

Indian Institute of Space Science and Technology
Thiruvananthapuram



M. Tech. Thermal and Propulsion
Curriculum and Syllabus
(Effective from 2026 Admission)

Department of Aerospace Engineering

Introduction to the Programme

Department of Aerospace Engineering, Indian Institute of Space Science and Technology (IIST) proposes to offer M.Tech. Programme in Thermal and Propulsion from the 2026 admission cycle onwards with the following curriculum and syllabus. The programme is designed to address the growing national and global demand for expertise in high-speed aerothermodynamics, aerospace propulsion, rocket combustion, spacecraft thermal systems, and advanced fluid–thermal sciences. In alignment with IIST’s mandate of supporting the Indian space programme and allied aerospace sectors, this M.Tech. programme emphasizes rigorous theoretical foundations, computational and experimental skills, and research-oriented training in aerospace thermal sciences and propulsion systems. The programme integrates core knowledge in advanced fluid dynamics and heat transfer with specialized electives in aerospace propulsion, rocket combustion chambers, space mission analysis, and spacecraft thermal control. Students will engage in laboratory work, design-oriented problem solving, and a two-phase research project aligned with aerospace applications.

Eligibility Criteria:

- (i) B.E./B. Tech. in any of the disciplines.
- (ii) A valid GATE Score in Aerospace Engineering / Mechanical Engineering / Chemical Engineering/ Engineering Science (with Fluid Mechanics and Thermodynamics as optional sections)

Program Educational Objectives (PEOs)

Graduates of the M.Tech. Programme in Thermal and Propulsion will:

PEO 1: Strong Theoretical and Analytical Foundation

Develop advanced knowledge in aerothermodynamics, aerospace propulsion, rocket combustion, spacecraft thermal systems, and fluid–thermal sciences, enabling rigorous analytical and computational problem-solving.

PEO 2: Research and Innovation Competence

Demonstrate the ability to conduct independent, high-quality research and develop innovative design solutions addressing contemporary challenges in aerospace thermal and propulsion systems.

PEO 3: Industry and National Relevance

Contribute effectively to the Indian space programme and global aerospace industries by applying system-level thinking to real-world thermal and propulsion engineering problems.

PEO 4: Experimental, Computational, and Design Proficiency

Exhibit expertise in experimental techniques, numerical simulation, and design-oriented problem solving for aerospace applications.

PEO 5: Professionalism and Lifelong Learning

Communicate technical ideas effectively, work collaboratively in multidisciplinary teams, uphold professional ethics, and continuously update knowledge to adapt to evolving aerospace technologies.

Program Outcomes (POs)

On successful completion of the programme, graduates will be able to:

PO1: Advanced Domain Knowledge

Apply advanced principles of fluid dynamics, heat transfer, combustion, and propulsion to solve complex aerospace thermal engineering problems.

PO2: Problem Analysis and Modeling

Formulate, analyze, and solve high-speed aerothermodynamic and propulsion-related problems using theoretical, numerical, and computational tools.

PO3: Research Capability

Identify research gaps through critical evaluation of scientific literature and develop innovative solutions in aerospace thermal and propulsion engineering.

PO4: Experimental and Computational Skills

Design and conduct experiments, perform CFD and multi-physics simulations, analyze data, and validate results through comparative assessment.

PO5: System-Level Design Approach

Develop system-level and multidisciplinary approaches for designing and optimizing propulsion systems, combustion chambers, and spacecraft thermal control systems.

PO6: Innovation and Optimization

Design, innovate, and optimize aerospace thermal and propulsion systems considering performance, reliability, safety, and mission requirements.

PO7: Technical Communication and Publication

Effectively document, present, and publish research findings in professional forums, journals, and conferences.

PO8: Professional Ethics and Responsibility

Demonstrate ethical conduct, accountability, and commitment to societal and national development through aerospace engineering practice.

PO9: Lifelong Learning and Adaptability

Engage in continuous learning and skill enhancement to address emerging challenges in advanced aerospace technologies and space missions.

