M.Tech. in Thermal and Fluids Engineering

Total credit requirement for the course completion: minimum **128 credits**

IC: Institute core = **64 credits**,

PC: Program core = **52 credits**,

PE: Program Electives = 12 **credits**

1st semester:

- 6 core courses = 32 credits prescribed program core (4 theory courses with 6 credits each, one core lab with 6 credits + Research Methodology with 2 credits)

2nd semester:

- 2 Core courses (6 credits each) = 12 credits prescribed program core
- 2 Elective courses (6 credits each)
- 1 Core-lab (5 credits)
- Practicum (3 credits)

3rd semester:

- MTech Technical Project work - Phase I (32 credits)

4th semester:

- MTech Technical Project work - Phase II (32 credits)

1st Semester: (32 Credits)

Course Name	L-T-P-C	Objective of the course	Category
Fluid Dynamics	3-0-0-6	To provide exposure to students on the concepts of kinematics of fluid motion, boundary layer and compressible flows.	PC
Advanced Thermodynamics	3-0-0-6	To understand relationships between thermodynamics properties, various cycles, engines and basics of combustion, flame speed, concept of exergy.	PC
Introduction to Computational **Fluid Dynamics**	3-0-0-6	To introduce numerical and mathematical concepts related to fluid flow and heat transfer problems.	PC
Engineering Mathematics for Advanced Studies (ME 903)	3-0-0-6	To introduce mathematical methods.	PC
Introduction to Programming and Modeling Laboratory (ME 621)	1.5-0-3-6	To introduce students to programming, analysis tools and software, Operating systems, R and Python programming, etc.	PC
Research Methodology	1-0-0-2	To introduce students to literature review, report preparations and seminar presentation to a large audience as seminar on research topics in Mechanical Engineering	PC

Allocate MTech Technical Project Supervisor at the end of 1st semester

1	**Title of the course** (L-T-P-C)	**Fluid Dynamics** **3-0-0-6**
2	**Pre-requisite courses(s)**	--
3	**Course content**	1. Continuum concept, control volume equations, Ideal fluid flow, derivation of N-S equations, exact solutions of N-S equations, boundary-layer equations, internal flows, Falkner-Skan similarity solutions of the laminar boundary-layer equations, von Kármán- Pohlhausen approximate method, coupling of thermal boundary layers and velocity field of the temperature field, 2. Potential flow, flow over a nose of a cliff, doublets, cylinder in a stream, and flow past other immersed bodies 3. High Re flows, energy-transfer concepts, turbulent boundary layers, free-shear flows, turbulence modeling (RANS and LES) 4. Concept of compressible flow, one dimensional isentropic flows, normal shock, flow with friction, heat transfer, quasi 1D flow and oblique shocks, expansion waves. 5. Surface tension and surface tension driven flows
4	**Texts/References**	1. Y Çengal, MA Boles, Fluid Mechanics: Fundamentals and Applications, Tata McGraw Hill, 2006. 2. Y Frank M. White, Fluid Mechanics, 4th Tata McGraw Hill, 1999. 3. Pope, Stephen B. Turbulent flows, (2001): 2020. 4. Tennekes, Hendrik, and John L. Lumley. A first course in turbulence, MIT press, 2018. 5. Hermann Schlichting, and Klaus Gersten, Boundary layer theory, 9th edition, Springer, 2017.

1	**Title of the course** (L-T-P-C)	**Advanced Thermodynamics** **3-0-0-6**
2	**Pre-requisite courses(s)**	--
3	**Course content**	Concepts of classical thermodynamics. Application of I and II laws to closed and open systems. Availability analysis of thermal systems and the concept of energy conservation. Phase and reaction equilibria. Equilibrium constants. calculation of equilibrium composition of multi component gasesous mixtures. Equations of state and calculation of thermodynamics and transport properties of substances. Reaction rates and first, second and higher order reactions. Reactions in gaseous, liquid and solid phases. Combustion and flame velocities, Laminar and turbulent flames. Premixed and diffusion flames their properties and structures. Theories of flame propagation, thermal, diffusion and comprehensive theories, Problems of flame stability, flashback and blow off. Combustion of solid, liquid and gaseous fuels. Combustion of fuel droplets and sprays. Measurements in combustion systems. Combustion systems. Combustion in closed and open systems. Applications to IC Engines. Boilers, gas turbine combustors and rocket motors.
4	**Texts/References**	1. K.G. Denbigh, Principles of Chemical Equilibrium, Cambridge, 1971. 2. A.G. Gaydon and H.G. Wolfhard, "Flames" Chapman Hall, 1979. 3. B. Lewis and G. Von Elbe, Combustion, Flames and Explosions of Gases, Academic Press, 1961. 4. M.W. Zemansky, Heat and Thermodynamics 4Ed. McGraw Hill, 1968.

