KERALA TECHNICAL UNIVERSITY

M.Tech

in

Energy Systems Analysis and Design

Curriculum, Scheme of Examinations and Syllabi
(With effect from 2015 admissions)

SCHEME OF EXAMINATIONS

SEMESTER - I

Exam Slot	Course Code	Subject	Hours per week			Marks		Total Marks	End Sem. exam duration (hrs)	Credits
			L	T	P	Intl.	End Sem.			
A	09ME 6211	Advanced Engineering Mathematics	3	1	0	40	60	100	3	4
B	09ME 6221	Advanced Fluid Dynamics	3	1	0	40	60	100	3	4
C	09ME 6231	Energy Conversion Systems	3	1	0	40	60	100	3	4
D	09ME 6241	Advanced Heat Transfer	3	0	0	40	60	100	3	3
E		Elective-I	3	0	0	40	60	100	3	3
	09ME 6251	Research Methodology	0	2	0	100	0	100		2
	09ME 6261	Seminar	0	0	2	100	0	100		2
	09ME 6271	Energy Systems Laboratory	0	0	2	100		100		1
	TOTAL							800		23

Electives -I

Sl.No.	Course code	Subjects
1	09ME 6215	Computational Methods
2	09ME 6225	Optimization Techniques
3	09ME 6235	Computational Methods in Fluid Flow and Heat Transfer
4	09ME 6245	Reliability Engineering

SEMESTER - II

Exam.Slot	Course Code	Subject	Hours per week			Marks		Total Marks	End Sem. Exam. Duration Hrs	Credits
			L	T	P	Intl.	End. Sem			
A	09ME 6212	Design of Energy Equipments	3	1	0	40	60	100	3	4
B	09ME 6222	Advanced Instrumentation Systems	3	0	0	40	60	100	3	3
C	09ME 6232	Renewable Energy Systems	3	0	0	40	60	100	3	3
D		Elective-2	3	0	0	40	60	100	3	3
E		Elective-3	3	0	0	40	60	100	3	3
	09ME 6262	Mini Project	0	0	4	100		100		2
	09ME 6272	Modeling and Simulation Laboratory	0	0	2	100		100		1
	TOTAL							700		19

Electives –2

Sl.No.	Course Code	Subjects
1	09ME 6216	Energy Efficient Buildings
2	09ME 6226	Wind Energy and its Utilization
3	09ME 6236	Cryogenics
4	09ME 6246	Materials Engineering & Tribology

Electives -3

Sl.No.	Course Code	Subjects
1	09ME 6266	Solar Engineering
2	09ME 6276	Advanced Thermodynamics and Combustion
3	09ME 6286	Refrigeration Engineering
4	09ME 6296	Nano-science and Technology

SEMESTER– III

Exam.Slot	Course Code	Subject	Hours per week			Marks		Total Marks	End Sem. Exam. Duration-Hrs	Credits
			L	T	P	Intl.	End Sem.			
A		Elective-4	3	0	0	40	60	100	3	3
B		Elective-5	3	0	0	40	60	100	3	3
	09ME 7263	Seminar	0	0	2	100	0	100		2
	09ME 7283	Project (Phase –I)	0	0	12	50	0	50		6
	TOTAL							350		14

Electives –4

Sl.No.	Course Code	Subjects
1	09ME 7217	Turbomachinery
2	09ME 7227	Power Generation and System Planning
3	09ME 7237	Co-generation & Waste Heat Recovery System
4	09ME 7247	Energy Conservation & Heat recovery System

Electives –5

Sl.No.	Course Code	Subject
1	09ME 7267	Energy Policies for Sustainable Development
2	09ME 7277	Electrical Energy Systems and Management
3	09 ME 7287	Combustion and Emission in IC Engines
4	09ME 7297	Energy Modeling and Management

SEMESTER – IV

Exam. Slot	Course Code	Subject	Hours per week			Marks		Total Marks	Exam Duration	Credits
			L	T	P	Internal	End Sem.			
	09ME 7284	Project (Phase -II)	0	0	21	70	30	100		12
	TOTAL							100		12

Total credit:68

Course No: 09ME 6211 Course Title: ADVANCED ENGINEERING MATHEMATICS
Credits: 3-1-0: 4 Year :2015

Pre-requisites: series and convergence of series, partial derivatives, methods of solving multiple integrals.

Course Objectives:

To provide necessary background in linear algebra, tensors and methods of solutions of differential equations needed for analyzing problems related to mechanical engineering.

Syllabus

Basics of linear algebra – from vector spaces to linear transformations between vector spaces; series solutions of ODE at regular and regular singular points; series solutions of Legendre and Bessel equations; methods of solving PDEs – solutions of special PDEs – the wave equation, heat equation and Laplace equation; tensor analysis.

Course Outcome:

Students completing the course will be able to gain theoretical knowledge in higher dimensional spaces and linear transformations and tensors therein. Also the course will help them to master special methods to solve ODEs and PDEs.

Text Books:

1. Hoffman, K. and Kunze, R., Linear Algebra, Prentice Hall of India, 1971.
2. Sneddon, I., Elements of Partial Differential Equations, McGraw-Hill,1985.
3. Spain, B., Tensor Calculus, Third Edition, Oliver and Boyd, 1965.
4. Ross, S. L., Differential Equations, Third Edition, John Wiley & Sons, 2004.

References:

1. Lay, D. C., Linear Algebra and its Applications, Addison Wesley, 2003.
2. Florey, F. G., Elementary Linear Algebra with Application, Prentice Hall, 1979.
3. Bell, W. W., Special Functions for Scientists and Engineers, Dover Publications, 2004.
4. Sokolnikoff, I. S. and Redheffer, R. M., Mathematics of Physics and Modern Engineering, Second Edition,McGraw-Hill, 1966.
5. Tychonov, A. N. and Samarskii, A. A., Partial Differential Equations of Mathematical Physics, Holden-Day, 1964.
6. Irving, J. and Mullineux, N., Mathematics in Physics and Engineering, Academic Press, 1959.
7. Pipes, L. A. and Harwill, L. R., Applied Mathematics for Engineers and Physicists, Third Edition, McGrawHill, 1970.
8. Akivis,M.A. and Goldberg, V.V., An Introduction to Linear Algebra and Tensors, Dover Publications, 1997.

COURSE PLAN

Course No: 09ME 6211 Course Title: ADVANCED ENGINEERING MATHEMATICS Credits:3-1-0: 4		
MODULES	**Contact hours**	**End Sem. Exam Marks;%**
MODULE : 1- Vector spaces, Basis, Dimension, Inner product spaces, Gram-Schmidth Process, Linear transformations, Range and Kernel, Isomorphism, Matrix of transformations and change of Basis.	13	25
MODULE:2- Power series solutions about ordinary point, Legendre equation and Legendre polynomials.	7	13
FIRST INTERNAL TEST		
MODULE : 2 - Solutions about singular points; The method of Frobenius, Bessel equation and Bessel Functions. Sturm-Liouville problem and Generalized Fourier series.	6	12
MODULE : 3- First order PDEs, Linear equations, Lagrange method, Cauchy method, Charpits method, Jacobi method. Second order PDEs, Classifications, Formulation and method of solutions of Wave equation, Heat equation and Laplace equation.	13	25
SECOND INTERNAL TEST		
MODULE : 4- Line, area and volume integrals, Spaces of N-dimensions, coordinate transformations, covariant and mixed tensors , fundamental operation with tensors, the line element and metric tensor, conjugate tensor, Christoffel's symbols , covariant derivative.	13	25
END SEMESTER EXAM		

Course No: 09ME 6221 Course Title: AVANCED FLUID DYNAMICS

Credits: 3-1-0: 4 **Year :2015**

Pre-requisites: Basic Knowledge in Fluid Mechanics

Course Objectives:

To make the students understand the concepts & broad principles of fluid mechanics

Syllabus

Review of fundamental concepts; integral and differential forms of continuity, momentum, and energy equations; Non-dimensionalization of equations and order of magnitude analysis; Exact solution of incompressible Navier-Stokes equations; Boundary layer theory; Introduction to turbulent flow.

Course Outcome:

Students who successfully complete this course will be able to analyze the fluid flow problems (both steady and unsteady) and design the flow systems that are having application in various engineering fields.

Text Books:

1. White, F. M., Viscous Fluid Flow, Third Edition, McGraw-Hill, 2006
2. Schlitching, H., Boundary Layer Theory, Seventh Edition, McGraw-Hill, 1987.
3. Papanastasiou, T. C., Georgiou, G. C., and Alexandrou, A. N., Viscous Fluid Flow, CRC Press, 2000.
4. Muralidhar, K. and Biswas, G., Advanced Engineering Fluid Mechanics, Second edition 2005

COURSE PLAN

Course No: 09ME 6221 Course Title: AVANCED FLUID DYNAMICS **(L-T-P : 3-1-0) Credits:4**		
MODULES	**Contact hours**	**End Sem. Exam Marks;%**
MODULE : 1- Review of fundamental concepts – continuum, control volume, Eulerian and Lagrangian methods of description of fluid flow; Reynolds transport equation – integral and differential forms of continuity, momentum, and energy equations, Navier-Stokes equations and boundary conditions; Non-dimensionalization of equations and order of magnitude analysis, dimensionless parameters and their significance; classification of flows based on the characteristic Reynolds number; equations for low and high Reynolds number flows.	14	25
MODULE:2- Exact solution of incompressible Navier-Stokes equations – Couette flow, fully developed flow through ducts; flow between rotating cylinders, Stokes problems	7	13
FIRST INTERNAL TEST		
MODULE : 2 - flow near a rotating disk, low Reynolds number flows, use of vorticity and stream function, creeping flow past a sphere, hydrodynamic theory of lubrication.	7	12
MODULE : 3- Boundary layer theory, D' Alemberts paradox, Prandtl's boundary layer equations, Blasius solution and other similarity solutions of the laminar boundary layer, flow in wakes and jets, Karman's momentum integral equations, prediction of boundary layer separations;.	14	30
SECOND INTERNAL TEST		
MODULE : 4- Introduction to turbulent flow- time averaged turbulent flow equations, Reynolds stresses, eddy viscosity, mixing length hypothesis, similarity hypothesis, flow through pipes and ducts.	10	20
END SEMESTER EXAM		

Course No: 09ME 6231 Course Title: ENERGY CONVERSION SYSTEMS

Credits: 3-1-0:4 Year: 2015

Pre-requisites: Nil

Course Objectives:

To make the students understand the technology of energy conversion in conventional thermal power plants and nuclear power plants.

Syllabus

Classification of energy sources; Conventional thermal power plant design and operation, Superheat, reheat and regeneration; Gas turbine and combined cycle analysis, Inter-cooling, reheating and regeneration; Nuclear energy conversion, Nuclear power plants; Steam cycles for nuclear power plants, LOCA, Time scales of transient flow and heat transfer processes.

Course Outcome:

Students who successfully complete this course will understand the fundamental concepts of energy conversion in conventional thermal power plants and nuclear power plants; will become proficient in engineering calculations of the performance and preliminary design of these systems.

