M. Tech. Degree in
THERMAL SCIENCE & ENGINEERING

SYLLABUS
FOR
CREDIT BASED
CURRICULUM

DEPARTMENT OF MECHANICAL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
AGARTALA - 799055
INDIA

1st Semester

Code No.	Subject Name	L – T - P	Cr.
PME-101	Advance Mathematics	3-1-0	4
PME-102	Advance Heat & Mass Transfer	3-1-0	4
PME-103	Design of Combustion Engine	3-1-0	4
PME-104	Computational Fluid Dynamics	3-1-0	4
PME-105	Finite Element Method	3-1-0	4
PME-106	Laboratory I	0-0-3	2
PME-107	Laboratory II	0-0-2	2
PME-108	Seminar	0-0-3	1
	Total		**25**

PME(201) ADVANCED MATHEMATICS: (3-1-0)4

Calculus of Variations: Variation and its properties, Euler's equation, Conditional extreme, Isoperimetric problems, Functional dependent on first and higher order derivatives, Functional dependent on functions of several independent variables, Some applications- Direct methods- Ritz and Kantorovich methods, Eulers finite difference method.

Laplace Transform & Fourier Transform: Applications of fourier transform in solving initial & boundary value problems. Laplace equation, Heat equation & wave equation.

Hankel's Transform: Eliminating properties of Hankel transform, Hankel inversion, and transform theorem, Hankel transform of derivatives of functions, Parsevel's theorem.

Simulation: Types, case studies in various fields using simulation technique, simulation software's used, use of mathematical models based on probabilistic and statistical methods.

Partial Differential Equation: Formation of PDE, Solution of PDE, Equation solvable by direct integration, linear equation of first order, Non-linear equation of first order, Charpit's method, Homogeneous linear equations with constant co-efficient, Non-homogeneous linear equation, Non-linear equation of second order.

Solution of parabolic & Hyperbolic equations: Implicit & Explicit schemes, ADI methods, Nonlinear parabolic equations – iteration method, Solution of elliptic equation-Jaccobi method, Gauss Seidel & SOR method, Ricardson method, RKF4 method, Galarkin's method.

Introduction to finite element method & scope.

(PME102) ADVANCE HEAT & MASS TRANSFER : (3-1-0)4

Two-dimensional heat conduction with and without heat generation, transient heat conduction, numerical solution to 2-D heat conduction problem.

Radiation heat transfer in absorbing, emitting media

Forced convection over bodies, inside ducts

Natural Convection

Convection by non-conventional processes

Analysis and design of heat exchangers

Introduction to heat pipes

Convective mass transfer

Reference:

1. **Frank P. Incropera and David P. DeWitt, Fundamentals of Heat and Mass Transfer, 5th Edition, Hemesphere, New York**
2. R. K. Shah , Compact Heat Exchangers , Hemesphere Publication,
3. Hand Book on Heat Transfer, Mc Graw Hill, New York
4. R. Siegel and J.R.Howell, Thermal Radiation Heat Transfer, 3rd. ed., Washington D.C., Hemesphere, 1992.
5. S.V.Patankhar, Numerical Heat Transfer and fluid flow, New York, Hemesphere,1980.
6. W.M.Kays and M.E.Krawford, Convective Heat and Mass Transfer, 3rd ed. New York, Mc Graw Hill,1993.
7. Y.A. Cengel, Heat and Mass Transfer- A practical Approach, 3rd. ed., Tata-Mc Graw Hill, New Delhi,2007

(PME103) DESIGN OF COMBUSTION ENGINE : (3-1-0) 4

Automotive Transmission, Newton Seed.

Analysis of Engine Cycle: analysis of fuel-air & actual cycle.

Power plant for automotive vehicles – details of engine contraction, Reciprocation & Rotary combustion engine, Stratified charged engine, starling engines.