1	**Title of the course** (L-T-P-C)	**Introduction to Computational Fluid Dynamics** **3-0-0-6**
2	**Pre-requisite courses(s)**	--
3	**Course content**	1. Review of Governing Equations: General conservation equation; specific mass, momentum, energy conservation equations. 2. Fundamentals of Numerical Methods: Direct and iterative solvers for linear equations; PDE, Classification, Basics of finite-difference, finite- volume finite-volume methods; Notion of accuracy, consistency, stability, convergence; Verification and validation. 3. Diffusion Equation: 1-D steady conduction; Source terms and non-linearity; 2-D steady conduction; Unsteady conduction; Non-trivial boundary conditions. 4. Advection-Diffusion Equation: Steady 1-D advection- diffusion equation; Upwinding, numerical diffusion, higher-order schemes; 2-D advection-diffusion equation 5. Incompressible Navier-Stokes equations, Incompressibility and pressure-velocity coupling; Staggered vs collocated grids; SIMPLE and PISO algorithms. 6. Special Topics: Non-Cartesian coordinate systems; Curvilinear grids; Unstructured grids; Advanced linear solution methods such as multigrid methods, preconditioning; Use of numerical libraries; Introduction to parallel programming for CFD. 7. Mesoscopic approaches to discrete simulation of fluid Dynamics 8. Tutorial on a commercial CFD code & an open-source code (e.g. Open FOAM).
4	**Texts/References**	1. "An Introduction to Computational Fluid Dynamics", by H. W. Versteeg and W. Malala Sekera; 2nd edition, Pearson Education Ltd., 2007. (ISBN: 9780131274983) 2. "Introduction to Computational Fluid Dynamics: Development, Application and Analysis", by Atul Sharma; Wiley, 2016. (ISBN: 9781119002994)

1	**Title of the course** (L-T-P-C)	**Engineering Mathematics for Advanced Studies** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	--
3	**Course content**	**Module-1:** Linear Algebra: Vector Spaces, Matrices, Linear algebraic equations, Eigenvalues and Eigen- vectors of matrices, Singular-value decomposition **Module-2:** Tensor Algebra: Index Notation and Summation Convection, Tensor Algebra **Module-3:** Vector Calculus: Dot and Cross Product, Curves. Arc Length. Curvature. Torsion, Divergence and Curl of a Vector Field, Line Integrals, Green's Theorem, Stokes's Theorem, use of Vector Calculus in various engineering streams **Module-4:** Ordinary Differential Equations: Initial Value Problem, Method to solve first order ODE, Homogeneous, linear, 2nd order ODE, Non-homogeneous, linear, 2nd order ODE, System of 1st order ODE **Module-5:** Laplace and Fourier transformation: First and Second Shifting Theorems, Transforms of Derivatives and Integrals, Fourier Cosine and Sine Transforms, Discrete and Fast Fourier Transforms **Module-6:** Partial Differential Equations: Basic Concepts of PDEs, Modeling: Wave Equation, Heat Equation, Solution by Separating Variables, Solution by Fourier Series, Solution by Fourier Integrals and Transforms **Module-7:** Numerical Methods: Methods for Linear Systems, Least Squares, Householder's Tridiagonalization and QR-Factorization, Methods for Elliptic, Parabolic, Hyperbolic PDEs **Module-8:** Complex Analysis and Potential Theory: The Cauchy-Riemann Equations, Use of Conformal Mapping, Electrostatic Fields, Heat and Fluid Flow Problems, Poisson's Integral Formula for Potentials **Module-9:** Optimization and Linear Programming: Method of Steepest Descent, Linear Programming Fundamental theorem of linear inequalities, Cones, polyhedra. and polytopes, Farkas' lemma, LP-duality, max-flow min-cut, Simplex Method, primal- dual, Fourier-Motzkin elimination, relaxation methods **Module-10:** Probability Theory and Statistics: Experiments, Outcomes, Events, Permutations and Combinations, Probability Distributions, Binomial, Poisson, and Normal Distributions, Distributions of Several Random Variables, Testing Hypotheses, Goodness of Fit, $\chi 2$-Test **Module-11:** Abstract Algebra: Groups, Sub-groups, Cosets and Lagrange's theorem, Group actions, direct and semi-direct products.
4	**Texts/References**	**1.** E. Kreyszig. Advanced Engineering Mathematics, John Wiley & Sons, 2011. **2.** P.V. O'Neil. Advanced Engineering Mathematics, CENGAGE Learning, 2011. **3.** D.G. Zill. Advanced Engineering Mathematics, Jones & Bartlett Learning 2016. **4.** B. Dasgupta. Applied Mathematical Methods, Pearson Education, 2006. **5.** A. Schrijver, Theory of Linear and Integer Programming, 1998. **6.** D.S. Dummit, R.M. Foote, Abstract Algebra, 2004.

