.N, Biomass Energy Systems, Tata Energy Research Institute
6. Mital K.M, Biogas Systems: Principles and Applications, New Age International publishers (P) Ltd.
7. Biogas Technology, Nijaguna, B.T., New Age International publishers (P) Ltd
8. Sobh Nath Singh, Non-Conventional Energy Resources, Pearson Education

Assessment:

Internal Assessment:

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination:

Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Course Code	Course Name	Credits
EME1024	ENVIRONMENTAL ENGINEERING & POLLUTION CONTROL	04

Module	Detailed Contents	Hrs.
01	Air Pollution Natural and anthropogenic sources of pollution, Primary and Secondary pollutants, Transport and diffusion of pollutants, Gas laws governing the behavior of pollutants in the atmosphere, air sampling methods, Methods of monitoring and control of air pollutants SO ₂ NO ₂ , CO, SPM	09
02	Effects of pollutants on human beings, plants, animals, materials and on climate, Acid Rain, Ambient Air Quality Standards, Air pollution control methods and equipment.	08
03	Water Pollution Types, sources and consequences of water pollution, Physico-chemical and Bacteriological sampling and analysis of water quality, Standards. sewage and waste water treatment and recycling ASP/STP, Water quality standard, treatment, utilization and disposal of sludge, Government norms	07
04	Land Pollution Sources and classification of land pollutants, Industrial waste effluents and heavy metals, their interactions with soil components, degradation of different insecticides, fungicides and weedicides in soil. Solid waste management, Process and equipments for energy recovery from municipal solid waste and industrial waste, MSW Act 2000.	08
05	Other sources of pollution Noise: Sources of noise pollution, measurement of noise and Indices, exposure levels and standards, Noise control and abatement measures. Impact of noise on human health. Marine : Sources and nature of pollutants, oil pollution, metallic pollutants, status of coastal and estuarine pollution in India, Chemicals and drugs from oceans, sea level rise, cause, effect and control Radiation: Introduction, types of radiation and radioactivity, sources and effects.	08
06	Pollution from power generation Pollutants from power generation points-thermal power plant, Control measures to Reduce them. Environmental considerations in cogeneration and waste heat recovery	08

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References:

1. Rao & Rao, Air Pollution
2. C J Rao, Environmental Engineering, New Age International
3. G. Masters, Introduction to Environmental Engineering & Science, Prentice Hall
4. H S Peavy, D R Rowe, G Tchobanoglous, Environmental Engineering, McGraw Hill
5. DeNevers Noel, Air Pollution control Engineering, McGraw Hill
6. Metcalf & Eddy, Waste Water Engineering: Treatment & Reuse, McGraw Hill

Assessment:

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End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Course Code	Course Name	Credits
EML101	MODELING AND SIMULATION LAB	01

Lab. Sessions	Detailed Contents	Hrs.
1	Study of Different Modeling Techniques practiced in Power Plant Engineering	6
2	Simulation study using Mathematical Simulation Software (or any programming language) on any two conventional power plants	8
3	Simulation study of any one non conventional power plant	8
4	Visit to Power Plant Control Room to Understand Automated Control System in Power Plant	2

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Course Code	Course Name	Credits
EML102	RENEWABLE ENERGY LAB[#]	01

Lab. Sessions	Detailed Contents	Hrs.
1	Measurement of solar radiation and sunshine hours,	2
2	Measurement of albedo, UV & IR radiation,	2
3	Measurement of emissivity, reflectivity, transmittivity,	2
4	Performance testing of solar flat plate water heater (forced flow & thermosyphon systems)	4
5	Performance testing solar air heater & dryer & desalination unit,	4
6	Performance testing of solar thermal concentrators,	2
7	Characteristics of photovoltaic devices & testing of solar PV operated pump,	2
8	Energy consumption & lumen measurement of lights & ballasts.	2
9	Properties of fuel oils & biomass,	2
10	Testing of Gasifier or Wind machines or Fuel cell	2