Test Books:

1. El-Wakil, M. M., Power Plant Technology, McGraw Hill, 1985
2. Culp Jr., A. W., Principles of Energy Conversion, McGraw Hill, 2001

References:

1. Sorensen, H. A., Energy Conversion Systems, J. Wiley, 1983
2. Morse, T. F., Power Plant Engineering, Affiliated East West Press, 1978
3. Winterton, R. H. S., Thermal Design of Nuclear Reactors, Pergamon Press, 1981
4. El-Wakil ,M.M., Nuclear Power Engineering , McGraw Hill
5. Murray, R. L., Introduction to Nuclear Engineering, Prentice Hall, 1961
6. Nag, P.K., Power Plant Engineering, Tata McGraw Hill, 2008

COURSE PLAN

Course No: 09ME 6231 Course Title: ENERGY CONVERSION SYSTEMS **(L-T-P : 3-1-0) Credits:4**		
MODULES	**Contact hours**	**End Sem. Exam Marks;%**
MODULE : 1- Classification of energy sources - Utilization, economics and growth rates , Fossil fuels, nuclear fuels and solar energy ,Combustion calculations ,Conventional thermal power plant design and operation - Superheat, reheat and regeneration -, Other auxiliaries of thermal plant ,High pressure boilers - Steam generator control.	13	25
MODULE : 2- Gas turbine and combined cycle analysis – Inter-cooling, reheating and regeneration-gas turbine cooling , design for high temperature	7	13
FIRST INTERNAL TEST		
MODULE : 2- Combined cycles with heat recovery boiler – Combined cycles with multi-pressure steam - STAG combined cycle power plant , Influence of component efficiencies on cycle performance.	6	12
MODULE : 3- Nuclear energy conversion, Chemical and nuclear equations , Nuclear reactions -Fission and fusion ,Energy from fission and fuel burn-up , Radioactivity ,Neutron energies - Fission reactor types , Nuclear power plants - Fast breeder reactor and power plants, Production of nuclear fuels.	13	25
SECOND INTERNAL TEST		
MODULE : 4- Fuel rod design , Steam cycles for nuclear power plants, reactor heat removal, Coolant channel orificing , Core thermal design , Thermal shields, Fins in nuclear plants , Core thermal hydraulics ,Safety analysis, LOCA - Time scales of transient flow and heat transfer processes.	13	25
END SEMESTER EXAM		

Course No: 09ME 6241 Course Title: ADVANCED HEAT TRANSFER

Credits: 3-0-0:3 **Year :2015**

Pre-requisites: Basic knowledge in Heat Transfer

Course Objectives:

Make the students to model heat transfer problems by integrating heat transfer physics with mathematical tools.

Syllabus

Review of fundamental concepts. Solutions of conduction problems using analytical and numerical methods. Forced and natural convection. Concepts of radiation.

Course Outcome:

- Develop mathematical model of heat transfer problems
- Justify the equations developed for heat transfer problems

Text Books:

1. Mayers, G.E. , Analytical methods in Conduction Heat Transfer,McGraw Hill, 1971.
2. Kays, W.M. and Crawford, M.E., Convective Heat and MassTransfer, McGraw Hill Int. Edition, 3rd edition, 1993.

References:

1. Spalding, D.B., Introduction to Convective Mass Transfer, McGraw Hill, 1963.
2. Siegel, R. and Howell, .J.R , Thermal Radiation Heat Transfer, Taylor and Francis, 2002
3. Poulikakos, Conduction Heat transfer, Prentice Hall, 1994

COURSE PLAN

Course No: 09ME 6241 **Course Title: ADVANCED HEAT TRANSFER** **(L-T-P : 3-0-0)** **Credits:3**		
MODULES	**Contact hours**	**End Sem. Exam Marks;%**
Module 1 Basic principles of heat transfer, Problem formulation, Energy balance and rate equations, Derivation of energy equation for conduction in three dimensions, Solution to elementary problems, Lumped system transients	6	20
Module 1I Solution of the general one dimensional unsteady problem by separation of variables, Laplace equation –solution by variable separable method – concept of superposition and homogeneous boundary conditions. Numerical solution of conduction problems-Basic ideas of finite difference method –forward, backward and central differences – Discretization for the unsteady heat equation.	12	25
FIRST INTERNAL TEST		
Module 1II Derivation of governing equation for convection. 2D laminar couette flow and non-dimensional numbers. Concept of Adiabatic wall temperature. Integral methods for momentum and thermal boundary layers. Pipe flow – concept of developed temperature profile and solutions.	8	20
Module 1II Solutions for constant wall flux and constant wall temperature boundary conditions. Solution of entry length problem for constant wall and constant wall flux boundary conditions. Natural convection – governing equation, integral solution for flat surface	8	20
SECOND INTERNAL TEST		
Module IV Introduction to radiation- Concept of black body, derivation of black body radiation laws from first principles, Need for view factors, Concept of view factors, mathematical definition, shape factor calculations, Radiosity, Irradiation method for grey diffuse enclosures.	5	15
END SEMESTER EXAM		

Course No: 09ME 6215 Course Title: COMPUTATIONAL METHODS

Credits: 3-0-0: 3 **Year :2015**

Pre-requisites: Nil

Course Objectives:

To make students learn computational techniques for numerical simulation, for heat transfer and fluid flow in particular.

Syllabus

Convergence and Stability issues in computational techniques (Newton Raphson and Fixed-point-Iteration as case studies), Polynomial Interpolation and Curve Fitting Using Splines, Popular methods for solution of system of linear algebraic equations, numerical integration, numerical solution of ordinary differential equations, explicit and implicit methods for PDEs and stability of the methods, control volume method, Pressure Velocity correction and SIMPLE algorithm.

Course Outcome:

On completion of the course, students would have learned the basic techniques for numerical simulation, pit falls and challenges in numerical modeling, issues related to numerical stability and the effect of time step and grid size in the results predicted. It would also apprise them of the strategies for numerical fluid flow problems, the challenges and methods of addressing them, which would help them in their future course while solving such problems either by generating a computational-code or while simulating them in CFD packages.

Text Books:

1. Chapra and Canale, Numerical Methods for Scientists and Engineers, Tata McGraw Hill,2007.
2. Patankar, S. V., Numerical Heat Transfer and Fluid Flow, Hemisphere, 1980.

References:

1. Anderson, D. A., Tannehill, J. C. and R. H. Pletcher, R. H., Computational Fluid Mechanics and Heat Transfer, Second Edition, Taylor & Francis, 1995.
2. Versteeg, H. K. and W. Malalasekera, W., An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Addison Wesley – Longman, 1995.

COURSE PLAN

Course No: 09ME 6215 Course Title: COMPUTATIONAL METHODS **(L-T-P : 3-0-0) Credits:3**		
MODULES	**Contact hours**	**End Sem. Exam Marks;%**
MODULE : 1- Taylor Series approximation of functions-finite differences, forward, backward and central differences for first and higher order derivatives, truncation and round off errors and order of accuracy, Newton Raphson and Fixed-point-iteration methods as numerical techniques for root estimation, stability and rate of convergence of these numerical solutions, Mullers method for complex roots. Interpolation and Curve Fitting using splines.	8	21
MODULE:2- Solutions of system of linear algebraic equations: Gauss' method as an Elimination Technique-Pitfalls of elimination methods and techniques for Improving Solution- Gauss-Seidal iteration – Convergence and improvement of convergence using relaxation method – Thomas algorithm for tri-diagonal systems- solution of system of nonlinear equations by Newton-Raphson method.	8	22
FIRST INTERNAL TEST		
MODULE : 3 - Numerical integration by trapezoidal and Simpson's rules, Gaussian quadrature. Numerical Methods for ordinary Differential Equations (ODE): Finite Difference Method, Runge – Kutta methods, Weighted residual method for an ODE, reduction of higher order equation to system of first order equations and solution of the simultaneous system.	9	23
MODULE : 4- Review of governing equations for heat transfer and fluid flow, numerical solution of steady state and transient heat conduction equations –explicit, implicit, semi implicit and Crank-Nicholson and Alternating-Direction-Implicit schemes, stability and convergence.	8	22
SECOND INTERNAL TEST		
MODULE : 4- The finite volume method, comparison of the finite difference, finite volumes and the finite element schemes during the formulation, treatment of boundary conditions , Upwind scheme, Pressure Velocity correction and SIMPLE algorithm for finite volume method.	6	12
END SEMESTER EXAM		

Course No: 09ME 6225 Cours

e Title: OPTIMIZATION TECHNIQUES

Credits: 3-0-0:3 **Year:2015**

Pre-requisites: Nil

Course Objectives:

To understand various optimization methods and algorithms fo xrsolving different types of optimization problems

Syllabus

Constrained and unconstrained minimization of linear and nonlinear functions of one or more variables, necessary and sufficient conditions in optimization, KKT conditions, numerical methods in unconstrained optimization, one dimensional search, steepest descent and conjugate gradient methods, Newton and quasi-Newton methods. Finite difference, analytical and automatic differentiation, linear programming, numerical methods for constrained optimization, response surface methods in optimization, orthogonal arrays, stochastic optimization methods, Evolutionary algorithms in optimization-genetic algorithm

Course Outcome:

Students who successfully complete this course will understand the fundamental concepts of different types of optimization, identify different types of optimization problems; they will gain the knowledge of how to analyze and solve various multivariable optimization problems

Text Books:

1. Ranjan Ganguli, Engineering Optimization: A Modern Approach, Universities Press, 2010.

References:

1. Smith, D.R., Variational Methods in Optimization, Dover Publication, 1998.
2. Haftka, R.T., and Gurdal, Z., Elements of Structural Optimization, Kluwer Academic Publishers, 1992.
3. Bendsoe, M.P., and Sigmund, O., Topology Optimization: Theory, Methods and Applications, Springer, 2003.
4. Hedayat, A.S., Sloane, N.J.A., Stufken, John, Orthogonal Arrays Theory and Applications.

COURSE PLAN

Course No: 09ME 6225 Course Title: OPTIMIZATION TECHNIQUES **(L-T-P :3-0-0) Credits:3**		
MODULES	**Contact hours**	**End Sem. Exam. Marks;%**
MODULE : 1- Constrained and unconstrained minimization of linear and nonlinear functions of one or more variables,	8	15
MODULE:2- Necessary and sufficient conditions in optimization, KKT conditions	5	15
FIRST INTERNAL TEST		
MODULE : 2 - Numerical methods in unconstrained optimization, one dimensional search, steepest descent and conjugate gradient methods, Newton and quasi-Newton methods	6	20
MODULE : 3-Finite difference, analytical and automatic differentiation, linear programming, numerical methods for constrained optimization	8	25
SECOND INTERNAL TEST		
MODULE : 4-Response surface methods in optimization, orthogonal arrays, stochastic optimization methods, Evolutionary algorithms in optimization-genetic algorithm	12	25
END SEMESTER EXAM		

Course No: 09ME 6235 Course Title: COMPUTATIONAL METHODS IN FLUID FLOW AND HEAT TRANSFER

Credits: 3-0-0: 3 **Year :2015**

Pre-requisites: Nil

Course Objectives:

To understand various numerical methods for solving fluid flow and heat transfer problems

Syllabus

Fundamentals of numerical analysis; Steady one-dimensional and two – dimensional steady state conduction problems in Cartesian and cylindrical co-ordinates; one-, two, and three-dimensional transient heat conduction problems in Cartesian and cylindrical co-ordinates; finite volume method for diffusion and convection–diffusion problems; steady one-dimensional convection and diffusion; solution algorithms for pressure–velocity coupling in steady flows; numerical marching techniques, two-dimensional parabolic flows with heat transfer.

Course Outcome:

Numerical analysis and design of various Flow equipments and Thermal systems.

Text Books:

1. Anderson, D. A, Tannehill, J. C., and R. H. Pletcher, R. H., Computational Fluid Mechanics and Heat Transfer, Second Edition, Taylor & Francis, 1995.
2. Patankar, S. V., Numerical Heat Transfer and Fluid Flow, Hemisphere, 1980.

