Rajasthan Technical University (RTU)
Mechanical
(Thermal Engineering)

M. Tech Program in Mechanical Engineering with specialization in
Thermal Engineering

Courses

The theory subjects will be of maximum 125 Marks each having 25 Marks as course work and 100 Marks for University examination.

First Semester

S. No.	Code No.	***Subject***	L	T	P	Marks	Ex. Hrs.
1.	1METE1	Advanced Fluid Mechanics	3	1	0	125	3
2.	1METE2	Advanced Thermodynamics	3	1	0	125	3
3.	1METE3	Numerical Methods	3	1	0	125	3
4.	1METE4	Advanced Heat Transfer	3	1	0	125	3
5.	1METE5	Thermal Engineering Lab - I	0	0	3	100	3
Total			12	4	3	600	

Second Semester

S. No.	Code No.	***Subject***	L	T	P	Marks	Ex. Hrs.
6.	2METE6	Computational Methods in Fluid Flow and Heat Transfer	3	1	0	125	3
7.	2METE7	Design of Thermal Systems	3	1	0	125	3
8.	2METE8	Thermal Power Plant Engineering	3	1	0	125	3
9.	2METE9	Turbo Machines	3	1	0	125	3
10.	2METE10	Thermal Engineering Lab - II	0	0	3	100	3
Total			12	4	3	600	

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Third Semester

S. No.	Code No.	***Subject***	L	T	Marks	Ex. Hrs.
11.	3METE 11	Elective 1	3	1	125	3
12.	3METE 12	Elective 2	3	1	125	3
13.	3METE 13	Seminar			150	
14.	3METE 14	Dissertation –I			100	
Total			6	2	500	

Fourth Semester

S. No.	Code No.	***Subject***	L	T	Marks	Ex. Hrs.
15.	4METE 15	Dissertation -II			500	
Total					500	

List of Electives (For 3METE11 & 3METE12):

Choose any two out of six given below.

3METE11&12.1:Theory and Design of Heat Exchangers

3METE11&12.2:Advanced Refrigeration and Air-conditioning Techniques

3METE11&12.3:Fuel Cell Technology

3METE11&12.4:Convection

3METE11&12.5:Numerical Methods in Conduction

3METE11&12.6:Advanced Gas Turbine and IC Engines

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1 METE 1: ADVANCED FLUID MECHANICS

3L+1T **MM:125** **Ex.Hrs. 3**

Basic Equations ;
Deformation and the rate of strain, the deformation tensor, skew-symmetry of the deformation tensor, symmetry of the stress tensor, polar and non-polar fluids, stokesian and Newtonian fluids.
Derivation of the general differential equations of continuity, momentum and energy in vector form; Euler and Navier-Stokes equations, integration of the momentum equation; the generalized Bernoulli's equation.

Two Dimensional Irrotational Flow:
Two dimensional flow in rectangular and polar coordinates; continuity equation and the stream function, irrotationality and the velocity potential function, vorticity and circulation, plane potential flow and the complex potential function.
Sources, sinks, doublets and vortices; superposition of uniform stream with above; flow around corners; Rankine ovals, flow around circular cylinders with the without circulation, pressure distribution on the surface of these bodies.
Elements of two dimensional aerofoils theory, symmetrical aerofoil theory; lift and moment.

Vortex Motion:
Definitions, vortex lines, surfaces and tubes, vorticity, circulation; Kelvin's circulation theorem, Helmholtz's vorticity theorems; the convection and diffusion of vorticy.

Viscous Flow:
Exact solution, plane Poiselie and Couette flows; Hagen Poiselle flow through pipes.
Flows with very small Reynolds number.
Flows with very large Reynolds number, elements of two dimensional boundary layer theory; displacement thickness and momentum thickness, skin friction, Blassius solution for boundary layer on a flat plate without pressure gradient; the Karman-Polhausen integral method for obtaining approximate solutions.
Drag on bodies; form drag and skin friction drag profile drag and its measurement.

1MERET2: ADVANCED THERMODYNAMICS (Common for 1METE2 & 1MERET2)

3L+1T MM:125 Ex.Hrs. 3

Review of basic thermodynamic principles; entropy; availability; irreversibility; first and second law analysis of steady and unsteady systems;

General thermodynamics relations; Fundamentals of partial derivatives; relations for specific heats; internal energy enthalpy and entropy; Joule - Thompson coefficient; Clapeyron equation.

Multi component systems; Review of equation of state for ideal and real gases; thermodynamic surfaces; gaseous mixtures; fugacity; ideal solutions; dilute solutions; activity; non ideal liquid solutions.