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Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Course Code	Course Name	Credits
EMC201	ENERGY PLANNING, MANAGEMENT AND AUDIT	04

Module	Detailed Contents	Hrs.
01	Energy Conservation Initiatives in India, Energy and Economic Development, Energy in National Planning, Concept of Energy Supply and Demand, Energy Supply Planning, Energy Demand Planning, Decision support systems for energy planning, Life Cycle Costing	09
02	Principles and Objectives of Energy Management. Design of Energy Management Programmes. Development of energy management systems, Importance, Indian need of Energy Management, Duties of Energy Manager	06
03	Electrical Energy Management Supply side: Methods to minimize supply-demand gap, renovation and modernization of power plants, reactive power management, HVDC, and FACTS. Demand side: conservation in motors, pumps and fan systems; energy efficient motors	09
04	Thermal energy Management Energy conservation in boilers, steam turbines and industrial heating systems; Application of FBC; Cogeneration and waste heat recovery; Thermal insulation; Heat exchangers and heat pumps; Building Energy Management	08
05	Categories of Energy Audit, Types of Energy Audit, Scope of Energy Audit Procedures for Energy Analysis and Audit. Types and Methodology	08
06	Energy Audit Reporting Format; Understanding Energy Costs; Benchmarking and Energy Performance; Matching Energy Usage to Requirement; Maximising System Efficiency; Fuel and Energy Substitution; Energy Audit Instruments; Duties and responsibilities of energy auditors.	08

References:

1. Amlan Chakrabarti, Energy engineering and management, PHI Learning, New Delhi 2012
2. Mirjana Golusin, Sinisa Dodic, Stevan Popov, Sustainable Energy Management, Academic Press
3. Shaligram Pokharel, Energy Analysis for Planning and Policy, CRC Press, 2014
4. Trivedi P R, Jolka K R, Energy Management, Commonwealth Publications, New Delhi
5. Y P Abbi, Shashank Jain, Handbook on Energy Audit and Environment Management, TERI
6. General Aspects of Energy Management and Energy Audit, Buro of Energy Efficiency
7. Frank Krieth, D Yogi Goswami, Energy Management and Conservation Handbook, CRC Press
8. Alburth Thumann, William J Younger, Terry Niehus, Handbook of Energy Audits, 9th Ed, BetterWorld Books

Assessment:

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Course Code	Course Name	Credits
EMC202	COGENERATION AND WASTE HEAT RECOVERY	04

Module	Detailed Contents	Hrs.
01	COGENERATION: Introduction, Principles of Thermodynamics, Combined Cycles, Topping, Bottoming, Organic Rankine Cycles, Advantages of Cogeneration Technology	07
02	APPLICATION & TECHNO ECONOMICS OF COGENERATION: Cogeneration Application in various process industries. Sizing of waste heat boilers, Performance calculations, Part load characteristics selection of Cogeneration Technologies, Financial considerations, Operating and Investments, Costs of Cogeneration	12
03	WASTE HEAT RECOVERY: Introduction - Principles of Thermodynamics and Second Law, Sources of waste heat and its potential applications, Waste heat survey and measurements, Data collection, Limitations and affecting factors Heat recovery equipment and systems	07
04	WASTE HEAT RECOVERY SYSTEMS: Recuperators, Regenerators, economizers WASTE HEAT BOILERS: Classification, Location, Service Conditions, Design Considerations, Unfired combined Cycle, Supplementary fired combined cycle, fired combined cycle, Thermic fluid heaters	08
05	APPLICATIONS & TECHNO ECONOMICS OF WASTE HEAT RECOVERY SYSTEMS: Applications in industries, selection of waste heat recovery technologies - financial considerations - operations and investment costs of waste heat recovery	10
06	Introduction to tri-generation and quad-generation	04

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, McGrawHill, New York, 1995.