References:

1. Muraleedhar, K. and T. Sundararaja, T. (eds.), Computational Fluid Flow and Heat Transfer, Second Edition, Narosa Publishing House, 2003.
2. Versteeg, H. K. and W. Malalasekera, W., An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Addison Wesley – Longman, 1995.
3. Hornbeck, R. W., Numerical Marching Techniques for Fluid Flows with Heat Transfer, NASA, SP – 297, 1973.
4. Hoffmann Klaus A., Computational Fluid Dynamics for Engineers – Volume 1, Engineering Education Systems, Wiehita

COURSE PLAN

Course No: 09ME 6235 Course Title: COMPUTATIONAL METHODS IN FLUID FLOW AND HEAT TRANSFER **(L-T-P : 3-0-0)** **Credits:3**		
MODULES	**Contact hours**	**End Sem. Exam Marks;%**
MODULE:1- Physical and mathematical classifications of partial differential equations; computational economy; numerical stability; validation of numerical results; round-off-error and accuracy of numerical results; iterative convergence, condition for convergence, rate of convergence; under – and over – relaxations, termination of iteration; tridiagonal matrix algorithm; discritization – converting derivatives to their finite difference forms – Taylor's series approach, polynomial fitting approach; discritization error.	8	20
MODULE:2- Steady one-dimensional conduction in Cartesian and cylindrical coordinates; handling of boundary conditions; two – dimensional steady state conduction problems in Cartesian and cylindrical co-ordinates– point-by-point and line-by-line method of solution.	5	15
FIRST INTERNAL TEST		
MODULE:2 - Dealing with Dirichlet, Neumann, and Robins type boundary conditions; formation of discretized equations for regular and irregular boundaries and interfaces; grid generation methods; adaptive grids.	4	10
MODULE: 3- One-, two, and three-dimensional transient heat conduction problems in Cartesian and cylindrical co-ordinates – explicit, implicit, Crank-Nicholson and ADI schemes; stability criterion of these schemes; conservation form and conservative property of partial differential and finite difference equations; consistency, stability and convergence for marching problems; discrete perturbation stability analysis, Fourier or von Neumann stability analysis.	11	30
SECOND INTERNAL TEST		
MODULE : 4- Finite volume method for diffusion and convection–diffusion problems – steady one-dimensional convection and diffusion; upwind, hybrid and power-law schemes, discritization of equation for two-dimension, false diffusion; computation of the flow field using stream function–vorticity formulation; SIMPLE, SIMPLER, SIMPLEC and QUICK schemes, solution algorithms for pressure–velocity coupling in steady flows; numerical marching techniques, two-dimensional parabolic flows with heat transfer.	11	25
END SEMESTER EXAM		

Course No: 09ME 6245 **Course Title: RELIABILITY ENGINEERING**

Credits: 3-0-0:3 **Year :2015**

Pre-requisites: Nil

Course Objectives:

To understand the basic principles of reliability engineering and its applications to various systems in engineering

Syllabus

Review of fundamental concepts of probability; reliability indices, hazard rate and hazard models, system reliability, reliability evaluation – quantitative and qualitative methods, interference theory, life testing.

Course Outcome:

Students who successfully complete this course will understand the fundamental concepts of reliability and they will be able to apply the concepts in various engineering fields.

Text Books:

1. Naikan ,A., Reliability Engineering and Life Testing, PHI, New Delhi, 2010
2. O'Connor P.D.T., Practical Reliability Engineering, John Wiley & Sons Ltd, Singapore, 2004

References:

1. Lewis, E.E., Introduction to Reliability Engineering, John Wiley & Sons, 1995.
2. Modarres, Reliability and Risk analysis, Mara Dekker Inc., 1993.
3. Kapur, K.C. and Lamberson, L.R., Reliability in Engineering Design, John Wiley & Sons, 1977

COURSE PLAN

Course No: 09ME 6245 Course Title: RELIABILITY ENGINEERING **(L-T-P : 3-0-0) Credits:3**		
MODULES	**Contact hours**	**End Sem. Exam Marks;%**
MODULE : 1- Probability: Conditional probability, Bayes theorem, Probability distributions – Normal, Lognormal, Poisson, Exponential and Weibull distributions – relationship between them and their significance - central tendency and dispersion Reliability: Definitions, Importance, Quality and reliability, bath tub curve -Failure data analysis: Hazard rate, failure rate, MTTF, MTBF, reliability functions, hazard functions, Availability and Maintainability Point estimation and interval estimation, goodness of fit tests – Chi-square and KS tests, Parameter estimation for normal and exponential distribution – method of moments and MLE.	10	25
MODULE:2- Reliability hazard models: Parts stress model, Constant, linearly increasing and time dependent failure rates, Weibull model, distribution functions and reliability analysis	5	13
FIRST INTERNAL TEST		
MODULE : 2 - System Reliability: System configurations, series, parallel, mixed configurations, k out of m system, standby systems	4	12
MODULE : 3- Reliability evaluation using Markov model, Development of logic diagram, set theory, optimal cut set and tie set methods, Markov analysis Fault tree analysis and event tree analysis – FMEA/FMECA	10	25
SECOND INTERNAL TEST		
MODULE : 4- Interference theory and reliability computations Normal, exponential and Weibull stress - strength distributions, Life Testing – Objectives, Types - Censoring, replacement, accelerated life testing – Temperature stress and failure rates – stress combinations, accelerated cycling, HALT and HASS.	10	25
END SEMESTER EXAM		

Course No: 09ME 6251 Course Title: RESEARCH METHODOLOGY

Credits: 0-2-0: 2 **Year :2015**

Objectives:

Generating a good understanding of research methodology

Syllabus: -

Research Methodology: An Introduction; steps in research process**;** conceptualizing a research design; methods of data collection; Mathematical modeling and simulation; Design of Experiments; Measures of relationship; Research writing in general.

Course Outcome:

Develop ability to handle a research problem in a systematic way and also establish ideas to write a good report.

Text books:

1. Ranjit Kumar, "Research Methodology: A Step-by-step Guide for Beginners", Pearson, Second Edition
2. Kothari, C.R, "Research Methodology : Methods and Techniques", New age International publishers

References:

1. Wayne Goddard and Stuart Melville, "Research Methodology : An Introduction", 2nd Edition, 2001, Juta & Co Ltd.
2. J.W Bames, Statistical Analysis for Engineers and Scientists, McGraw Hill, N.York
3. Schank Fr., Theories of Engineering Experiments, Tata Mc Graw Hill Publication.
   Willktnsion K. L, Bhandarkar P. L, Formulation of Hypothesis, Himalaya Publication

COURSE PLAN

Course No.: 09ME 6251 Course Title: RESEARCH METHODOLOGY **(L-T-P : 0-2-0) Credits:2**		
MODULES	**Contact hours**	
MODULE:1- Research Methodology: An Introduction Meaning of Research, Objectives of Research, Motivation in Research, Applications of Research, Definition of Research, Characteristics of Research, Types of Research, Steps in Research Process-Reviewing the Literature, Formulating a Research Problem, Identifying Variables,	6	
MODULE:2- Conceptualizing a research design:-Definition of a Research Design, Need for Research Design, Functions of Research Design, Features of a Good Design, Methods of Data Collection:-Collection of Primary Data, Observation Method, Interview Method, Collection of Data through Questionnaires, Collection of Data through Schedules.	6	
FIRST INTERNAL TEST		
MODULE: 3- Mathematical modeling and simulation – Concepts of modeling – Classification of mathematical models – Modeling with – Ordinary differential equations – Difference equations – Partial differential equations – Graphs – Simulation – Process of formulation of model based on simulation. Design of Experiments- uncertainty analysis, Measures of relationship-Correlation – correlation coefficient for ungrouped data and grouped data, rank correlation, auto correlation, linear regression - simple regression and multiple regression.	9	
SECOND INTERNAL TEST		
MODULE : 4- Research writing in general, Referencing, Developing an outline, Interpretation of Data and Paper Writing – Layout of a Research Paper, Journals in Mechanical Engineering, Impact factor of Journals, When and where to publish ? Ethical issues related to publishing, Plagiarism and Self-Plagiarism Software for paper formatting like LaTeX/ MS Office	5	
END SEMESTER EXAM		

Course No.:09ME 6261 **Course Title: SEMINAR**

Credits: 0-0-2:2 **Year 2015**

Objectives: *To assess the debating capability of the student to present a technical topic. Also to impart training to a student to face audience and present his ideas and thus creating in him / herself esteem and courage that are essential for an engineer.*

Individual students are required to choose a topic of their interest from energy related topics preferably from outside the M.Tech syllabus and give a seminar on that topic about 30 minutes. A committee consisting of at least three faculty members (preferably specialized in Mechanical engineering) shall assess the presentation of the seminar and award marks to the students. Each student shall submit two copies of a write up of his / her seminar topic. One copy shall be returned to the student after duly certifying it by the Chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

Course Outcome:

Attain good presentation skill.

Course No.:09ME 6271 Course Title: ENERGY SYSTEMS LAB

Credits: 0-0-2: 1 Year :2015

Course Objectives

To acquaint with energy systems and their basic principles.
To acquire knowledge on various advanced energy conversion equipments

Syllabus

1. Experimental study of solar water heating systems
2. Experimental study of solar PV cells
3. Analysis and study of bio-mass gasifier based power plant
4. Performance monitoring of refrigeration systems
5. Performance evaluation of IC engine in computerised test rig
6. Experimental study of horizontal axis wind turbine
7. Experimental study of electrolysis
8. Experimental study of fuel cell
9. Efficiency evaluation of pumps, fans and compressors
10. Energy efficiency in motors
11. Design of measurement and control systems using virtual instrumentation software
12. Power quality measurements

Course Outcome:

Students who successfully complete this course will understand the fundamental concepts of energy conversion systems and measure various parameters for evaluating the efficiency. They will be able to use measured data for performance evaluation of various equipments and systems.

Text Books:

1. El-Wakil, M. M., Power Plant Technology, McGraw Hill, 1985
2. Culp Jr. A.W., Principles of Energy Conversion, McGraw Hill, 2001

References:

1. Sorensen, H. A., Energy Conversion Systems, J. Wiley, 1983
2. Morse, T. F., Power Plant Engineering, Affiliated East West Press, 1978

Course No: 09ME 6212 Course Title: DESIGN OF ENERGY EQUIPMENTS

Credits: 3-1-0: 4 **Year :2015**

Pre-requisites: Nil

Course Objectives:

To provide knowledge on design of pressure vessels and piping and to impart the concepts of design of heat transfer equipments.

Syllabus:

Introduction to Presssure vessels; theory and design of shell of pressure vessels, various types of head, Elastic buckling of vessels and introduction to piping. Heat exchangers-classification – theory - design of shell and tube, plate, compact heat exchangers and regenerators

Course Outcome:

To get familiarized with the various theories and practice on various energy equipments and procedures which are necessary to solve the industrial practical problems that arise and also for the research in the field of design of energy equipments.

Text Books:

1. Harvey,J.F., Theory and Design of Pressure Vessels, CBS Publishers and Distributors, 1987.
2. Brownell, L. E., and Young, E. H., Process Equipment Design, John Wiley and Sons
3. Kern, D. Q., Process Heat Transfer, Tata McGraw-Hill, 2000.

References:

1. Henry H. Bedner, Pressure Vessels, Design Hand Book , CBS Publishers and Distributors, 1987.
2. Stanley, Wales, M., Chemical Process Equipment, Selection and Design, Buterworths series in Chemical Engineering, 1988.
3. ASME Pressure Vessel Codes Section VIII, 1998.
4. Fraas, A. P., Heat Exchanger Design, Second Edition, John Wiley & Sons, 1989.
5. Hewitt , Process heat transfer .
6. Das, S.K., Process heat transfer, Narosa publishing house,2005.

COURSE PLAN

Course No: 09ME 6212 Course Title: DESIGN OF ENERGY EQUIPMENTS **(L-T-P : 3-1-0) Credits:4**		
MODULES	**Contact hours**	**End Sem. Exam. Marks;%**
MODULE : 1- Factors influencing the design of pressure vessels, design criterion of elliptical, hemispherical, conical, toriconical and torispherical heads, Stresses in pressure vessels, Autofrettage, Thermal stresses, Design of pressure vessel components such as shell, heads, Nozzles, Flanges as per ASME & IS codes.	13	25
MODULE: 2 - Design of vessels - Buckling phenomenon – Elastic buckling of circular ring and cylinders under external pressure.	7	13
FIRST INTERNAL TEST		
MODULE : 3 - Stiffeners for vessels. Piping- - Flexibility analysis- Design as per ANSI Codes.	6	12
MODULE : 4 - Heat exchangers - classification – selection – heat transfer and flow friction characteristics – pressure drop analysis – basic thermal design – theory of heat exchangers – E-NTU, P-NTU and MTD method - F-factor for various configurations - applications to design. Shell and tube heat exchanger – construction and thermal features – thermal design procedure – Kern method – Bell Delaware method.	13	25
SECOND INTERNAL TEST		
MODULE : 5 - Thermal design of regenerators – classifications – governing equations – design parameters. Design of compact heat exchangers – plate and fin, fin-tube and plate and frame heat exchangers – fouling and corrosion in heat exchanger.	13	25
END SEMESTER EXAM		

Course No: 09ME 6222 **Course Title: ADVANCED INSTRUMENTATION SYSTEM**

Credits: 3-0-0: 3 **Year :2015**

Pre-requisites: Nil

Course Objectives:

To understand the basic principles of instrumentation and working of various measuring devices

Syllabus

Dynamic characteristics, Post processing of experimental data, Measurement of thermophysical properties, fluid velocity and pressure, Thermometry, radiation properties of surfaces, Measurement of power, gas concentration and light intensity.