Curriculum

Framework

Semester	Course allocation	Total Credits
S-1	Core (3 Credits) - 4 Nos Elec/Core (3 Credits) - 1 No Lab & Mini Project (2 Credit)– 1 No	17
S-2	Core (3 Credits) - 1 No Elec/Core (3 Credits) - 4 Nos Design Project (2 Credit)– 1 No	17
S-3	Project Phase I (* Starts from June)	16
S-4	Project Phase II	18
	Total	68

Semester- 1

Sl No	Course Name	L-T-P	Credits	Type
	Mathematical methods in Aerospace Engineering \$	3-0-0	3	Core
AE621	Fluid Dynamics	3-0-0	3	Core
AE602	Compressible flow	3-0-0	3	Core
AE623	Advanced Heat transfer	3-0-0	3	Core
	Stream Elective-1	3-0-0	3	Elective
AE804	Fluid Thermal Lab and Mini Project- \$\$	0-0-6	2	Lab
Total for semester 1			17	

\$ - Any PG level Mathematics course

\$\$- Mini project will be based on the lab work

Semester- 2

Sl No	Course Name	L-T-P	Credits	Type
AE624	Aerospace Propulsion	3-0-0	3	Core
2	Stream Elective-2	3-0-0	3	Elective
3	Stream Elective-3	3-0-0	3	Elective
4	Stream Elective-4	3-0-0	3	Elective

5	Elective-5 \$\$\$	3-0-0	3	Elective
AE805	Design Project	0-0-6	2	Other
Total for semester 2			17	

\$\$\$- Any relevant NPTEL/Swayam course can be taken as Elective 5. Electives from other Departments could be chosen in consultation with Faculty Advisor/ Project guide.

Semester- 3

Sl	Course Name	L-T-P	Credits	Type
AE852	Project Work – Phase I - \$\$\$	0-0-0	16	Other
Total for semester 3			16	

\$\$\$- Starts immediately after the second semester End Examination, (Project starts during Summer Break)

Semester- 4

Sl. No.	Course Name	L-T-P	Credits	Type
AE852	Project Work – Phase II	0-0-0	18	Other
Total for semester 4			18	

Summary

- Core Courses – 5 No
- Electives Courses – 5 Nos - Ratio of elective-credits to total-credits (excluding project/labs credits): 50%
- Lab Course – 1 No.
- Mini Project- 1No
- Design Project- 1 No
- Project Phase I & II

Core courses

Mathematical methods in Aerospace Engineering

Fluid Dynamics

Compressible flow

Advanced Heat transfer

Aerospace Propulsion

Elective courses

AE603 Elements of Aerospace Engineering.

AE613 Spaceflight mechanics

AE731 Combustion

AE732 Computational Fluid Mechanics

AE733 Convective heat transfer

AE734 Design and Modeling of Rocket Propulsion System

AE735 Finite Element Method with Applications to Heat Transfer and Fluid Flow

AE736 Heat transfer in Aerospace applications

AE737 Introduction to Human Space Flight

AE738 Inverse Heat Transfer

AE739 Non-Intrusive Diagnostics for Thermal and Fluid Flows

AE740 Microscale heat transfer

AE741 Physiological Fluid Mechanics

AE742 Radiation heat transfer

AE743 Spacecraft thermal control

AE744 Space Vehicle Mission Design

AE745 Turbomachines

AE746 Two phase flow I

AE747 Two phase flow II

AE748 Viscous flow

Any other elective with the approval of the Faculty Advisor/Guide

Commented [S1]: Dynamics

Syllabus for core courses

AE XXXX Mathematical methods in Aerospace Engineering

3-0-0-3

Introduction to Linear algebra, systems of linear equations, vector spaces, linear transformation, Eigen values and Eigen vectors, inner product spaces. Review of Ordinary Differential Equations: analytical methods, stability – Fourier series, orthogonal functions, Fourier integrals, Fourier transform – Partial Differential Equations: first-order PDEs, method of characteristics, linear advection equation, Burgers' equation, shock formation, Rankine-Hugoniot jump condition; classification, canonical forms; Laplace equation, min-max principle, cylindrical coordinates; heat equation, method of separation of variables, similarity transformation method; wave equation, d'Alembert solution .