Engine components: Materials, construction & design aspects of engine components, piston assembly, connecting rod, cylinder head, cylinder block, fly wheel, valve-ports, valve, valve actuating mechanism, cams, cam shaft drives, vibration dampers.

Fuel supply in C.I Engine: Carburetion & Mixture requirements, transfer pump, carburetors-type, constructional & design aspects, Mixture distribution & inlet manifold, multipoint fuel injection system.

Fuel supply in S.I Engine: Injection system components, jerk & distributor pumps, max & min speed governors, Mech & pneumatic governors, injector & spray characteristics.

Combustion Chamber: Ignition & combustion in SI engine, Flame trouble, Review of detonation & diesel knock fuel, effects of various factors, combustion chamber for SI engine, combustion in CI engine, ignition delay & diesel knock, Excess air supply & air motion, combustion & performance aspect in combustion chamber.

Scavenging & super charging: Scavenging process & efficiencies in 2-stroke engines, super charging power required & effects on engine performance, different types of turbo-charges.

Cooling System: necessity, air cooling system, water cooling system, construction of Radiator, water pump thermostat & cooling fan, antifrize solutions, engine release & cooling system design.

Engine Friction & Lubrication: Friction estimates & lubrication requirements.

Development of I.C Engine: Lean combustion engine, Adiabatic, Duel-fuel, crinkle engines, starling engines & 3-Piston engines.

References:

1. The industrial Combustion Engine in Theory & Practice, Vol. I – Charles Faille Taylor.

2. Internal Combustion Engines – L.C.Lichty.

(PME104) COMPUTATIONAL FLUID DYNAMICS : (3-1-0)4

Philosophy of Computational Fluid Dynamics, the impact of Computational Fluid Dynamics – some other examples- Automobile and Engineering applications, Industrial Manufacturing applications, Civil Engineering applications, Environmental Engineering applications.

The governing equations of fluid dynamics: their derivation, a discussion of their physical meaning and presentation of forms particularly suitable to CFD: Introduction, finite control volume, infinitesimal fluid element, the substantial derivative, divergence of velocity-its physical meaning, physical boundary condition, Comments on the conservation form, shock fitting & shock capturing.

Mathematical Behavior of Partial Differential Equation – The Impact on CFD: Classification of quasi-linear partial differential equation, a general method of determining the classification of partial differential equations: the eigenvalue method, general behavior of the different classes of partial differential equation: impact on physical & computational fluid dynamics.

Basic aspect of Discretization methods; finite difference and finite volume formulations, difference equation, explicit and implicit approaches: definition and contrasts, Errors and an analysis of stability.

Numerical solution of elliptical equations - Linear system of algebraic equations.

Numerical solution of parabolic equations - Stability analysis.

Numerical solution of hyperbolic equations - Burgers equation.

Some simple CFD Techniques: The lax-Wendroff Technique, MacCormack's Technique, The Relaxation Technique & its use with Low-Speed Inviscid flow, Aspects of Numerical Dissipation and Dispersion; Artificial Viscosity, The Alternating Direction Implicit (ADI) Technique.

Incompressible Navier-Stokes equations and algorithms - Basics of grid generation.

References:

1. Anderson John D, "Computational Fluid Dynamics"
2. Tannehill, J.e., Anderson, D.A., and Pletcher, R.H., Computational Fluid Mechanics and Heat Tran5fer, 2nd ed., Taylor & Francis, 1997.
3. Hoffmann, K.A. and Chiang, S.T., Computational Fluid Dynamics for Engineers, Engineering Education Systems, 2000.