Course Outcome:

Students who successfully complete this course will understand the fundamental concepts of instrumentation and measurement systems; they will gain the knowledge of how to perform measurement of various parameters, selection of instruments and analyze measured data.

Text Books:

1. Venkatesan, S. P., Mechanical measurements, Ann publications, 2008
2. Holman, J. P., Experimental Methods for engineers, Tata McGraw Hill, 2010

References:

1. Doebelin, E. O., Measurements Systems: Application and Design, McGraw Hill, 2010
2. Eckert, E. R. G. and Goldstein R. J., Measurements in Heat Transfer, McGraw Hill, 1976
3. Beckwith,T. G., Marangoni, R. D. and Lienhard, J. H., Mechanical measurements, Pearson Education, 2001
4. Ghosh, A.K., Introduction to measurements and Instrumentation, PHI, 2012
5. Barney, Intelligent Instrumentation, Prentice Hall, 1988.

COURSE PLAN

Course No: 09ME 6222 Course Title: ADVANCED INSTRUMENTATION SYSTEM **(L-T-P: 3-0-0)** **Credits: 3**		
MODULES	**Contact hours**	**End Sem. Exam Marks;%**
MODULE : 1- Dynamic characteristics - zero, first and second order instruments - step, ramp, frequency and impulse response – Data acquisition - analog and digital conversion, Post processing of experimental data - statistical analysis - goodness of data - correlating data - linear and non-linear regression.	10	25
MODULE:2- Measurements of viscosity - use of Poiseuille flow, falling and rotating bodies, Thermal conductivity of solids, liquids and gases - measurement of calorific value of fuels.	5	13
FIRST INTERNAL TEST		
MODULE : 2 - Fluid pressure measurement – pressure transducers – low pressure measurement Fluid velocity measurement - anemometer, Doppler velocitymeter.	4	12
MODULE : 3- Temperature measurement - thermoelectric and resistance thermometry, pyrometry - systematic errors in temperature measurements – measurement of heat flux - high temperature measurement in gases – calorimetric probe and optical measurements - Schlieren shadow - graph and interferometer, Measurement of radiation properties of surfaces – reflectivity and emissivity.	10	25
SECOND INTERNAL TEST		
MODULE : 4- Force, acceleration, torque and shaft power measurement Gas concentration measurement – Non separation and separation methods Light intensity and Electrical power measurement.	10	25
END SEMESTER EXAM		

Course No: 09ME 6232 Course Title: RENEWAB LE ENERGY SYSTEMS

Credits: 3-0-0: 3 Year:2015

Pre-requisites: Nil

Course Objectives: *To understand the principles of renewable energy technologies.*

Syllabus

Renewable energy scenario in India, their reserves, potentials, applications and environmental aspects. Solar thermal energy, their collection ,utilization and applications. Solar photovoltaic technology. Wind energy systems, Biomass and Biogas energy resources and other non conventional energy resources including tidal energy, wave energy, geothermal energy, OTEC, hydro, fuel cells etc.

Course Outcome:

Students who successfully complete this course will gain knowledge of various renewable energy technologies including solar energy, wind energy, biomass energy, biogas, tidal energy, wave energy, geothermal energy, OTEC, hydro, fuel cells etc. They will understand the working principle and applications of each and will be able to compare and suggest the technology suited for a particular application/location.

Text Books:

1. G.D Rai :Non conventional Energy Sources. Khanna Publishers, New Delhi
2. S.P Sukhatme : Solar Energy. Tata McGraw Hill Publishing company Ltd, New Delhi

References:

1. Godfrey Boyle : Renewable energy, Power for a sustainable future. Oxford University press U.K
2. Twidell J W & Weir A : Renewable energy sources. EFN spon Ltd U.K
3. G N Tiwary : Solar Energy-Fundamental Design, modelling and application. Narosa Publishing house, New Delhi
4. L LFreris : Wind energy conversion system. Prentice Hall U K

COURSE PLAN

Course No: 09ME 6232 Course Title: RENEWAB LE ENERGY SYSTEMS **(L-T-P : 3-0-0) Credits:3**		
MODULES	**Contact hours**	**End Sem. Exam. Marks;%**
MODULE : 1- World energy use – Reserves of energy resources – Environmental aspects of energy utilisation– Renewable energy scenario in India – Potentials – Achievements – Applications.	10	25
MODULE:2- Solar thermal – Flat plate and concentrating collectors – Solar heating and cooling techniques –Solar desalination – Solar Pond – Solar cooker	5	13
FIRST INTERNAL TEST		
MODULE : 2 - Solar thermal power plant – Solar photo voltaic conversion – Solar cells – PV applications.	4	12
MODULE : 3-Wind data and energy estimation – Types of wind energy systems – Performance – Details ofwind turbine generator – Safety and Environmental Aspects. Biomass direct combustion – Biomass gasifier – Biogas plant – Ethanol production – Bio diesel – Cogeneration – Biomass applications.	10	25
SECOND INTERNAL TEST		
MODULE : 4- Tidal energy – Wave energy – Open and closed OTEC Cycles – Mini and Micro hydro –Geothermal energy – Fuel cell systems.	10	25
END SEMESTER EXAM		

Course No: 09ME 6216 Course Title: ENERGY EFFICIENT BUILDINGS

Credits: 3-0-0:0 Year: 2015

Pre-requisites: Nil

Course Objectives:

To make the students understand the principles & design of energy efficient buildings

Syllabus

Modern architecture, Thermal comfort, Heating and cooling loads, Principles of Energy conscious building design, Heat gain/loss through building components, solar heating, Cooling, Thermal storage wall, Energy conservation in building**,** Control systems for energy efficient buildings, Intelligent building design principles.

Course Outcome:

Students who successfully complete this course will get a general understanding of the principles of energy conscious building design, the different opportunities for energy conservation in building, utilizing renewable energy resources in improving the energy efficiency of buildings.

Text Books

1. Clarke, J.A. , Energy Simulation in Building Design ,(2e), Butterworth, 2001.
2. Nayak, J.K. and Prajapati, J.A. , Handbook on Energy Conscious Buildings, Solar Energy Control MNES, 2006.

References:

1. Energy Conservation Building Codes 2006, Bereau of Energy Efficiency.
2. Williams, J.R., Passive Solar Heating, Ann Arbar Science, 1983.
3. Jones, R.W. , Balcomb, J.D., Kosiewiez, C.E. , Lazarus, G.S. , McFarland, R.D., and Wray, W.O., Passive Solar Design Handbook, Vol.3, Report of U.S. Department of Energy (DOE/CS-0127/3),1982.
4. Sodha, M.S. , Bansal, N.K., Bansal, P.K. ,Kumar, A and Malik, M.A.S., Solar Passive Building, Science and Design, Pergamon Press, 1986.
5. Threlkeld, J.L. , Thermal Environmental Engineering, Prentice Hall, 1970.

COURSE PLAN

Course No: 09ME 6216 Course Title: ENERGY EFFICIENT BUILDINGS **(L-T-P : 3-0-0) Credits:3**		
MODULES	**Contact hours**	**End Sem. Exam. Marks;%**
MODULE : 1- Climate and shelter – Historic buildings – Modern architecture – Examples from different climate zones – Thermal comfort – Solar geometry and shading – Heating and cooling loads – Energy estimates and site planning – Integrative Modeling methods and building simulation.	10	25
MODULE:2- Principles of Energy conscious building design – Energy conservation in buildings – Day lighting – Water heating and photovoltaic systems.	5	13
FIRST INTERNAL TEST		
MODULE : 2 - Advances in thermal insulation – Heat gain/loss through building components – Solar architecture.	4	12
MODULE : 3-Passive solar heating – Direct gain – Thermal storage wall – Sunspace – Convective air loop – Passive cooling – Ventilation – Radiation – Evaporation and Dehumidification – Mass effect – Design guidelines.	10	25
SECOND INTERNAL TEST		
MODULE : 4- Energy conservation in building–Air conditioning–HVAC equipments– Computer packages for thermal design of buildings and performance prediction – Monitoring and instrumentation of passive buildings – Control systems for energy efficient buildings – Illustrative passive buildings – Integration of emerging technologies – Intelligent building design principles.	10	25
END SEMESTER EXAM		

Course No. 09ME 6226 Course Title: WIND ENERGY AND UTILIZATION

Credits: 3-0-0: 3 **Year: 2015**

Pre-requisites: Nil

Course Objectives:

To understand various methods available for utilization of wind energy

Syllabus

Historical developments and state of the art of wind energy technology in Indian scenario, turbine rating, wind power plant economics, installation and operation costs, decommissioning,
wind resource characteristics and assessment .Aerodynamics of aerofoil, design of wind turbine blade; blade materials. Vertical and horizontal axis turbines, design characteristics, tip losses;
rotational sampling, wind turbine design programs, aerodynamic loads, tower shadow, wind shear, blade coning, gyroscopic, transient and extreme loads. Aerodynamic damping and stability Power train dynamics. effect of wind turbulence. Converter and Inverter interfaces for wind energy, isolated and grid connected system. Wind farm electrical design, Planning, maintenance and operation, wind farm management, site selection. Environmental assessment, Instrumentation.

Course Outcome:

Students who successfully complete this course will be capable of selection and design of wind energy systems

Text books:

1. Joshua Earnest and Tore Wizelius, Wind Power Plants and Project Development, PHI Learning Pvt. Ltd., New Delhi, 2011.
2. Johnson, G. L., Wind Energy Systems, Manhattan, KS, 2004
3. Lysen, E. H. , Introduction to Wind Energy, CWD Report 82-1, Consultancy Services Wind Energy Developing Countries, CWD 82-1, Consultancy Services Wind Energy Developing Countries, The Netherlands, May 1983.
4. Erich Hau, Wind Turbines- Fundamentals: Technologies, Application, and Economics. Springer - Verlag Berlin -Heidelbeg, 2000.

References:

1. Sathyajith Mathew, wind energy: fundamentals, resource analysis and economics, Springer - Verlag Berlin -Heidelbeg, 2005
2. Ahmed,Wind Energy Theory and Practice, PHI, Eastern Economy Edition, 2012
3. Freris, L.L., Wind Energy Conversion System, Printice Hall.
4. Tony Burton, Wind energy Hand Book, John Wiley & Sons Inc.