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Course Code	Course Name	Credits
EMC203	NON CONVENTIONAL POWER PLANTS	04

Module	Detailed Contents	Hrs.
01	Potential of renewable energy sources, renewable electricity and key elements, Global climate change, CO ₂ reduction potential of renewable energy.	09
02	Solar thermal power plants (Concentrators, solar chimney etc.), Solar thermal conversion devices, Economics and social considerations, Design considerations of component selection. Solar photovoltaic power plants, photovoltaic technology, Design of a photovoltaic system, economics and costing, Application as a distributed power supply strategy.	08
03	Wind Power Technology: Wind energy potential measurement, wind mill component design, economics and demand side management, energy wheeling, and energy banking concepts.	08
04	Biogas: properties of biogas (Calorific value and composition), biogas plant technology and status	09
05	Other plants: Fuel cell based power plants, tidal and wave energy plant design, OTEC power plants. Geothermal energy: hot springs and steam ejection site selection, power plants, and economics.	09
06	Environmental impacts, Economic and social considerations, Financing mechanisms, Carbon credits, clean development mechanisms	05

References:

1. S.P.Sukhatme, Solar Energy – Principles of Thermal Collection and Storage, 3rd edition, Tata McGraw Hill, New Delhi, 1996.
2. J.A.Duffie and W.A.Beckman, Solar engineering of Thermal processes, 2nd edition, John Wiley, New York, 1991.
3. D.Y.Goswami, F.Kreith and J.F.Kreider, Principles of Solar Engineering, Taylor and Francis, Philadelphia, 2000.
4. Joshua Earnest, Wind Power Technology, PHI Learning, 2014
5. C S Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications, 2nd Edition, PHI Learning, 2013
6. D.D.Hall and R.P.Grover, Biomass Regenerable Energy, John Wiley, New York, 1987.
7. Mukund R Patel, Wind and Solar Power Systems, CRC Press, 1999.
8. J F Manwell, J.C.McGowan, A.L.Rogers, Wind Energy Explained: Theory, Design and Application, John Wiley and Sons, May 2002.
9. R D Begamudre, Energy Conversion Systems, New Age International (P) Ltd., Publishers, New Delhi ,2000.
10. D P Kothari, K C Singal, Rakesh Ranjan, Renewable Energy Sources and Emerging Technology, 2nd Ed, PHI Eastern Economy Edition, 2011

Assessment:

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End Semester Examination:

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Course Code	Course Name	Credits
EME2031	NUCLEAR POWER PLANTS	04

Module	Detailed Contents	Hrs.
01	Nuclear Power Plant: Concept of energy generated from atomic fission. Block diagram of an Atomic power station. Constructional features of nuclear power plants. Site selection for NPP	08
02	Nuclear power production, fission and fusion, nuclear fuels, prospecting, processing of nuclear fuels.	08
03	Reactor Technology: Basic Reactor Systems – BWR, PHWR/CANDU, GCR, fast breeder – comparison. Fuel handling and reprocessing.	07
04	Types of coolants. Control of chain reaction. Radio activity and safety measures. Layout of control rooms.	09
05	Nuclear Waste disposal and environmental management.	08
06	Review of Nuclear Power Programs, Nuclear power in Indian context	08

References:

1. Raymond L Murray, Nuclear Energy An Introduction to the Concepts, Systems and Applications of Nuclear Processes, 6th Edition, Butterworth-Heinmann, ELSEVIER, 2009
2. Manoj Kumar Gupta, Power Plant Engineering, PHI Learning
3. James Rust, Nuclear Power Plant Engineering, Haralson Publishing Company
4. Nuclear Power Plants, Edited by Soon Heung Chang, InTech Publishers, 2012
5. Geotge Petridis and Dimitrios Nicolau, Nuclear Power Plants, NOVA Publishers, 2011
6. John R Lamarsh, Introduction to Nuclear Reactor Theory, American Nuclear Society, 2002

Assessment:

Internals Assessment:

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End Semester Examination:

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Course Code	Course Name	Credits
EME2032	CONTROL SYSTEM DESIGN	04

Module	Detailed Contents	Hrs.
01	Basics of control system - Types of control – proportional control, Derivative control, Integral control, PID control-Programmable logic controllers.	06
02	Control system performance objectives, Review of design of cascade compensators for continuous time and discrete time control systems, Scalar and multivariable control systems, Feed back compensation	10
03	Industrial PID controllers. state space systems and PID control, Pole placement techniques for design of controllers and observers, design of integral controllers, Kalman filter, Robust control	10
04	Non-linear control system design, Linearization, use of describing function to predict oscillations, compensation and design of non-linear systems, design of non-linear control system using phase plane analysis, selection of best non-linear control system method	10
05	Lyapunov stability, optimal control theory and applications, Adaptive Control -	06
06	Automatic PID controller tuning, Self tuning control, model reference adaptive control, practical aspects, Control system design examples	06

References:

1. Stanley M. Shinnars, Advanced modern control system theory and design, John Wiley & Sons, 1998.
2. Michael A. Johnson, Mohammad M. Moradi, PID Control: New Identification and Design Methods, Springer 2005.
3. Norman S. Nise, Control Systems Engineering (5e), John Wiley & Sons Inc, 2010.
4. Kuo, B.C., Farid Golnaraghi, Automatic Control Systems (8e), Wiley India, 2009.
5. Katsuhiko Ogata, Modern Control Engineering (5e), PHI, 2010.

Assessment:

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End Semester Examination:

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Course Code	Course Name	Credits
EME2033	HEAT EXCHANGER DESIGN[§]	04

Module	Detailed Contents	Hrs.
01	Constructional Details and Heat Transfer: Types - Shell and Tube Heat Exchangers - Regenerators and Recuperators - Industrial Applications Temperature Distribution and its Implications - LMTD – Effectiveness	8
02	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	8
03	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	8
04	Condensers and Evaporators Design: Design of Surface and Evaporative Condensers - Design of Shell and Tube - Plate Type Evaporators	8
05	Cooling Towers: Packing - Spray Design - Selection of Pumps - Fans and Pipes - Testing and Maintenance, Compact cooling towers	8
06	Design of Special Purpose Heat Exchangers: corrosive environment. Marine/space applications, compact heat exchanger	8

[§] Common for Thermal Engineering and Energy Systems and Management

References:

1. Shah R K, Sekulic D P, Fundamentals of Heat Exchanger Design, John Wiley, 2003
2. KakacSadik, Liu Hongtan, Heat exchangers : selection, rating and thermal design , 2nded, CRC Press, 2002
3. T. Taborek, G.F. Hewitt and N.Afgan, Heat Exchangers, Theory and Practice, McGraw Hill Book Co., 1980
4. Walker, Industrial Heat Exchangers - A Basic Guide, McGraw Hill Book Co., 1980
5. Nicholas Cheremisiouff, Cooling Tower, Ann Arbor Science Pub 1981
6. Arthur P. Fraas, Heat Exchanger Design, John Wiley & Sons, 1988

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End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Course Code	Course Name	Credits
EME2034	STEAM AND GAS TURBINE[§]	04

Module	Detailed Contents	Hrs.
01	Classification of steam turbines, combination of turbines, overview of turbines, Flow of steam through impulse turbine blades / impulse and reaction turbines blades, Energy losses in steam turbines, governing and performance of steam turbines	10
02	Steam turbine auxiliary systems: turbine protective devices, tripping devices, unloading gears, lubricating systems, glands and sealing systems	09
03	Construction, Operation and Maintenance of Steam Turbines	05
04	Gas Turbine-shaft power cycles, velocity diagram and work done by gas turbine, turbine blade cooling, blade materials, blade manufacture, matching of turbine components,	09
05	Combustion chambers, requirements, types, factor affecting performance of CC, performance of turbines	06
06	GT auxiliary systems, operation and maintenance, starting and ignition systems, lubrication systems, Fuel system and controls, operation, maintenance and trouble shooting	09