1	**Title of the course** (L-T-P-C)	**Introduction to Programming and Modeling Laboratory** **1-0-3-5**
2	**Pre-requisite courses(s)**	--
3	**Course content**	**SESSION A – Programming in C and Python** 1. Elements of programming 2. Compiling - Coding and Machine representation 3. Integrated Development Environments (IDEs) 4. Types of Variables and Arrays 5. Control Loops 6. Functions 7. Introduction to source code version control 8. Best Practices and Documentation **SESSION B – Introduction to Mathematical Toolkits** 1. Basic programming syntax 2. Working with Arrays - Initialization of arrays, extracting intrinsic matrix properties 3. Evaluation of commonly used statistical metrics 4. Plotting for research – data visualization, data conditioning, different types of plots 5. Primer to Data Science **SESSION C – Exposure to 3D modelling and grid generation** 1. Use of software to create basic geometrical shapes 2. Grid generation and mesh quality assessment **SESSION D – Software project** 1. Hands-on implementation to appreciate comprehensive project execution
4	**Texts/References**	2. R. Pratap, Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers, Oxford, (2010). 3. C Programming Language– Brian Kernighan and Dennis Ritchie, Second Edition, Pearson Education India. 4. Technical guides, user manuals, and tutorials for various software packages

1	**Title of the course** (L-T-P-C)	**Research Methodology** 1-0-0-2
2	**Pre-requisite courses(s)**	--
3	**Course content**	**Scientific Literature:** Research articles, resources, types of publications, identifying authentic sources **Reading:** Reading research articles; experimental, numerical, analytical, and review publications. **Writing:** Communicating formally (letters, emails) Styling; Units; Writing research articles; Automations using LaTeX, MS Word, Mendeley, BibTex; Research ethics **Presentations:** Presenting research work, Content and time management. Presentation tools: MS PowerPoint, Beamer, Excel; Plotting tools: Grapher, Origin, Tecplot, Matlab; Figures: quality, scaling, vector vs raster formats. **Oral Communication:** Stage manners, voice modulation **Hybrid Mode Presentations:** Initial setup and the tools required.
4	**Texts/References**	1. A Manual for Writers of Research Papers, Theses, and Dissertations, Kate L Turabian, Ninth Edition, The University of Chicago Press, 2018. 2. Communication Skills for Engineers and Scientists, Sangeeta Sharma and Binod Mishra, Second Edition, PHI Learning, 2009. 3. The elements of style, William Strunk Jr and E White, Fourth Edition, Pearson Education, 1999. 4. A New Approach to Research Ethics Using Guided Dialogue to Strengthen Research Communities, Henriika Mustajoki and Arto Mustajoki, First Edition,Routledge Publications, 2017. References: 1. Wren and Martin "High School English Grammar and Composition", Regular edition, January 2017.

Programme Structure (M.Tech. in Thermal and Fluids Engineering)

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1st semester:

- 6 core-courses = 32 credits prescribed program core (4 theory courses with 6 credits each, one core lab with 6 credits + Research Methodology with 2 credits)

2nd semester:

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3rd semester:

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2nd Semester: 32 Credits

Course Name	L-T-P-C	Objective of the course	Course Category
Experimental Theory & Laboratory (ME 611)	1-0-3-5	To introduce students with experimental analysis, data analysis, measurement tools and to introduce basic and advance level experiments in Thermo-Fluids Engineering	PC
Experimental Methods in Thermal and Fluid Engineering (ME 626)	3-0-0-6	To introduce number of intrusive and optical techniques for flow and flame visualization, data acquisition procedure, data analysis methods.	PC
Advanced Heat Transfer (ME 601)	3-0-0-6	To introduce and orient students to the concepts of different modes of heat transfer, two phase flow, radiation and extinction, scattering properties.	PC
ME 634 Practicum	0-0-3-3	Presentation to a large audience as seminar on topics in Mechanical Engineering	PC
Elective I	3-0-0-6	To give a choice to the student to choose a postgraduate level course	PE
Elective II	3-0-0-6	To give a choice to the student to choose a postgraduate level course	PE

Out of two Departmental Electives for the PG students, a maximum of one UG level departmental course is allowed.