(PME105) FINITE ELEMENT METHOD : (3-1-0)4

Introduction, Stress and Equilibrium, Boundary conditions, **Potential Energy and Equilibrium:** The Rayleigh-Ritz Method, Galarkin's method; Matrix Algebra and Gaussian Elimination; **One dimensional Problems:** Finite element Modelling, Coordinate and Shape functions, Potential energy approach, Assembly of Global Stiffness matrix and load Vector, Finite element Equation; Treatment of boundary Condition, Elimination approach, Penalty approach, Multipoint Constraints; Quadratic Shape Function, **Plane Trusses:** Local and Global Coordinate System, **Two dimensional problem with CST:** Finite Element Modelling, CST, Isoperimetric representation, Two Dimensional Isoperimetric Elements and Numerical Integration; The four node quadrilateral ,Numerical Integration, One point , Two point formula, Gaussian Quadrature approach, Nine node quadrilateral, Eight Node quadrilateral, Six node Triangle, **Steady state heat transfer:** One dimensional heat conduction, Boundary condition, One dimensional element, Functional approach for heat conduction, ,Galarkins approach for heat conduction, One dimensional heat transfer in thin Fins, Two dimensional steady state heat conduction.

(PME 106) LABORATORY I : (0-0-3)2

Laboratory work based on the syllabus of the subject PME 102.

(PME 107) LABORATORY: (0-0-3)2

Laboratory work based on the syllabus of the subject PME 105.

(PME 108) SEMINAR : (0-0-3)1

Each student shall prepare a seminar paper on any topic of his/her interest. However, the topic must be someway related to the core/elective courses being credited by him/her during the first semester. He/She shall get the paper approved by the faculty advisor and present it in the class in the presence Faculty in charge. Every student shell participate in the seminar. Grade will be awarded on the basis of the quality of the paper, his/her presentation and participation in the seminar.

2nd Semester

Code No.	Subject Name	L – T - P	Cr.
PME-201	Computational Methods in Fluid Flow and Heat transfer	3-1-0	4
PME-202	Design of Thermal System	3-1-0	4
PME-203	Two phase Flow and Heat Transfer	3-1-0	4
PME-204	Alternative Fuels & Energy Systems	3-1-0	4
PME-205	Project Preliminary	0-0-4	4
PME-206	Laboratory III	0-0-2	2
PME-207	Laboratory IV	0-0-2	2
PME-208	Comprehensive Viva-voce.		1
	Total		**25**

PME 201 COMPUTATIONAL METHODS IN FLUID FLOW AND HEAT TRANSFER (3-1-0)4

Finite Difference applications in heat conduction & convection.

Solution of viscous incompressible flows by the stream function - vorticity formulation.

Solution of Navier-Stokes equation for incompressible flows using MAC & SIMPLE algorithm.

Finite volume method, Finite element method.

Introduction to turbulence, isotropic & anisotropic turbulence.

The dynamics of turbulence, Classical idealization of turbulent flows, Structure of vortex dominated flows.

Turbulence modeling, the k-€ model, the RNG k- € model and phase-averaged model.

Modeling of near wall turbulent flows.

Direct numerical simulation, Large eddy simulation of turbulence, turbulent modeling of compressible flows.

References:

1. Anderson, D. A, Tunnehill. J.C., & R.H. Pletcher, "Computational Fluid Mechanics and Heat Transfer".

2. Patankar, S.V. "Numerical Heat Transfer and Fluid Flow"

3. Muraleedhar, K and T. Sundararaja, " Computational Fluid flow and Heat Transfer, second edition, Narosa publishing house,2003."

4. G.Biswas & V.Eswaran "Turbulent flows- Fundamentals, Experiment & Modelling"

PME202 DESIGN OF THERMAL SYSTEM (3-1-0)4

1. Introduction to thermal System Design.
2. Review of fluid properties and basic equations of fluid Mechanics.
3. Piping Systems
    a. Head losses
    b. Design of Piping System- Series and parallel
    c. Design of piping networks.

4. Prime Movers
    a. Pump Characteristics and selection.
    b. Fan Characteristics and selection

5. Heat transfer Fundamentals
    a. Heat Exchanger Design
    b. Design of double pipe Heat exchanger
    c. Design of Shell- and –tube heat exchanger
    d. Design of cross flow heat exchanger
    e. Heat exchanger design option.