[§] Common for Thermal Engineering and Energy Systems and Management

References:

1. R Yadav, Steam and Gas Turbines and Power Plant Engineering, Central Publishing House, Allahabad, 2004
2. Ganesan, V., Gas Turbines, Tata McGraw-Hill Pub.Co.Ltd., New Delhi, 1999.
3. Lee J F, Theory and Design of Steam and Gas Turbines, McGraw-Hill, New York
4. Meherwan P Boyce, Gas Turbine Engineering Handbook, Gulf Publishing Company.
5. Cohen, H., Rogers, G.E.C., and Saravanamuttoo, H.I.H., Gas Turbine Theory, Longman Group Ltd, 1989
6. Gordon C, Dates, Aero-thermodynamics of Gas Turbine and Rocket Propulsion AIAA Education Series, NY, 1984.

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Course Code	Course Name	Credits
EME2041	HYDROGEN ENERGY	04

Module	Detailed Contents	Hrs.
01	Introduction: fossilFuel scenario, Why hydrogen, Fuel evolution concept, hydrogen Properties, Hydrogen economy and sustainability, comparison with other fuels.	06
02	Sources and production technologies, Steam Methane Reforming, Electrolysis, Biological sources, Thermochemical methods	10
03	Distribution and delivery Pipelines, tube trailers cryo containers	06
04	Hydrogen Storage Gaseous liquid and solid state storage, comparison, boil off loss, hydrogen liquefaction, ortho and para hydrogen, compression and compressors and work calculations. Metal hydrides, adsorption and absorption, physisorption and chemisorptions, chemical and complex hydrides	12
05	Hydrogen utilisation Fuel cells and internal combustion engine, types of fuel cells, comparison of fuel cell technologies. simple calculations. Challenges and barriers for implementation of hydrogen economy.	08
06	Safety issues Possible hazards, solutions, Preventive measures	06

References:

1. Vishwanathan B and M Aulice Scibioh, Fuel Cells, Universities Press, Hyderabad, India, 2006
2. Hirscher, Michael. Handbook of Hydrogen Storage: New Materials for Future Energy Storage. Weinheim : WILEY-VCH Verlag GmbH & Co. KGaA, 2009
3. Gupta R B. Hydrogen fuel: Production, transport and storage. Boca Raton : CRC Press, 2008
4. Lennie Klebanoff, Hydrogen Storage Technology Material and Applications, CRC Press
5. Joseph M Norbeck, James W Haffel, Thomas D Durbin, Bassam Tabbara, John M Bowden, Michelle C Montano, Hydrogen Fuel for Surface Transportation, Society of Automotive Engineers Inc, 1996

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Course Code	Course Name	Credits
EME2042	DIAGNOSTIC MAINTENANCE TECHNIQUES*	04