REFERENCES:

1. David Poole., Linear Algebra: A modern Introduction., 4th ed., Brooks /Cole Pub.Co,2014.
2. Brown, J. W. and Churchill, R. V., Fourier Series and Boundary Value Problems, 8th ed., McGraw-Hill Education, 2011.
3. Bleecker, D. D. and Csordas, G., Basic Partial Differential Equations, Chapman and Hall/CRC, 2018.
4. Myint-U, T. and Debnath, L., Linear Partial Differential Equations for Scientists and Engineers, 4th ed., Birkhäuser, 2007.
5. Strauss, W. A., Partial Differential Equations: An Introduction, 2nd ed., Wiley, 2018.
6. Arfken, G. B., Weber, H. J., and Harris, F. E., Mathematical Methods for Physicists: A Comprehensive Guide, 7th ed., Academic Press, 2012.
7. Greenberg, M. D., Advanced Engineering Mathematics, 2nd ed., Pearson, 1998

AE XXXX Fluid dynamics

3-0-0-3

Eulerian and Lagrangian approach – fluid kinematics: material derivative, rotation, deformation – Reynolds transport theorem – physical conservation laws – integral and differential formulations – Navier–Stokes equations – exact solution of Navier–Stokes equations: steady and unsteady flows – potential flows: basic flow patterns, superposition – boundary layer theory: momentum integral approach, Blasius solution, Falkner–Skan solutions – turbulent flows: time-averaged equations – closure problem – turbulence modeling.

References:

1. Fay, J. A. (1994). *Introduction to fluid mechanics*. MIT Press.
2. R. W. Fox, A. T. McDonald, and J. W. Mitchell, *Fox and McDonald's Introduction to Fluid Mechanics*, 10th ed., Indian adaptation. New Delhi: McGraw-Hill, 2021.
3. Kundu, P. K., Cohen, I. M., Dowling, D. R., & Capecelatro, J. (2024). *Fluid mechanics* (7th ed.). Academic Press.
4. Panton, R. L. (2024). *Incompressible flow* (5th ed.). Wiley.
5. Schlichting, H., & Gersten, K. (2017). *Boundary-layer theory* (9th ed.). Springer.
6. White, F. M. (2017). *Viscous fluid flow* (3rd ed.). McGraw-Hill Education.

AE XXXX Compressible flow

3-0-0-3

1-D Gas Dynamics: governing equations– isentropic flow with area change, area-Mach number relations– R-H equations– normal shocks. 1-D Wave Motion: wave propagation– simple and finite waves– Riemann shock tube problem– 2-D waves, governing equations– oblique shocks, charts, shock polar and pressure deflection diagrams– Prandtl–Meyer expansion waves– reflection and interaction of waves– supersonic free jets. Linearized Flow: subsonic flow– Goethert’s and Prandtl Glauert rules– hodograph methods– supersonic flow– supersonic thin airfoils– 2-D airfoils– method of characteristics, the compatibility equation– applications, supersonic nozzle design– generalised one-dimensional flow: working equations– influence coefficients– combined friction and heat transfer – combined friction and area change– conditions at sonic point– transonic flow– flow separation in nozzles - measurements in compressible flows.

References:

1. Shapiro, A. H., Dynamics and Thermodynamics of Compressible Fluid Flow, Vol. 1 & 2, Wiley & Sons (1953).
2. Liepmann, H. W. and Roshko, A., Elements of Gasdynamics, Dover Publications (2001).
3. Thompson, P. A., Compressible Fluid Dynamics, McGraw-Hill (1972).
4. Saad, M. A., Compressible Fluid Flow, 2nd ed., Prentice Hall (1993).
5. John, J. E. A. and Keith, T., Gas Dynamics, 3rd ed., Prentice Hall (2006).
6. Rathakrishnan, E., Gas Dynamics, 2nd ed., Prentice Hall (2009)

AE XXXX Advanced Heat transfer

3-0-0-3

Introduction to heat transfer, Heat conduction governing equation, extended surface heat transfer, multi-dimensional steady and unsteady conduction, conduction in semi-infinite domain.

Fundamental conservation equations; dimensionless parameters and scaling approaches to solve flow with heat transfer, laminar boundary layer solutions –momentum and thermal, laminar heat transfer in ducts, free convection.

Laws of thermal radiation, radiation properties of surfaces, view factor for diffuse radiation, radiation exchange in black and diffuse gray enclosure.