6. Optimization
7. Design of complete thermal Fluid Systems.

References: 1. Stoecker, W., Design of thermal Systems, McGraw-Hill.
2. Jaluria,Y., Design and Optimization of Thermal system , McGraw-Hill.,1998.
3.Burmeister, L.C.,Elements of thermal-Fluid System design, Printace Hall,1998

PME 203 TWO-PHASE FLOW AND HEAT TRANSFER: (3-1-0)4

Phase change principles, Fundamentals of boiling, Boiling of external surfaces, condensation, Two-phase internal flow patterns, Two-phase flow pressure loss, Two-phase flow with heat transfer, Critical heat flux and burnout, Flow stability, Cavitations, Two component, Gas-liquid flow, Process steam line Design, Measurement of two-phase flows, Simulation of two-phase flow and heat transfer.

References:

1. Pitts, Donald R and L.E.Sissom, 1998, " Theory and problems of heat transfer (2^{nd} ed). Schaum's Outline series.

2. Collier, J.G and J.R. Thome 1996, " Convective boiling and condensation, 3^{rd} edition. Oxford University press.

3. Tong, L.S . 1975, "Boiling heat transfer and two-phase flow, Kriegler publishing"

4. Burmeister, Louis C, 1993. " Convective heat transfer, 2^{nd} edition, Wiley & Sons".

5. Wallis, G C. Annular two-phase flow, part I: A simple theory, part II: Additional effect, ASME Transactions, J.Basic Engineering, 92D:59,73.

PME 204 ALTERNATIVE FUELS & ENERGY SYSTEMS (3-1-0)4

Introduction:
Estimates of petroleum reserve, Need for alternative fuel, Availability and comparative properties of alternate fuels, use of alcohols, LPG, Hydrogen, CNG and LNG, Vegetable oils and Biogas in automotive engines, Relative merits and demerits of various alternative fuels, Potential of Electronic vehicle, Solar car.

Alcohols:
Manufacture of alcohols, Properties as engine fuels alcohols and gasoline blends, Performance in S.I engines: Methanol and gasoline blends, effects of compression ratio, alcohols in stratified charge engines, combustion characteristics in engines, reformed alcohols, Use in C.I Engines – Ignition accelerators, alcohols diesel emulsions, duel fuel systems, spark assisted diesel engines, surface ignition engines.

Natural Gas, LPG, Hydrogen:
Availability of CNG, properties, Modification required to use in Engines, Performance and emission characteristics of CNG, Using LPG in SI and CI Engines, Performance and emission data for LPG, Hydrogen – production method, Storage and handling, Performance, Safety aspects.

Vegetable Oils and Biogas:
Various vegetable oils for engines, Esterification performance in engines, Using biogas in engines, performance and emission characteristics, shale oil, coal liquid and Tars and fuel – Performance and Emission characteristics.

Electric Vehicle:
Layout of an electric vehicle, Advantages and limitation specifications, System components, Electric control system, High energy and power density batteries, Hybrid vehicles.

Sterling Engine and its Systems:
Constructional and Operational aspects.

References:

1. Environment, Ecology and Sustainable Management – P.K.Bose, Everest publishing house.

2. Alcohols as Motor fuels, Progress in Technology Series No.19, SAE publications, USA,1980.

3. SAE Paper Nos. 840367,841156,841210,841333,841334,780459,780948,780087, 810249,810345,810430,811375,811212,760378,760378,760119,810349.

PME 205 PROJECT PRELIMINARIES (0-0-4)4

Preliminary work about project will be carried out.

PME 206 LABORATORY III (0-0-2)2

Laboratory work based on the subject PME 201.

PME 207 LABORATORY IV (0-0-2)2

Laboratory work based on the subject PME 202.

PME 208 COMPREHENSIVE VIVE VOCE

Each student is required to appear for the Comprehensive Viva-voce Examination. This is an oral examination based on the courses (Theory, laboratory and seminars) undergone by the students during the first and second semester M.Tech Programme.