Multi component phase equilibrium ; Criteria of equilibrium; stability; heterogeneous equilibrium; binary vapour liquid systems; the nucleus of condensation and the behaviour of stream with formation of large and small drops; Gibbs Phase rule; higher order phase transitions.

Thermodynamics of chemical reaction (combustion); internal energy and enthalpy - first law analysis and second law analysis; basic relations involving partial pressures; third law of thermodynamics; chemical equilibrium and chemical potential equilibrium constants; thermodynamics of low temperature.

Statistical mechanics - Maxwell - Boltzmann statistics; microstate and macrostates; thermodynamic probability; entropy and probability Bose Einstein statistics; Fermi Dirac statistics.

Elementary concepts of irreversible thermodynamics

1METE3: NUMERICAL METHODS (Common for IMETE3 & 1MERET3)

Approximations: Accuracy and precision, definitions of round off and truncation errors, error propagation Algebraic equations : Formulation and solution of linear algebraic equations, Gauss elimination, LU decomposition, iteration methods (Gauss - Siedel), convergence of iteration methods, eigen values and eigen vectors. Interpolation methods: Newton's divided difference, interpolation polynomials, Lagrange interpolation polynomials. Differentiation and Integration: High accuracy differentiation formulae, extrapolation, derivatives of unequally spaced data, Gauss quadrature and integration. Introduction to optimization methods: Local and global minima, Line searches, Steepest descent method, Conjugate gradient method, Quasi Newton method, Penalty function.

1METE 4: ADVANCED HEAT TRANSFER (Common for IMETE4 & 1MERET4)

3L+1T **MM:125** **Ex.Hrs. 3**

Objective of Course :

It provides the knowledge of advanced techniques for analysis of heat transfer processes in thermal systems.

Syllabus :

Review :

Review of the basic laws of conduction, radiation and convection.

Conduction :

One dimensional steady state conduction with variable thermal conductivity and with internal distributed heat source; local heat source in non adiabatic plate.

Extended surfaces-review; optimum fin of rectangular profile; straight fins of triangular and parabolic profiles; optimum profile; circumferential fin of rectangular profile; spines; design considerations.

Two dimensional steady state conduction; semi-infinite and finite flat plates temperature field in finite cylinders and in infinite semi cylinders.

Unsteady state conduction; sudden changes in the surface temperatures of infinite plate, cylinders and spheres; solutions using Groeber's and Heisler's charts for plates, cylinders and spheres suddenly immersed in fluids.

Radiation :

Review of radiation principles; diffuse surfaces and the Lambert's Cosine law.

Radiation through non-absorbing media; Hottel's method of successive reflections.

Radiation through absorbing media; logarithmic decrement of radiation; apparent absorptivity of simple shaped gas bodies; net heat exchange between surfraces separated by absorbing medium; radiation of huminous gas flames.

Convection :

Heat transfer in laminar flow; free convection between parallel plates; forced internal flow through circular tubes, fully developed flow; velocity and thermal entry lengths solutions with constant wall temperature and with constant heat flux; forced external flow over a flat plate; the two dimensional velocity and temperature boundary layer equations. Karman Pohlhoursen approximate integral method.

1 METE 5: THERMAL ENGINEERING LAB-I

3P **MM:100**

The experiments may be designed based on the courses 1METE1, 1METE2 and 1METE4.

2 METE 6: COMPUTATIONAL METHODS IN FLUID FLOW AND HEAT TRANSFER

3L+1T MM:125 Ex.Hrs. 3

Review of basic fluid mechanics and the governing (Navier-Stokes) equations, Techniques for solution of PDEs – finite difference method (FD), finite element method and finite volume method.
Finite volume (FV) method in one-dimension, Differencing schemes, Steady and unsteady calculations, Boundary conditions, FV discretizationin two and three dimensions, SIMPLE algorithm and flow field calculations,variants of SIMPLE, Introduction to Turbulence and turbulence modeling, illustrative flow computations, Introduction to commercial softwares FLUENT and CFX – grid generation, flow prediction and post-processing.
Application of FD methods for unsteady and steady heat conduction problems.

2 METE 7: DESIGN OF THERMAL SYSTEMS

3L+1T MM:125 Ex.Hrs. 3

Engineering design, Designing a workable systems, Economic analysis, Depreciation, Gradient- present worth factor.
Equation fitting, Emperical equation, Best fit method, method of least squares.
Optimization, Objective function formulation, Constraint equations, Mathematical formulation, Calculas method, Dynamic programming, Geometric programming, Linear programming methods, solution procedures.
Modeling of thermal equipments such as turbines, compressors, pumps, heat exchangers, evaporators and condencers.