COURSE PLAN

Course No. 09ME 6226 Course Title: WIND ENERGY AND UTILIZATION **(L-T-P : 3-0-0) Credits:3**		
MODULES	**Contact hours**	**End Sem. Exam. Marks;%**
MODULE : 1- Historical developments and state of the art of wind energy technology, Indian scenario. turbine rating, wind power plant economics, installation and operation costs, decommissioning, Nature of atmospheric winds; wind resource characteristics and assessment; anemometry; wind statistics; speed frequency distribution, effect of height, wind rose, Weibull distribution, atmospheric turbulence, gust wind speed, effect of topography	8	25
MODULE:2- Aerodynamics of aerofoil; lift; drag; stall; effect of Reynold's number; actuator disc; momentum theory and Betz coefficient; design of wind turbine blade; effect of stall and blade pitch on coefficient of power vs tip speed ratio and cut-out wind speeds, blade materials.	8	10
FIRST INTERNAL TEST		
MODULE:2 - Vertical and horizontal axis turbines, design characteristics, multiple stream tube theory, vortex wake structure; tip losses; rotational sampling, wind turbine design programs, aerodynamic loads, tower shadow, wind shear, blade coning, gyroscopic, transient and extreme loads. Aerodynamic damping and stability, teetering motion, stiff and soft towers, Power train dynamics.	8	15
MODULE: 3- Pitch control, yaw control, Electrical and Mechanical aerodynamic braking, teeter mechanism. Wind turbine dynamics with DC and AC generators: induction and synchronous generators, variable speed operation, effect of wind turbulence. Power electronics Converter and Inverter interfaces for wind energy utilization system for isolated and grid connected system	8	25
SECOND INTERNAL TEST		
MODULE : 4- Wind farm electrical design, Planning of wind farms, special application for developing countries, maintenance and operation, wind farm management, site selection. Environmental assessment; noise, visual impact etc. Instrumentation, data loggers, remote monitoring and control.	7	25
END SEMESTER EXAM		

Course No: 09ME 6236 Course Title: CRYOGENICS

Credits: 3-0-0: 3 Year :2015

Pre-requisites: Nil

Course Objectives: *Generating a good understanding of various cryogenic systems*

Syllabus

Gas liquefaction systems **;** gas separation and purification; cryogenic refrigeration systems; cryogenic temperature measurement; cryogenic fluid storage and transfer systems, two-phase flow in cryogenics transfer systems, cool down process; introduction to vacuum technology, low temperature properties of materials, pump down time, application of cryogenic systems.

Course Outcome: Analysis, design and development of different cryogenic systems.

Text Book

1. Barron, R., Cryogenic Systems, McGraw-Hill, 1966.

References

1. Timmerhaus, K. D. and Flynn, T. M., Cryogenic Process Engineering, Plenum Press, 1989.
2. Scott, R. B., Cryogenic Engineering, D'Van-Nostrand, 1962.
3. Vance, R. W. and Duke, W. M., Applied Cryogenic Engineering, John Wiley, 1962.
4. Sitting, M., Cryogenics, D' Van-Nostrand, 1963

COURSE PLAN

Course No: 09ME 6236 Course Title: CRYOGENICS **(L-T-P : 3-0-0) Credits:3**		
MODULES	**Contact hours**	**End Sem. Exam Marks;%**
MODULE:1- Gas liquefaction systems, thermodynamically ideal systems, Joule Thomson effect, adiabatic expansion; liquefaction system for air, Neon, hydrogen and helium, effect of component efficiencies on system performance.	10	25
MODULE:2- Gas separation and purification – principles, plant calculation.	4	12
FIRST INTERNAL TEST		
MODULE:2 - air, hydrogen, and helium separation systems.	5	13
MODULE: 3- Cryogenic refrigeration systems, ideal and practical systems, cryogenic temperature measurement; cryogenic fluid storage and transfer systems, storage vessels and insulation, two-phase flow in cryogenics transfer systems, cool down process.	10	25
SECOND INTERNAL TEST		
MODULE : 4 Introduction to vacuum technology, low temperature properties of materials, pump down time, application of cryogenic systems, super-conductive devices, rocket and space simulation, cryogenics in biology and medicine, cryopumping.	10	25
END SEMESTER EXAMINATION		

Course No: 09ME 6246 Course Title: MATERIAL ENGINEERING AND TRIBOLOGY

Credits: 3-0-0: 3 **Year :2015**

Pre-requisites: Nil

Course Objectives:

To make students learn fundamentals of tribology so as to enable them to address materials and tribological problems in energy conversion systems, and also to make them equipped for a research on tribology at a later stage.

Syllabus

Engineering materials and their classification, alloys and their applications in engines and gas turbines. Theories of Wear, quantification and case studies. Lubrication theories, Stribeck curve, roughness-parameters and surface characterization. Surface Analysis using SEM, XPS etc. Lubricant selection and the state of the art in lubricant technology.

Course Outcome:

On completion of the course, students would have learned essential elements related to materials application in energy conversion systems (heat engines and turbines), analyse wear problems in engineering systems, appreciate the role played by the regimes of lubrication in governing the tribological issue, materials characterization methods like SEM, EDS, XPS etc. The course would also teach about selection of lubricants, and the latest research in lubricant technology.

Text Books:

1. Stachowiak,G.W., Batchelor,A.W., Engineering Tribology, Butterworth-Heinemann, 2013.
2. Williams,J., Engineering Tribology, Cambridge University Press, 2005.

References:

1. Collins,J.A., Failure of Materials in Mechanical Design: Analysis, Prediction, Prevention, John Wiley & Sons; 2nd Edition, 1993.
2. Bharat Bhushan, Modern Tribology Handbook, Two Volume Set, CRC Press, 2000.

COURSE PLAN

Course No: 09ME 6246 Course Title: MATERIAL ENGINEERING AND TRIBOLOGY **(L-T-P : 3-0-0)** **Credits:3**		
MODULES	**Contact hours**	**End Sem. Exam. Marks;%**
MODULE : 1- Engineering Materials- Classification: Metals, Alloys etc.,- Phase diagrams. Stainless steels, Material alloys for engine components and gas turbines with emphasis on manufacturing methods. High temperature behaviour of materials, creep, creep mechanisms, creep testing methods, hot corrosion, high temperature oxidation. Methods of combating these failure scenarios.	10	30
MODULE:2- Alloys and surface treatment for wear resistance in engines. Theories of wear, Quantification of wear, wear parameters, experimental wear rate estimation, Wear Maps, Case studies of wear resistance in mechanical components, Effect of material structure on wear , Strategies for wear resistance.	9	20
FIRST INTERNAL TEST		
MODULE : 3 Role of friction in the wear of metallic systems- Effect of Lubricant action on wear and friction- Theories of friction- Regimes of lubrication- Stribeck curve- Effect of roughness of friction- Roughness Parameters, Surface Characterisation- Contact Analysis- Plasticity Index.	9	25
MODULE : 4 Surface analysis using Profilometers, SEM: secondary and back scattered modes in SEM, EDS (EDX) in SEM, XPS (ESCA), FTIR and XRD. Lubricants-Structure, properties and action. Selection of Lubricants-antifriction and anti wear additives.	7	18
SECOND INTERNAL TEST		
MODULE : 4- New generation lubricants, role of Nanotechnology in lubricant synthesis- case studies. Green Lubricants, opportunities and Challenges.	4	7
END SEMESTER EXAM		

Course No: 09ME 6266 Course Title: SOLAR ENGINEERING

Credits: 3-0-0: 3 Year 2015

Pre-requisites: Nil

Course Objectives:

To understand the basics of solar engineering, its collection and its applications.

Syllabus

Sun and it's Energy; Measurement of Solar Radiation; Collection of Solar Energy ; Flat plate collectors- Analysis of flat plate collectors; Solar Air Heater ; Solar Water heater; Solar Concentrators; Passive Solar House; Solar Distillation; Solar Cookers; Solar Refrigeration

Course Outcome:

Students who successfully complete this course will understand the basic concepts of solar Engineering; they will gain the knowledge of how to estimate the hourly, monthly and yearly solar radiations at different places and will be able to design various solar system.

Text Books:

1. Sukhatme, Solar Engineering. Tata Mc Graw Hill ,2005

References:

1. Tiwari, G.N. and Sayesta Suneja., Solar Thermal Engineering Systems, Narosa Publishing House.
2. Gupta, H.P., Solar Engineering
3. Duffie and Backuran, Solar Thermal Engineering.

COURSE PLAN

Course No: 09ME 6266 Course Title: SOLAR ENGINEERING **(L-T-P : 3-0-0) Credits:3**		
MODULES	**Contact hours**	**End Sem. Exam Marks;%**
MODULE : 1- Sun and it's Energy: Solar spectrum, solar constant & solar radiations, Sun earth angles, solar hourly radiations - Radiations on Horizontal and inclined surfaces. Measurement of Solar Radiation: Pyrheliometer, Pyranometer, Sunshine-Recorder.	10	25
MODULE:2- Collection of Solar Energy : Flat plate collectors, classification, construction, heat transfer coefficients, optimization of heat losses - Analysis of flat plate collectors, testing of collectors	5	13
FIRST INTERNAL TEST		
MODULE : 2 -Solar Air Heater : Description & classification, conventional air heater, air heater above the collector surface air heaters with flow on both sides of absorbers to pan air heater, air heater with finned absorbers, porous absorber.	4	12
MODULE : 3- Solar Water heater: Collection cum storage water heater, Natural circulation & forced circulation water heater, shallow solar ponds. Solar Concentrators: Classification, characteristic parameters, types of concentrators materials in concentrators.	10	25
SECOND INTERNAL TEST		
MODULE : 4- Passive Solar House: Thermal gain, Thermal cooling, Ventilation. Energy Storage: Sensible heat storage, Liquid, Solid, packed bed, Latent heat storage. Solar Distillation, Solar Cookers, Solar Refrigeration.	10	25
END SEMESTER EXAMINATION		

Course No: 09ME 6276 Course Title: ADVANCED THERMODYNAMICS AND COMBUSTION

Credits: 3-0-0: 3 **Year: 2015**

Pre-requisites: Nil

Course Objectives:

To understand the principals of combustion and broaden the knowledge in thermodynamics

Syllabus

First law of thermodynamics applied to combustion, stoichiometric combustion, equivalence ratio calculations, adiabatic flame temperature. Second law of thermodynamics, concept of chemical equilibrium and equilibrium constants, Gibbs free energy. Exergy concepts.
Chemical kinetics, Premixed and diffusion combustion Gas jets and combustion of gaseous fuel jets. Flashback and liftoff. Detonation and deflagration. Ignition, Flammability limits and quenching. Fuels and properties, Vaporization and Combustion of liquid fuel droplet. Drop and particle size , Combustion of a coal particle. Flame stabilization.

Course Outcome:

Students who successfully complete this course will be able to evolve various design and operational parameters involved in a combustion system

Text books:

1. Stephen R. Turns , An introduction to combustion: Concepts and Applications McGraw-Hill Series in Mechanical Engineering
2. Kuo, K.K., Principles of combustion, Wiley Inter science , New york,1986.
3. Mukunda H.S, Understanding combustion, Narosa publications, India

References:

1. Glassman, I. Yetter ,R.A. and Glumac, N.G., Combustion, fifth edition, Academic press.2014
2. Cengel, Y.A and Boles,M.A., Thermodynamics an engineering approach, sixth edition, Tata McGraw Hill Pub.2008.
3. Murthy,K.A., Introduction to combustion, Golden and Breach, New York, 1975.
4. Sharma, S.P and Chandra Mohan, Fuels and combustion, McGraw Hill, 1984.

COURSE PLAN

Course No: 09ME 6276 Course Title: ADVANCED THERMODYNAMICS AND COMBUSTION **(L-T-P : 3-0-0)** **Credits:3**		
MODULES	**Contact hours**	**End Sem. Exam Marks;%**
MODULE : 1- Thermodynamics-equation of state, properties of gas mixtures, First law of thermodynamics, enthalpy of formation and heat of reaction, stoichiometric combustion and equivalence ratio calculations, calculation of adiabatic flame temperatures at constant volume and constant pressure.	10	25
MODULE:2- Second law of thermodynamics and concept of chemical equilibrium, equilibrium constants, Composition products in equilibrium. Gibbs free energy. Exergy concepts – flow and non-flow exergy.	5	13
FIRST INTERNAL TEST		
MODULE:2 - Chemical kinetics- elementary and global reactions, chain initiation, branching and termination reactions. molecularity, order of reaction, reaction rate equation – activation energy, collision theory of reaction rates, geometric and energy factor.	5	12
MODULE: 3- Premixed and diffusion combustion – laminar and turbulent flame structures and characteristics. Flame velocity and influencing factors. Gas jets and combustion of gaseous fuel jets. Flashback and liftoff. Detonation and deflagration. Ignition – minimum ignition energy. Flammability limits and quenching of laminar flames.	10	25
SECOND INTERNAL TEST		
MODULE : 4- Fuels and properties– fuel properties and measurement, Vaporization and Combustion of liquid fuel droplet. Drop and particle size - Sauter mean diameter. Combustion of a coal particle. Flame stabilization.	9	25
END SEMESTER EXAM		

Course No: 09ME 6286 Course Title: REFRIGERATION ENGINEERING

Credits: 3-0-04 Year :2015

Pre-requisites: Nil

Course Objectives: *Generating a good understanding of various refrigeration systems*

Syllabus

Introduction to refrigeration systems; Vapor compression refrigeration system; Vapor absorption system; Different types of Refrigeration systems- details and applications ; Advanced vapor compression systems Vapor Absorption system – Description – analysis – applications; Solar based refrigeration technologies ; Introduction to Magnetic refrigeration; Principles and application of steam jet refrigeration system ; Conventional and alternative refrigerants .