Module	Detailed Contents	Hrs.
01	<p>INTRODUCTION TO MAINTENANCE: Introduction to Maintenance, Bath tub curve, Types of maintenance: Preventive maintenance, Reaction to failure maintenance, Condition Based maintenance. Total productive maintenance (TPM), Reliability Centered maintenance (RCM), RCM logic Tree, Merits and demerits of above maintenance system.</p> <p>Condition Monitoring Techniques: Vibration Monitoring, Oil/debris analysis, Manual inspection, Current monitoring, Conductivity/insulation monitoring, Performance monitoring, Thermal monitoring (Thermography), Corrosion monitoring, How condition monitoring is implemented, why vibration monitoring is predominantly used in industry</p>	04
02	<p>FUNDAMENTALS OF VIBRATION MONITORING: Causes and effects of vibrations, Characteristics of vibrations, What is phase, Measurement of Phase, Phase Fundamentals, Comparing two waveforms using reference, Cross Channel Phase Analysis.</p> <p>Transducer Characteristics: Basic signal attributes, Different Probes: Proximity Displacement probes, Velocity probe, Piezoelectric Accelerometers. Application of above probes, all probes advantages and disadvantages.</p> <p>Dynamic Signal Characteristics: Electronic Filters, Time and orbital domain, Time and frequency Domain</p> <p>Standards for Vibration Monitoring and Analysis: ISO standard for Evaluation of Vibration Severity: ISO 10816 and ISO 7919, Selection Criteria of measurement and evaluation of vibration severity.</p>	10
03	<p>VIBRATION ANALYSIS FOR MACHINERY MALFUNCTION: Analysis: Analysis of machinery vibration problems, Methodology of vibration analysis: Condition/vibration monitoring data collection, Trending of data, Time wave form analysis, Signature analysis, Absolute Phase analysis and cross channel phase analysis, Orbit analysis. Root Cause Analysis.</p> <p>Machinery malfunction diagnosis with case studies by using vibration analysis tool: Methodology of diagnosis of unbalance, misalignment and antifriction bearings defect. Frequency calculation and their significance in signature analysis of antifriction bearing, Mechanical Looseness, diagnosis of foundation problem</p>	14
04	<p>FUNDAMENTAL OF OIL AND WEAR DEBRIS ANALYSIS: Types of Wear: Mechanism of Mechanical wear, Adhesive wear, Erosive wear, Abrasive wear, fretting wear, Fatigue wear of surfaces, cavitation's wear.</p> <p>Mechanism of chemical corrosion wear: Wear of bearing materials, wear of bearing surfaces, Factors influencing wears.</p> <p>Oil Analysis as Condition Monitoring Techniques: Oil sampling, Guide lines for representative oil sampling points for machinery, Oil sampling tools, Sampling Analysis, Interpretation of results, oil replacement strategy</p>	06

	Lube oil Testing/Analysis and its significance: Physical Test- Viscosity test, Flash & Fire point Test, Cloud & pour point test, Carbon residue test etc. Chemical Test- Total Acidic Number (TAN) and Total Basic Number (TBN), Sulphur, Chlorine, Phosphate test.	
05	DETECTION AND DIAGNOSIS OF WEAR THROUGH OIL AND WEAR DEBRIS ANALYSIS: Basic components of wear debris analysis, their characteristics and relationship to wear. The proactive & reactive components of wear & associated products. Wear in lubricated systems. Types of debris, Debris collections, Debris Analysis, Ferrography, Types of debris harmful to lube oil and machinery.	06
06	NON DESTRUCTIVE TESTING (NDT) TECHNIQUES: Need of inspection, Types of inspection system, Quality of inspection, Reliability of defect detection, and Benefit & Role of NDT in maintenance of rotating machinery, NDT techniques used: Visual inspection, Liquid Penetrant Testing (LPT), Magnetic Particle Testing (MPT), Ultrasonic testing, Eddy Current Testing, Radiography. Features and Applications of above test in maintenance along with their limitations.	08

* Common for Machine Design and Energy Systems and Management

References:

1. Devies, "Hand Book of Condition Monitoring: Techniques and Methodology", Springer
2. B.K.N. Rao, "Handbook of Condition Monitoring", Elsevier
3. Steve Goldman, "Vibration Spectrum Analysis: A Practical Approach", Industrial Press Inc.
4. Richard O. Duda, Peter E. Hart and David G. Stork, "Pattern Recognition", Wiley
5. Paresh Girdhar and Cornelius Scheffer, "Practical Machinery Vibration Analysis and Predictive Maintenance", Elsevier
6. R. Keith Mobley, "An Introduction to Predictive Maintenance", Butterworth-Heinemann
7. Robert B. McMillan "Rotating Machinery: Practical Solutions to Unbalance and misalignment", Fairmont Press
8. Joel Levitt, "Complete Guide to Preventive and Predictive Maintenance Industrial", Press Inc.
9. R. K. Prasar, "Lubrication Simplified", Publisher, English Edition
10. Barry Hull, Vernon John, "Non-Destructive Testing", ELBS Publication
11. Ron Barroon, "Engineering Condition Monitoring Practice, Methodology and Applications", Pearson Education
12. Robert Bond Randall, "Vibration-based Condition Monitoring: Industrial, Aerospace and Automotive Applications", John Wiley and Sons, Inc.
13. R. A. Collacott, "Mechanical Fault Diagnosis and Condition Monitoring", Chapman & Hall
14. John Piotrowski, "Shaft Alignment Handbook", CRC Press
15. Victor Wowk, "Machine Vibration: Alignment", McGraw-Hill