PC: Program Core
IC: Institute Core

PE: Program Elective

1	**Title of the course** (L-T-P-C)	**Experimental Methods in Thermal and Fluid Engineering (3-0-0-6)**
2	**Pre-requisite courses(s)**	Nil
3	**Course content**	Planning experiments: preliminary intermediate and final stages in experimental investigations. Steady state and transient techniques, selection measuring devices based on static dynamic characteristic and allowable uncertainties .Analysis of experimental data and determantion of overall uncertainties in experimental investigation curve filting and report writing calibration of condition optical and radiation Method of measuring heat fluxes Measurement of thermal radiation and associated parameters calibration of pressure vacuum measuring devices Estimation of uncertainness in measurements of pressure vacuum calibration of flow and velocity measuring devices uncertainties in measurement under various condition. Measurement of turbulence, Hot wire film anemometers measurement of thermophysical properties
4	**Texts/References**	**1.** Mesurement system: Application Design, E, O Docbelin Fourth ed.1990 McGraw Hill **2.** theory and Deign for mechanical measurement, R S Fagiola and D E Beasley, fourth edition,2008,john wily and sons **3.** Mechanical Measurement, T J Beck with ,Marangoni, J H Line hard,2007 Prentice Hall **4.** Measurement and instrumentation principles, Alan moirés Third Edition 2001, Butterworth Heinemann **5.** Op – amps and linear integrated Circuits, R A Gayakwad. 2000 prentice Hall

1	**Title of the course** (L-T-P-C)	**Advanced Heat Transfer** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Nil
3	**Course content**	**Module-1: Conduction:** Equations and boundary conduction in different coordinate systems; Analytical Solutions: separation of variables, Laplace Transform, Duhamel's theorem: Non-impulse initial conditions; Numerical Methods: Finite difference and flux conservation; Interfacial heat transfer. **Module-2: Convection:** Conservation equations and boundary conditions; Heat transfer in laminar developed and developing boundary layers: duct flows and external flows, analytical and approximate solutions, effects of boundary conditions; Heat transfer in turbulent boundary layers and turbulent duct flows; Laminar and turbulent free convection, jets, plumes and thermal wakes, phase change. **Module-3: Radiation:** Intensity, radiosity, irradiance, view factor geometry and algebra; formulations for black and non–black surfaces, spectrally–selective surfaces (solar collectors); Monte Carlo methods for radiation exchange; The radiative transfer equation, extinction and scattering properties of gases and aerosols, overview of solution methods and applications. **Module-4: Interaction between conduction, convection and radiation:** Coupled problems; Examples in manufacturing and electronic cooling applications; Micro channels and micro fins.
4	**Texts/References**	**1.** M N Ozisik, Heat Conduction, 2nd ed, John Wiley & Sons, 1993. **2.** Kakaç, S., Yener, Y., Heat Conduction, 3rd edition, Taylor & Francis, 1993. **3.** F P Incropera and D P Dewitt, Introduction to Heat Transfer, 3rd ed, John Wiley & Sons, 1996. **4.** W. M. Kays and E. M. Crawford, Convective Heat and Mass Transfer, Mc Graw Hill,1993. **5.** Adrian Bejan, Convective Heat Transfer, John Wiley and Sons, 1995. **6.** M F Modest, Radiative Heat Transfer, McGraw-Hill, 1993. **7.** R Siegel and J R Howell, Thermal Radiation Heat Transfer, 3rd ed, Taylor & Francis, 1992.

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Semester – III: 32 Credits			**Semester – IV: 32 Credits**		
Course Name	L-T-P-C	Course Category	Course Name	L-T-P-C	Course Category
M.Tech. Project - I	0-8-16-32	IC	M.Tech. Project - II	0-8-16-32	IC

PC: Program Core

IC: Institute Core

PE: Program Electrics