Course Outcome:

Students who successfully complete this course will be able to identify the type of refrigeration system and can explain the working of different refrigeration systems; they will gain the knowledge of how to analyze the Vapor Compression and Vapor Absorption Refrigeration Systems that are having application in various engineering fields.

Text Books:

1. Arora C. P, Refrigeration and Air conditioning-Tata Mc Graw Hill, 2004

References:

1. Gosney W. B, Principles of Refrigeration, Cambridge University Press, 1983
2. Stanley W Angrist, Direct Energy conversions, Allyn & Bacon, 1982
3. Goldsmid, Thermoelectric Refrigeration, Springer, 1st Ed. 1995
4. Arora, Ramesh Chandra , Refrigeration and Air-conditioning, PHI, Eastern Economy Edition, 2012

COURSE PLAN

Course No: 09ME 6286 Course Title: REFRIGERATION ENGINEERING **(L-T-P : 3-0-0) Credits:3**		
MODULES	**Contact hours**	**End Sem. Exam. Marks;%**
MODULE : 1- Introduction to refrigeration systems, Review of basics - methods of refrigeration, units of refrigeration, COP. Vapor compression refrigeration system, vapor absorption system. Magnetic refrigeration, pulse tube refrigeration, acoustic refrigeration, Thermo electric refrigeration, vortex tube refrigeration -details and applications.	10	25
MODULE:2- Advanced vapor compression systems – compound compression, multi stage evaporation. Vapor Absorption system – Description – analysis – applications.	5	13
FIRST INTERNAL TEST		
MODULE : 2 - Solar based refrigeration technologies – absorption and adsorption type systems.	4	13
MODULE : 3- Introduction to Magnetic refrigeration - magneto-caloric effect, magnetic materials, advantages over traditional refrigeration system. Principles and application of steam jet refrigeration system – performance analysis	10	25
SECOND INTERNAL TEST		
MODULE : 4- Conventional and alternative refrigerants – Refrigerant Designation-Need for alternative refrigerants –environmental issues – mixture refrigerants – modifications required for retrofitting, safety precautions and compatibility of refrigerants.	10	25
END SEMESTER EXAM		

Course No: 09ME 6296 Course Title: NANO-SCIENCE AND TECHNOLOGY

Credits: 3-0-0: 3 **Year :2015**

Pre-requisites: Nil

Course Objectives:

To make students learn the fundamentals of nano-science and technology, especially in the context of energy conversion systems.

Syllabus

Synthesis of Nanomaterials including chemical methods and lithographic techniques, Analytical methods- Spectroscopic and other methods (TGA, DTA, DSC etc.), Thin film technology-growth techniques and characterization, Nanotechnology in photovoltaic systems.

Course Outcome:

On completion of the course, students would have learned essential elements of Nano-science and technology, with special emphasis on thin films and Photo Voltaic Technology. The course is designed as a primer to Nano-science and engineering which should serve as a basis for further studies and research in these areas.

Text Books:

1. Pradeep, T.,NANO: The Essentials: Understanding Nanoscience and Nanotechnology, McGraw Hill Education (India) Private Limited; 1st edition, 2007.
2. Ramachandra Rao,M.S and Shubra Singh, Nanoscience and Nanotechnology: Fundamentals to Frontiers, Wiley India Private Limited, 2013.

References:

1. Yong X. Gan, Advanced Materials and Systems for Energy Conversion, Nova
2. SciencePublishers Inc., NewYork, 2010.
3. Cao, Guozhong, Ying Wang, Nanostructures and Nanomaterials - Synthesis, Properties and Applications -, World Scientific, 2011.
4. Loucas Tsakalakos, Nanotechnology for Photovoltaics,CRC Press, Boca Raton, 2010.

COURSE PLAN

Course No: 09ME 6296 Course Title: NANO-SCIENCE AND TECHNOLOGY **(L-T-P : 3-0-0) Credits:3**		
MODULES	**Contact hours**	**End Sem. Exam Marks;%**
MODULE : 1- Synthesis of Nanomaterials: Chemical precipitation and co-precipitation; Sol-gel synthesis; Microemulsions or reverse micelles; Solvothermal synthesis; Thermolysis routes, Microwave heating synthesis; Sonochemical synthesis; photolithography, other optical lithography (EUV, X-Ray, LIL), particle-beam lithographies (e-beam, FIB, shadow mask evaporation), scanning probe lithographies.	10	30
MODULE:2- Analytical Techniques: Scanning Probe Microscope (AFM and STM); XPS, Scanning Electron Microscopy; Transmission Electron Microscopy; X-ray Diffraction; FTIR, and Raman Spectroscopy. Thermal Gravimetric Analysis (TGA); Differential thermal analysis (DTA); Differential scanning calorimetry (DSC); BET surface area analyzer; Dynamic Light Scattering .	9	20
FIRST INTERNAL TEST		
MODULE : 3 Thin Film Technology: Introduction to thin films, Thin film growth techniques with examples and limitations; Spin and dip coating; Langmuir Blodgett technique; Metal organic chemical vapor deposition; Electron Beam Deposition; Pulsed Laser deposition; DC, RF and Reactive Sputtering; Molecular beam epitaxy; Characterization of Thin films and surfaces; Thin Film processing from Devices and other applications perspective.	9	25
MODULE : 4 Nanomaterials for Solar Energy and Photovoltaics: Solar cell technologies (Si-wafer based, Thin film, GaAs based, dye-sensitized, PESC and organic solar cells), Efficiency of solar cells and PV array analysis.	6	16
SECOND INTERNAL TEST		
MODULE : 4- Photovoltaic system design (stand alone and grid connected) and applications; Case study for performance evaluation and problem identification in wide-spread commercialization of the technology.	5	9
END SEMESTER EXAM		

Course No: 09ME 6262 Course Title: MINI PROJECT

Credits: 0-0-4:2 **Year :2015**

Course Objectives:

To practice the steps involved for the selection, execution, and reporting of the project.
To train the students for group activities to accomplish an engineering task.

For Mini Project, individual students are required to choose a topic of their interest. The subject content of the mini project shall be from emerging / thrust areas, topics of current relevance having research aspects or shall be based on industrial visits. At the end of the semester, the students should submit a report duly authenticated by the respective guide, to the head of the department.

Course Outcome:

Should be able to design and fabricate an experimental set up or able to model and simulate available experimental results.

Course No: 09ME 6272 Course Title: MODELING AND SIMULATION LABORATORY

Credits: 0-0-2: 1 Year :2015

Course Objectives:

To develop a thorough understanding of the Programming of numerical methods, Computer Aided Finite Element Analysis and CFD analysis packages with an ability to effectively use the tools of the analysis for solving practical problems arising in design.

Syllabus

WRITING PROGRAMS AND DEMONSTRATION ON

- Declination of earth, hour angle, day length, local apparent time
- Monthly average, hourly global and diffuse radiation on a horizontal surface and tilted surfaces.
- Power generation from a wind turbine, Variation of wind velocity and power with altitude
- Solution of one-dimensional steady state heat conduction equation
- Roots of algebraic and transcendental equations
- Solution of simultaneous algebraic equations
- Curve fitting and optimization
- Numerical integration and differentiation
- Numerical solution of ODEs: Initial value problems
- Numerical solution of ODEs: Boundary value problems
- Numerical solution of PDEs

FINITE ELEMENT ANALYSIS

- Two dimensional heat conduction
- One dimensional transient heat conduction

CFD ANALYSIS

- Flow through a pipe bend
- Flow through a nozzle

References

1. S.C.Chapra and R.P. Canale: Numerical Methods for Engineers, 2nd edn, McGraw Hill, 1990
2. Y. Jaluria: Computer Methods for Engineers, 2nd edn, McGraw Hill, 1990
3. J.M.L. Smith and J.C. Wolford: Applied Numerical Methods for digital computation, Harper & Row, 1977

Course Outcome:

To get familiarized with the various theories and practice on various energy equipments and procedures which are necessary to solve the industrial practical problems that arise and also for the research in the field of design of energy equipments.

Course No: 09ME 7217 Course Title :TURBOMACHINERY

Credits: 3-0-0:3 Year :2015

Pre-requisites: Nil

Course Objectives:

To make the students understand the concepts & broad principles of hydro and thermal turbo machines

Syllabus

Definition and classification of turbomachines ; energy transfer in turbo machines; Euler equation of turbo machinery; Flow mechanism through the impeller; Degree of reaction Similarity; Cavitations in pumps and turbines ;Steam turbines; gas turbines; hydraulic turbines

Course Outcome:

Students who successfully complete this course will have the ability to describe the energy transfer mechanism in turbomachines and will be able to estimate the specific work. They will gain the knowledge of how to evaluate the performance of Steam turbine, Gas turbine and Hydraulic turbines that are having application in various engineering fields.

Text Books:

1. Gopalakrishnan, G. and Prithviraj, D., Treatise on Turbomachines,Schitech Publications,2002

References:

1. Yahya, S. M., Turbines, Compressors and Fans, Tata McGraw-Hill, 1983.
2. Shepherd, D. G., Principles of Turbomachinery, Macmillan Publishing Company, 1957.
3. Csanady, G. T., Theory of Turbomachines, McGraw-Hill, 1964.
4. Dixon, S. L., Fluid Mechanics, Thermodynamics of Turbomachinery, Third Edition, Pergamon Press, 1978.
5. Nechleba, M., Hydraulic Turbine, Arita, 1957.

COURSE PLAN

Course No: 09ME 7217 Course Title :TURBOMACHINERY **(L-T-P : 3-0-0) Credits:3**		
MODULES	**Contact hours**	**End Sem. Exam Marks;%**
MODULE : 1- Definition and classification of turbomachines; principles of operation; specific work and its representation on T-s and h-s diagrams; losses and efficiencies; energy transfer in turbo machines; Euler equation of turbo machinery.	10	25
MODULE:2- Flow mechanism through the impeller – velocity triangles, ideal and actual flows, slip and its estimation;	5	13
FIRST INTERNAL TEST		
MODULE : 2 - degree of reaction - impulse and reaction stages; significance of impeller vane angle.	4	12
MODULE : 3- Similarity; specific speed and shape number; cavitations in pumps and turbines; performance characteristics of pumps and blowers; surge and stall; thin aerofoil theory; cascade mechanics	10	25
SECOND INTERNAL TEST		
MODULE : 4- Steam turbines - flow through nozzles, compounding, effect of wetness in steam turbines; gas turbines; hydraulic turbines – Pelton, Francis and Kaplan turbines, draft tube, performance and regulation of hydraulic turbines.	10	25
END SEMESTER EXAM		

Course No: 09ME 7227 Course Title: POWER GENERATION AND SYSTEM PLANNING

Credits: 3-0-0: 3 **Year :2015**

Pre-requisites: Nil

Course Objectives:

To make the students understand the basics of power generation and its control systems.

Syllabus

Overview of the Indian power sector, Advanced power cycles, Overview of nuclear power plant, Steam turbine, Hydro-power plants, Power plant control systems, Analysis of system load curve, Maintenance Scheduling Pricing of Power, Least Cost Power Planning.

Course Outcome:

Students who successfully complete this course will understand the fundamental concepts of power generations such as nuclear power plant, steam turbine and hydro power plant. They will also have an understanding of power plant control systems, analysis of systems and maintenance scheduling and pricing of power.

Text Books:

1. R.W.Haywood, Analysis of Engineering Cycles, 4th Edition, Pergamon Press, Oxford, 1991
2. A.B.Gill, Power Plant Performance, Butterworths, 1984.