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Course Code	Course Name	Credits
EME2043	BOILER TECHNOLOGY	04

Module	Detailed Contents	Hrs.
01	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	08
02	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	08
03	Boiler Design Design of Boiler Drum, Steam Generator Configurations For Industrial Power and Recovery Boilers, Pressure Loss and Circulation in Boilers	08
04	Design of Accessories Design of Air Preheaters, Economizers and Superheaters for high Pressure Steam Generators, Design Features of Fuel Firing Systems and Ash Removing Systems	08
05	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 Boilers Drums and Pressure Parts, Safety of Fuel Storage and Handling, Safety Methods for Automatic Operation of Steam Boilers	08
06	New Developments in Boiler Technology, Advanced high performance boilers	08

References:

1. David Gunn, Robert Horton, Industrial Boilers - Longman Scientific & Technical Publication, 1986
2. Carl Schields, Boilers - Type, Characteristics and Functions, McGraw Hill Publishers, 1982
3. Modern Power Station Practice(8 vol) - Central Electricity Generation Board, 1980
4. Large Boiler Furnaces, Richard Dolezal Elsevier Publishing Company, 1980

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Course Code	Course Name	Credits
EME2044	EMERGING BIO-FUEL TECHNOLOGIES	04

Module	Detailed Contents	Hrs.
01	INTRODUCTION: Liquid fossil fuels- transportation, industrial & domestic fuels; their properties; consumption pattern, prices and future scarcity; scope for biomass derived liquid fuels; use in boilers, I.C. engines, cooking etc.	08
02	OIL DERIVED FUELS: Vegetable oils- extraction methods, properties, suitability as combustion and IC engine fuel; Biodiesel- Base raw materials used, transesterification chemistry & processes, properties, use in diesel engines	08
03	ETHANOL FUEL: Fuel properties of ethanol; suitability as thermal and IC engine fuel, current status of use in Brazil, USA, India	06
04	ETHANOL PRODUCTION: 1st generation ethanol production by fermentation route, processes, reactors, applicable biomass sources; Ethanol production from lignocellulosic agro-residues (2nd generation)- potential, problems faced, technologies used	08
05	THERMOCHEMICAL ROUTES: Steam gasification of biomass- chemistry, reactors used- free fall, fluidised bed, entrained; Fischer-Tropsch conversion of synthesis gas to methanol, ethanol, or synthetic diesel - chemistry, operating parameters, catalysts; India's national hydrogen energy program	08
06	THERMOCHEMICAL PYROLYSIS ROUTE: Pyrolysis process- slow and fast, reactors packed bed, ablative pyrolysis, rotating cone, fluidised bed; properties and use of oil produced BIO-FUELS FROM MICRO-ALGAE: Process description, present status; MICROBIAL FUEL CELLS	10

References:

1. J. Twidell and T. Weir, Renewable Energy Resources, Taylor and Francis (special Indian edition), 2006
2. G.N. Tiwari, M.K. Ghosal, Fundamentals of Renewable Energy Sources, Alpha Science Intl. Ltd., 2007
3. Hans P. Blaschek, Thaddeus Ezeji, Jürgen Scheffran, Biofuels from Agricultural Wastes and Byproducts, Wiley Blackwell, 2010
4. V. V. N. Kishore (Editor), Renewable Energy Engineering And Technology: Principles And Practice, Earthscan Publications (Apr 2009)
5. Caye M. Drapcho, Nghiem Phu Nhuan, Terry H. Walker, Biofuels Engineering Process Technology; McGraw Hill, 2008
6. Prabir Basu; Biomass gasification and pyrolysis: Practical design and theory; Elsevier, 2010

Assessment:

Internal Assessment:

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination:

Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students. Minimum 80% syllabus should be covered in question papers of end semester examination.