2 METE 8: THERMAL POWER PLANT ENGINEERING

3L+1T MM:125 Ex.Hrs. 3

Types of thermal power stations. Steam power stations based on fossil fuels. Economics of the steam power stations. Thermal power plant equipment: boilers, superheaters, economizers, condensers, combustion chamber and gas loop, turbines etc.
Coal handling, types of furnaces, methods of fuel firing, automatic boiler control, pulverized coal and its firing, Cooling towers for thermal pollution and solid waste treatment plants, fly ash disposal and utilization.
Pollutants in power plants, Particulate, Gaseous pollutants, Thermal pollution, Solid waste pollution strategies to control pollution from coal based thermal plants. Pollution control methods (i) Pre-combustion controls, (ii) Combustion controls Low NOx burners, fluidized bed boilers, (iii) Post Combustion Controls.
Gas turbine power stations, peak load generating sets. Efficiency improvement of power plants, Combined cycle, Integrated gasification combined cycle (IGCC).

2 METE 9: TURBOMACHINES

3L+1T MM:125 Ex.Hrs. 3

Basic concepts of turbomachines: Definition of Turbomachine, classification; Euler's pump equation and Euler's turbine equation, dimensional analysis applied to hydraulic machines and compressible flow machines.
Review of centrifugal pumps and centrifugal compressors. Velocity diagrams, slip factor, energy transfer, power input factor, stage pressure rise and loading coefficient, pressure coefficient, degree of reaction. Centrifugal compressor characteristic, surging, rotating Stall and Choking.
Axial flow pumps; Description, velocity triangles, work done on the fluid, energy transfer, axial pump characteristics, cavitation. Axial flow compressors and fans: Basic constructional features; turbine v/s compressor blades; Advantages of axial flow compressors, working principle, velocity triangle, elementary theory; stage work, work done factor, stage loading, degree of reaction; vortex theory; simple design calculations; introduction to blade design; cascade test; compressibility effects; operating characteristics.
Two dimensional cascade theory. Introduction to axial flow turbines.

2 METE 10: THERMAL ENGINEERING LAB-II

3P MM:100

The experiments may be designed based on the course 2METE6 with application of the commercially available CFD softwares such as FLUENT, CFX.

III SEMESTER M.TECH(THERMAL ENGINEERING) SYLLABUS (FOR 3METE11 AND 3METE12)

3METE11&12.1: THEORY AND DESIGN OF HEAT EXCHANGERS

Applications, Basic Design methodologies- LMTD and effectiveness NTU methods. Overall heat transfer coefficient, fouling. Correlations for heat transfer coefficient and friction factor. Classification and types of heat exchangers and construction detail. Design and rating of double pipe heat exchangers, compact heat exchangers, plate and heat pipe type, condensers, and cooling towers. Heat exchanger standards and testing, heat transfer enhancement and efficient surfaces. Use of commercial software packages for design, analysis and optimization.

3METE11&12.2: ADVANCED REFRIGERATION AND AIR CONDITIONING TECHNIQUES

Introduction, Environmental impact of refrigerants. Analysis of VCR cycles-multistage, multi evaporator, cascade systems, supercritical and other advanced cycles. Properties and selection of pure and mixed refrigerants. Properties of binary mixtures. Analysis of vapor absorption cycles-Aqua ammonia and Li Br water cycles. Air cycle refrigeration, vortex tube, steam jet ejector refrigeration, thermoelectric refrigeration, cryogenics, desiccant, cooling-solid and liquid systems, hybrid systems, heat pumps and heat transformers.

3METE11&12.3: FUEL CELL TECHNOLOGY

Introduction: Fuel cells- definition, relevance and importance, classification of fuel cells.
Electrochemistry basis of fuel cells.
Alkaline fuel cells (AFC): Description, working principle, components, general performance characteristics, Ammonia as AFC fuel. Phosphoric Acid fuel cell.
Solid oxide fuel cell (SOFC): History, benefits and limitations, cell components, Cathode and Anode materials, fuel, configuration and performance. Environmental impact of SOFC. Application and future
of SOFC.
Molten carbonate fuel cells (MCFC): General principle, cell components, mechanisms of electrode reactions, status of MCFC.
Introduction to Direct Methanol Fuel Cell and Proton Exchange Membrane Fuel Cell.
Hydrogen processing and Storage: Processing from Alcohols, Hydrocarbons and other sources.
Hydrogen as an engine fuel, methods of hydrogen storage.