References:

1. D. Lindsay, Boiler Control Systems, Mcgraw Hill International, London, 1992.
2. H.G. Stoll, Least Cost Electrical Utility / Planning, John Wiley & Sons, 1989.
3. T.M. O' Donovan, Short Term Forecasting: An introduction to the Box Jenkins Approach, Wiley, Chichester, 1983.

COURSE PLAN

Course No: 09ME 7227 Course Title: POWER GENERATION AND SYSTEM PLANNING (L-T-P :3-0-0) Credits:3		
MODULES	**Contact hours**	**End Sem. Exam Marks;%**
MODULE : 1- Overview of the Indian power sector, Thermodynamic analysis of Conventional Power Plants, Advanced Power Cycles, Kalina (Cheng) Cycle, IGCC, AFBC/PFBC, Overview of Nuclear power plant, Radio activity, Cross sections, Fission process, reaction rates, diffusion theory, elastic scattering and slowing down, criticality calculations, critical heat flux, power reactors, nuclear safety.	9	25
MODULE:2- Steam Turbine – Super heater, re-heater and partial condenser vacuum. Combined Feed heating and Re-heating. Regenerative Heat Exchangers, Re-heaters and Intercoolers in Gas Turbine power plants.	6	13
FIRST INTERNAL TEST		
MODULE : 2 - Hydro power plants - turbine characteristics. Auxiliaries - Water Treatment Systems, Electrostatic Precipitator / Flue gas Desulphurisation, Coal crushing / Preparation - Ball mills / Pulverisers, ID/FD Fans, Chimney, Cooling Towers.	6	13
MODULE : 3-Power plant control systems- Review of control principles, Combustion control, pulveriser control, control of air flow, Furnace pressure and feed water, steam temperature control, Safety provisions / Interlocks	8	25
SECOND INTERNAL TEST		
MODULE : 4- Analysis of System load curve -plant load factor, availability, Loss of load Probability calculations for a power system, Maintenance Scheduling Pricing of Power - Project cost components, Analysis of Power Purchase Agreements (PPA), Debt/Equity Ratio and effect on Return on Investment, Environmental Legislations/Government Policies Optimal Dispatch - Scheduling of Hydro-Thermal plants. Load Forecasting - Time series, Econometric, end use techniques. Least Cost Power Planning - Integration of DSM, Renewables into supply.	10	25
END SEMESTER EXAM		

Course No: 09ME 7237 Course Title: CO-GENERATION AND WASTE HEAT RECOVERY SYSTEM

Credits: 3-1-0:4 **Year: 2015**

Pre-requisites: Nil

Course Objectives:

To make the students understand the concepts & broad principles of Co-generation and waste heat recovery system

Syllabus

Combined cycle, organic rankine cycle, concept of tri generation, cogeneration systems, configuration and thermodynamic performance; cogeneration plants; waste heat recovery technologies, Waste heat boilers; Investment cost, economic concepts , measures of economic performance , procedure for economic analysis.

Course Outcome:

Students who successfully complete this course will understand the fundamental concepts of co-generation systems and their types; the co-generation plants their impact and their applications. They will gain the knowledge of different waste heat recovery technologies, their design considerations, applications and economic analysis.

Text Books

1. Horlock JH, Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford, 1987.
2. Institute of Fuel, London, Waste Heat Recovery, Chapman and Hall Publishers, London, 1963
3. Charles H.Butler, Cogeneration, McGraw Hill Book Co., 1984.

References:

1. EDUCOGEN – The European Educational tool for cogeneration, Second Edition, 2001
2. Sengupta Subrata, Lee SS EDS, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.
3. De Nevers, Noel, Air Pollution Control Engineering, McGrawHill, New York, 1995.

COURSE PLAN

Course No: 09ME 7237 Course Title: CO-GENERATION AND WASTE HEAT RECOVERY SYSTEM **(L-T-P : 3-0-0)** **Credits:**3		
MODULES	**Contact hours**	**End Sem. Exam Marks;%**
MODULE : 1- Introduction - principles of thermodynamics – cycles – topping, bottoming , combined cycle - organic rankine cycles – performance indices of cogeneration systems, waste heat recovery – sources and types – concept of tri generation. Configuration and thermodynamic performance – steam turbine cogeneration systems ,gas turbine cogeneration systems ,reciprocating IC engines cogeneration systems , combined cycles cogeneration systems ,advanced cogeneration systems, fuel cell, Stirling engines etc.,	10	25
MODULE:2- Cogeneration plants electrical interconnection issues – utility and cogeneration plant interconnection issues- applications of cogeneration in utility sector.	5	13
FIRST INTERNAL TEST		
MODULE : 2 - Industrial sector ,building sector ,rural sector, impacts of cogeneration plants – fuel, electricity and environment.	4	12
MODULE : 3- Selection criteria for waste heat recovery technologies - recuperators , Regenerators , economizers , plate heat exchangers ,thermic fluid heaters , Waste heat boilers classification, location, service conditions, design considerations - fluidized bed heat exchangers, heat pipe exchangers , heat pumps , sorption systems.	10	25
SECOND INTERNAL TEST		
MODULE : 4- Investment cost – economic concepts – measures of economic performance – procedure for economic analysis – examples – procedure for optimized system selection and design – load curves - sensitivity analysis – regulatory and financial frame work for cogeneration and waste heat recovery systems.	10	25
END SEMESTER EXAM		

Course No: 09ME 7247 Course Title: ENERGY CONSERVATION AND HEAT RECOVERY SYSTEM

Credits: 3-0-0: 3 **Year :2015**

Pre-requisites: Nil

Course Objectives:

To impart basic knowledge about energy conservation and heat recovery system.

Syllabus

Energy conservation schemes, Waste heat management, Energy auditing; Thermodynamics and economics, Investment optimization, Process improvements, Effective management of energy use; Thermodynamic analysis of common unit operations, Systematic design methods, Improving process operations; waste heat boilers, Power economics, General economic problems.

Course Outcome:

Students who successfully complete this course will be able to select appropriate energy conservation method to reduce the wastage of energy in process industries and to evaluate the techno economic feasibility of the energy conservation technique adopted.

Text Books:

1. Kenney, W.F., Energy Conservation in the Process Industries, Academic Press, 1984
2. Thummann, A.P.E., Fundamentals of Energy Engineering, Prentice Hall, 1984

References:

1. Chiogioji, M.H., Industrial Energy Conservation, Marcel Dekker, 1979
2. Thummann, A.P.E.,Plant Engineers and Managers Guide to Energy Conservation, van Nostrand, 1977
3. Murphy, W. R. and McKay, G.,Energy Management, Butterworth-Heinemann, 2001
4. Dubin, F.B., Energy Conservation Standards, McGraw Hill, 1978

COURSE PLAN

Course No: 09ME 7247 Course Title: ENERGY CONSERVATION AND HEAT RECOVERY SYSTEM **(L-T-P : 3-0-0)** **Credits:3**		
MODULES	**Contact hours**	**End Sem. Exam Marks;%**
MODULE : 1- Definition of energy management - Energy conservation schemes - Optimizing steam usage - Waste heat management - Insulation - Optimum selection of pipe size – Energy conservation in space conditioning – Energy and cost indices - Energy diagrams – Energy auditing - Thermodynamic availability analysis – Thermodynamic efficiencies - Available energy and fuel.	10	25
MODULE : 2- Thermodynamics and economics - Systematic approach to steam pricing - Pricing other utilities – Investment optimization - Limits of current technology - Process improvements - Characterizing energy use	5	13
FIRST INTERNAL TEST		
MODULE : 2 - Optimum performance of existing facilities - Steam trap principles - Effective management of energy use - Overall site interactions - Total site cogeneration potential - Linear programming approach.	4	12
MODULE : 3- Thermodynamic analysis of common unit operations - Heat exchange - Expansion - Pressure let down – Mixing - Distillation - Combustion air pre-heating – Systematic design methods - Process synthesis - Application to cogeneration system – Thermo-economics - Systematic optimization - Improving process operations – Chemical reactions - Separation - Heat transfer - Process machinery - System interaction and economics.	10	25
SECOND INTERNAL TEST		
MODULE : 4- Potential for waste heat recovery - Direct utilization of waste heat boilers – Use of heat pumps – Improving boiler efficiency - Industrial boiler inventory – Use of fluidized beds - Potential for energy conservation – Power economics - General economic problems - Load curves - Selections of plants - Specific economic energy problems - Energy rates.	10	25
END SEMESTER EXAM		

Course No: 09ME 7267 Course Title: ENERGY POLICIES FOR SUSTAINABLE DEVELOPMENT

Credits: 3-0-0: 3 Year:2015

Pre-requisites: Nil

Course Objectives:

To impart basic knowledge about energy policies for sustainable development.

Syllabus

Energy policies of India, energy policies and development, Energy and environment, Greenhouse effect, Environmental laws, Energy conservation schemes, Capital investments in energy saving equipment, Social cost benefit analysis, Energy planning, energy management systems.

Course Outcome:

Students who successfully complete this course will be able to critically analyze the various energy policies, their effect on environment and society. They will also gain knowledge of energy auditing, social cost benefit analysis, energy planning and energy management systems.

Text Books:

1. Goldemberg, J. , Johansson, T.B. , Reddy, A.K.N and Williams, R.H. ,Energy for a Sustainable World, Wiley Eastern, 1990

References:

1. IEEE Bronze Book, Energy Auditing, IEEE Publications, 1996
2. Chandra, P.,Financial Management Theory and Practice, Tata McGraw Hill, 1992
3. Annual Energy Planning Reports of CMIE, Govt. of India
4. Reddy, A.K.N. and Bhalla A.S., The Technological Transformation of Rural India, UN Publications, 1997
5. Reddy, A.K.N., Williams, R.H. and. Johanson, J.B., Energy After Rio-Prospects and Challenges, UN Publications, 1997
6. Meier, P. and Munasinghe, M., Energy Policy Analysis & Modeling, Cambridge University Press, 1993
7. Pindyck, R.S. and Rubinfeld, D.L., Economic Models and Energy Forecasts, 4e, McGraw Hill, 1998

COURSE PLAN

Course No: 09ME 7267 Course Title: ENERGY POLICIES FOR SUSTAINABLE DEVELOPMENT **(L-T-P : 3-0-0) Credits:3**		
MODULES	**Contact hours**	**End Sem. Exam Marks;%**
MODULE : 1- Energy policies of India - Supply focus approach and its limitations - Energy paradigms – defendus approach - end use orientation - energy policies and development - case studies on the effect of Central and State policies on the consumption and wastage of energy - Critical analysis - Need for renewable energy policies in India.	10	25
MODULE:2- Energy and environment - Greenhouse effect - Global warming - Global scenario - Indian environmental degradation	5	13
FIRST INTERNAL TEST		
MODULE : 2 - Environmental laws - Water (prevention & control of pollution) act 1974 - The environmental protection act 1986 - Effluent standards and ambient air quality standards - Latest development in climate change policies & CDM.	4	12
MODULE : 3-Energy conservation schemes - Statutory requirements of energy audit - Economic aspects of energy audit - Capital investments in energy saving equipment - Tax rebates - Advantages of 100% depreciation – India's plan for a domestic energy cap & trade scheme.	10	25
SECOND INTERNAL TEST		
MODULE : 4- Social cost benefit analysis - Computation of IRR and ERR - Advance models in energy planning – Dynamic programming models in integrated energy planning - Energy planning case studies - Development of energy management systems - Decision support systems for energy planning and energy policy simulation.	10	25
END SEMESTER EXAM		

Course No: 09ME 7277 Course Title: ELECTRICAL ENERGY SYSTEMS AND MANAGEMENT

Credits: 3-0-0: Year :2015

Pre-requisites: Nil

Course Objectives:

To make the students understand the concepts of electrical energy systems

Syllabus

Overall structure of electrical systems,Energy efficiency,Electricity audit instruments,Lighting,Luminaries, Types and operating characteristics of electric motors,Industrial drives,Pumps and fans,Electric loads of air conditioning and refrigeration,Furnace operation and scheduling, Computer controls case studies.