Course Code	Course Name	Credits
EML201	ENERGY AUDIT LAB[@]	01

Experiments and Case Studies on

- 1 Calculation of heating and cooling load
- 2 Preparation of energy audit plan and analysing energy audit data
- 3 Preparation of heat balance for a thermal machine
- 4 Determination energy efficiency of different machines
- 5 Preparation process flow diagram and energy utility diagram

Note:

The experiments will focus on the following:

1. Ability to select and install the measuring instruments
2. Take accurate readings
3. Analyse the data
4. Interpret the results

Industrial Training:

To acquaint the students with the methodology of Energy Audit, industrial training shall be arranged for not less than 4 weeks and not more than 8 weeks after completion of Sem-II exams and before commencement of Sem-III. The students are expected to implement energy audit procedures for any utility, system or process in the industry. The student will submit a report on the training which will be assessed by the concerned faculty.

[@] Common for Energy Engineering and Energy Systems and Management

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Course Code	Course Name	Credits
EML 202	MEASUREMENT & VIRTUAL INSTRUMENTATION LAB	01

Topic	Lab.Sessions (each of 02 Hrs)
I. Study of sensor characteristics, selection, calibration and measurement of minimum 05 mechanical parameters such as flow, load, pressure, speed and temperature	04
II. Virtual Instrumentation a. Simulation of any system with Virtual Instrumentation (VI) environment using any suitable software b. Interfacing of sensors used for measuring above mentioned parameters in I with VI software and measurement of these parameters on any laboratory model or actual working system	07
III. Demonstration of interfacing of VI software with suitable generic hardware	01

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Course Code	Course Name	Credits
EMS301	Seminar	03

Guidelines for Seminar

- Seminar should be based on thrust areas in Mechanical Engineering
- Students should do literature survey and identify the topic of seminar and finalize in consultation with Guide/Supervisor. Students should use multiple literature and understand the topic and compile the report in standard format and present in front of Panel of Examiners appointed by the Head of the Department/Institute of respective Programme.
- Seminar should be assessed based on following points
 - Quality of Literature survey and Novelty in the topic
 - Relevance to the specialization
 - Understanding of the topic
 - Quality of Written and Oral Presentation

Course Code	Course Name	Credits
EMD 301 / EMD 401	Dissertation (I and II)	12 + 15

Guidelines for Dissertation

- Students should do literature survey and identify the problem for Dissertation and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the problem. Students should attempt solution to the problem by analytical/simulation/experimental methods. The solution to be validated with proper justification and compile the report in standard format.

Guidelines for Assessment of Dissertation I

- Dissertation I should be assessed based on following points
 - Quality of Literature survey and Novelty in the problem
 - Clarity of Problem definition and Feasibility of problem solution
 - Relevance to the specialization
 - Clarity of objective and scope
- Dissertation I should be assessed through a presentation by a panel of internal examiners appointed by the Head of the Department/Institute of respective Programme.

Guidelines for Assessment of Dissertation II

- Dissertation II should be assessed based on following points
 - Quality of Literature survey and Novelty in the problem
 - Clarity of Problem definition and Feasibility of problem solution
 - Relevance to the specialization or current Research / Industrial trends
 - Clarity of objective and scope
 - Quality of work attempted
 - Validation of results
 - Quality of Written and Oral Presentation
- Dissertation II should be assessed through a presentation jointly by Internal and External Examiners appointed by the University of Mumbai

Students should publish at least one paper based on the work in reputed International / National Conference (desirably in Refereed Journal)