Course Outcome:

Students who successfully complete this course will understand the overall structure of electrical system, its economic operation, energy efficiency, energy accounting and monitoring and lighting systems. A basic understanding of operating characteristics of electric motors and Electric loads of air conditioning and refrigeration is expected.

Text Books:

1. IEEE Bronze Book: IEEE Standard 739-1984 – Recommended Practice for Energy Conservation and Cost Effective Planning in Industrial Facilities, IEEE Publications, 1996.
2. Thumann, A.P.W., Plant Engineers and Managers Guide to Energy conservation, 7e, UNR, 1977.

References:

1. Partab, H. , Art and Science of Utilisation of Electrical Energy, Pritam, 1985.
2. Tripathy, Electric Energy Utilization and Conservation, Tata McGraw Hill, 1991.
3. Turner, W.C. Energy Management Handbook, 2nd edn., Fairmont press, 1993.
4. UNESCAP- Guide Book on Promotion of Sustainable Energy Consumption (www.unescap.org/enrd/energy)

COURSE PLAN

Course No: 09ME 7277 Course Title: ELECTRICAL ENERGY SYSTEMS AND MANAGEMENT **(L-T-P :3-0-0)** **Credits:3**		
MODULES	**Contact hours**	**End Sem. Exam Marks;%**
MODULE : 1 Overall structure of electrical systems – Supply and demand side – Economic operation – Input-output curves – Load sharing – Industrial Distribution – Load profiling – Electricity tariff types and calculation – Reactive Power – Power factor – Capacitor sizing – Capacitor losses, location, placement and maintenance – Case studies.	9	25
MODULE:2- Energy efficiency,Energy accounting, monitoring and control , Electricity audit instruments , Energy consumption models , Specific Energy Consumption , ECO assessment and Evaluation methods , Transformer loading/efficiency analysis , Feeder loss evaluation	6	13
FIRST INTERNAL TEST		
MODULE : 2 - Lighting – Energy efficient light sources – Domestic/commercial/industrial lighting – Lighting controls – Energy conservation in lighting schemes – Luminaries – Case studies	5	12
MODULE : 3- Types and operating characteristics of electric motors – Energy efficient control and starting – Load matching – Selection of motors – Efficiency and load analysis – Energy efficiency – High efficiency motors – Industrial drives – Control schemes – Variable speed drives and Energy conservation schemes – Pumps and fans – Efficient control strategies – Over-sizing - Case studies.	10	25
SECOND INTERNAL TEST		
MODULE : 4- Electric loads of air conditioning and refrigeration – Energy conservation – Power consumption in compressors – Energy conservation measures – Electrolytic process – Electric heating – Furnace operation and scheduling – Cogeneration schemes – Optimal operation – Case studies – Computer controls – Software – EMS.	9	25
END SEMESTER EXAM		

Course No: 09ME 7287 Course Title: COMBUSTION AND EMISSIONS IN IC ENGINES

Credits: 3-0-0: 3 **Year: 2015**

Pre-requisites: Nil

Course Objectives:

Understanding combustion and pollutant formation in IC engines

Syllabus

Combustion fundamentals, exhaust gas analysis. Measurement of combustion parameters in IC engines, Combustion in S.I. and C.I engine, design considerations for combustion chambers. Advanced combustion concepts - Common rail direct injection, homogenous charged compression ignition, gasoline direct injection. Air motion in engines, Major pollutants in SI and CI engines – sources, formation, measuring principles and instruments..

Course Outcome:

Students who successfully complete this course will be capable of selection and development of appropriate combustion and emission control strategies for IC engines

Text books

1. Stephen R. Turns , An introduction to combustion: Concepts and Applications McGraw-Hill Series in Mechanical Engineering
2. Obert,E.F., Internal Combustion Engine and Air Pollution, International Text Book Publishers, 1983
3. John B. Heywood, Internal Combustion Engine Fundamentals, McGraw Hill Book, 1998

References

1. Ferguson, C.R and Kirkpatrick, A.T. , IC engines - Applied Thermosciences, John Wiley & Sons, second edition, 2004.
2. Richard Stone, introduction to IC engines, Palgrave Macmillan Books, 4 th edition,2012
3. Heinz Heisler, Advanced Engine Technology, E. Arnold Publication, 1995.
4. B.P Pundir, Engine Emissions: Pollutant Formation and Advances in Control Technology, Narosa Publishing House Pvt. Ltd., Delhi, 2007.

COURSE PLAN

Course No: 09ME 7287 Course Title: COMBUSTION AND EMISSIONS IN IC ENGINES **(L-T-P : 3-0-0)** **Credits:3**		
MODULES	**Contact hours**	**End Sem. Exam Marks;%**
MODULE : 1- Combustion fundamentals– Heat of combustion, adiabatic flame temperature, premixed and diffusion combustion, combustion stoichiometry – exhaust gas analysis. Measurement of combustion parameters in IC engines	9	25
MODULE:2- Combustion in S.I. engine: Initiation of combustion, phases of combustion, design considerations for combustion chambers..	4	10
FIRST INTERNAL TEST		
MODULE:2 - . Flame structure and speed, Cycle by cycle variations, combustion systems - lean burn, stratified charge, gasoline direct injection.	4	10
MODULE: 3- Combustion in C.I. engine: phases of combustion, vaporization of fuel droplets and spray formation, air motion, swirl measurement, design considerations for combustion chambers, Advanced combustion concepts - Common rail direct injection, homogenous charged compression ignition	10	25
SECOND INTERNAL TEST		
MODULE : 4- Emissions: Major pollutants in SI and CI engines – sources and formation of NO_x, HC, CO and smoke emissions. Soot formation and oxidation, Particulates in diesel engines, Emission control measures for SI and CI engines, Instruments for emission measurements - Smoke meters, NDIR, FID, Chemiluminescence analyzers.	12	30
END SEMESTER EXAM		

Course No: 09ME 7297 Course Title: ENERGY MODELING AND MANAGEMENT
Credits: 3-0-0:3 Year: 2015

Pre-requisites: Nil

Course Objectives:

To impart basic knowledge about energy modeling and management

Syllabus

Models and modeling approaches, energy demand analysis and forecasting, macroeconomic concepts, Economics of Energy Sources, Econometric Methods, Economics of Waste Heat Recovery and Cogeneration; Basic concept of econometrics and statistical analysis, Econometric techniques used for energy analysis and forecasting, Input – Output Analysis; Energy Modeling, Modeling concept, and application, Simulation and forecasting of future energy demand; Project Evaluation & Management, Financial analysis, Network analysis for project management, Project evaluation techniques

Course Outcome:

Students who successfully complete this course will understand the fundamental concepts of energy modelling and will be able to apply the principles of economics and management techniques to evaluate energy projects.

Text books

1. Energy Policy Analysis and Modeling, M.Munasinghe and P.Meier Cambridge University Press 1993
2. Th, Donnelly W.A. Econometrics of Energy Demand: A Survey of Applications New York 1987.

References:

1. Econometrics Models and Economic Forecasts, S.Pindyck and Daniel L.Rubinfeld, 3rd edition MC Graw -Hill, New York. 1991
2. Sectoral Energy Demand Studies: Application of the END-USE Approach to Asian Countries,UNESCAP, New York 1991.
3. Guide Book on Energy -Environment Planning in Developing Countries- Methodological Guide on Economic Sustainability and Environmental Betterment Through Energy Savings and Fuel Switching in Developing Countries, UN-ESCAP, New York 1996
4. Forecasting Methods and Applications, S.Makridakis , Wiley 1983

COURSE PLAN

Course No: 09ME 7297 Course Title: ENERGY MODELING AND MANAGEMENT **(L-T-P : 3-0-0) Credits:3**		
MODULES	**Contact hours**	**End Sem. Exam Marks;%**
MODULE: 1- Models and modelling approaches**:** Multiplier Analysis-Energy Aggregation-Econometric Energy Demand Modelling-Overview of Econometric Methods. Methodology of Energy Demand Analysis-Methodology for Energy Technology Forecasting-Sectoral Energy Demand Forecasting. Economics of Waste Heat Recovery and Cogeneration-Energy Conservation Economics.	10	25
MODULE:2- Basic concept of econometrics and statistical analysis: The 2-variable regression model; The multiple regression model; Tests of regression coefficients and regression equation; Econometric techniques used for energy analysis and forecasting with case studies form India;	5	13
FIRST INTERNAL TEST		
MODULE : 2 - Basic concept of Input-output analysis; concept of energy multiplier and implication of energy multiplier for analysis of regional and national energy policy; Energy and environmental Input - Output analyses using I-O model	5	12
MODULE:3-Energy Modeling: Modeling concept, and application, Methodology of energy demand analysis; Methodology for energy forecasting; Sectoral energy demand forecasting; SIMA model, and I-O model for energy policy analysis; Simulation and forecasting of future energy demand consistent with macroeconomic parameters in India; Energy Economics and Policies	9	25
SECOND INTERNAL TEST		
MODULE : 4- Project Evaluation & Management: Financial analysis; Project planning matrix; Aims oriented project planning; Social cost benefit analysis. Network analysis for project management; Time estimation; PERT, CPM and CERT; Fuzzy logic analysis; Stochastic based formulations; Project evaluation techniques; Project material management, evaluation & analysis; Implementation and monitoring; Performance indices; Case studies	10	25
END SEMESTER EXAM		

Course No: 09ME 7263 **Course Title: SEMINAR**

Credits: 0-0-2:2 **Year: 2015**

Course Objectives:

To assess the debating capability of the student to present a technical topic. Also to impart training to a student to face audience and present his ideas and thus creating in him / herself esteem and courage that are essential for an engineer.

- Individual students are required to choose a topic of their interest from energy related topics preferably from outside the M.Tech syllabus and give a seminar on that topic about 30 minutes. A committee consisting of at least three faculty members (preferably specialized in Mechanical engineering) shall assess the presentation of the seminar and award marks to the students. Each student shall submit two copies of a write up of his / her seminar topic. One copy shall be returned to the student after duly certifying it by the Chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

Course Outcome:

Attain good presentation skill.

Course No: 09ME 7283 Course Title: MASTERS RESEARCH PROJECT (PHASE – I)

Credits: 0-0-12: 6 Year: 2015

Course Objective:

To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes. The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.

The project work can be a design project / experimental project and or computer simulation project on engineering or any of the topics related with energy engineering stream. The project work is allotted individually on different topics. The students shall be encouraged to do their project work in the parent institute itself. If found essential, they may be permitted to continue their project outside the parent institute subject to the conditions in clause 10 of M.Tech regulations. Department will constitute an Evaluation Committee to review the project work. The Evaluation committee consists of at least three faculty members of which internal guide and another expert in the specified area of the project shall be two essential members.

The student is required to undertake the masters research project phase-I during the third semester and the same is continued in the 4^{th} semester.(Phase-II). Phase-I consists of preliminary thesis work, two reviews of the work and the submission of preliminary report. First review would highlight the topic, objectives, methodology and expected results. Second review evaluates the progress of the work, preliminary report and scope of the work which is to be completed in the 4^{th} semester

Course Outcome:

- Attain the ability to design and fabricate an experimental setup or to simulate an industrial problem.
- Create an aptitude towards research in the area of interest.

Course No: 09ME 7284 Course Title: MASTERS RESEARCH PROJECT (PHASE –I I)

Credits: 0-0-21: 12 Year 2015

Course Objectives:

To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes. The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.

Requirements

Masters Research project phase-II is a continuation of project phase-I started in the third semester. Before the end of the fourth semester, there will be two reviews, one at middle of the fourth semester and other towards the end. In the first review, progress of the project work done is to be assessed. In the second review, the complete assessment (quality, quantum and authenticity) of the Thesis is to be evaluated. Both the reviews should be conducted by guide and Evaluation committee. This would be a pre qualifying exercise for the students for getting approval for the submission of the thesis. At least one technical paper is to be prepared for possible publication in journal or conferences. The technical paper is to be submitted along with the thesis. The final evaluation of the project will be external evaluation.

Course outcome

- Attain the ability to design and fabricate an experimental setup or to simulate an industrial problem.
- Create an aptitude towards research in the area of interest.