TEXT BOOK:

Fundamentals of Heat and Mass Transfer, Frank P. Incropera, David P. DeWitt, Theodore L. Bergman, Adrienne S. Lavine, John Wiley and Sons, 8th edn 2020

REFERENCES:

1. Heat conduction, David W. Hahn, M. Necati Ozisik, John Wiley and Sons, 3rd edn 2012
2. Thermal Radiation Heat Transfer, John R. Howell, M. Pinar Mengüç, Kyle J. Daun, Robert Siegel, CRC press 7th edn, 2020
3. Convective heat and mass transfer, S. Mostafa Ghiaasiaan, Cambridge Univ Press

AE XXXX Aerospace Propulsion

3-0-0-3

Introduction to air-breathing and rocket propulsion systems - Classification of air-breathing engines - Thrust and performance evaluation - Cycle analysis of ramjet, turbojet, turbofan, turboprop - Diffuser and nozzle component analysis - Combustion chambers

Rocket propulsion systems classification - Performance parameters of rocket propulsion - Nozzle flow theory - Chemical rockets - Liquid rocket engine cycles - Liquid propellants - Solid propellant rockets a

Introduction to Electric Propulsion and Hybrid Propulsion.

Overview of UAV propulsion systems

Textbook:

1. Farokhi, S., Aircraft Propulsion, Wiley (2009).
2. Sutton, G. P. and Biblarz, O., Rocket Propulsion Elements, 7th ed., Wiley (2001).
3. Ramamurthi, K., Rocket Propulsion, Macmillan (2010).
4. Fahlstrom P.G., Gleason T.J., Sadraey M.H., Introduction to UAV Systems, 5th ed., John Wiley (2022).

References:

1. Mattingly, J., Elements of Gas Turbine Propulsion, McGraw-Hill (1995)
2. Hill, P. and Peterson, C., Mechanics and Thermodynamics of Propulsion, 2nd ed., Pearson (1992).
3. Flack, R. D., Fundamentals of Jet Propulsion with Applications, Cambridge Univ. Press (2005).

Syllabus for Elective courses

AE XXXX Combustion

3-0-0-3

Chemical Thermodynamics – Flame Temperatures –Species Conservation Equation - Reaction Kinetics and Mechanisms – Reactor Modeling – Laminar Premixed Flames and Characteristics – Detonation –Turbulent Premixed Combustion and Its Classification – Non-Premixed Gaseous Combustion – Droplet Combustion – Solid Combustion - Emissions and Control –NASA CEA chemical equilibrium analysis.

Text Book

1. Turns, S. R., An Introduction to Combustion, 3rd ed., McGraw-Hill (2017).

References

1. Glassman, I. and Yetter, R. A., Combustion, 4th ed., Academic Press (2008).
2. Kuo, K. K., Principles of Combustion, 2nd ed., John Wiley (2012).
3. Warnatz, J., Maas, U., and Dibble, R. W., Combustion 4th ed., Springer (2006).
4. Law, C. K., Combustion Physics, Cambridge Univ. Press (2010).

AE XXXX Computational Fluid dynamics

3-0-0-3

Mathematical models for fluid dynamics – classification of partial differential equations – discretization methods – finite difference formulation – numerical solution of elliptic equations – linear system of algebraic equations – numerical solution of parabolic equations – stability analysis – numerical solution of hyperbolic equations – finite volume method – time integration schemes – incompressible Navier–Stokes equations and their solution algorithms – isentropic flow through CD nozzle- compressible flow equations and their solution algorithms - basics of grid generation – Turbulence modelling.

References:

1. Hirsch, C., Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics, Vol. 1, 2nd ed., Butterworth-Heinemann (2007).
2. Pletcher, R. H., Tannehill, J. C., and Anderson, D. A., Computational Fluid Mechanics and Heat Transfer, 3rd ed., Taylor & Francis (2011).
3. Hoffmann, K. A. and Chiang, S. T., Computational Fluid Dynamics for Engineers, 4th ed., Engineering Education Systems (2000).
4. Anderson, J. D., Computational Fluid Dynamics: The Basics with Applications, McGraw-Hill (1995).
5. Patankar, S. V., Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corporation (1980).
6. Ferziger, J. H. and Perić, M., Computational Methods for Fluid Dynamics, 3rd ed., Springer (2002).
7. Roache, P. J., Fundamentals of Computational Fluid Dynamics, Hermosa Publishers (1998).
8. Fletcher, C. A. J., Computational Techniques for Fluid Dynamics 1: Fundamental and General Techniques, 2nd ed., Springer (1996).

AE XXXX Convective Heat transfer

3-0-0-3

Fundamental conservation equations; dimensionless parameters and scaling approaches to solve flow with heat transfer– solution of Newtonian viscous flows, boundary layer solutions – laminar shear layers momentum, thermal –laminar heat transfer in ducts – incompressible turbulent mean flows – free convection flows –mass transfer coupled flows- convection with phase change – convection in porous media.

References

1. Bejan, A., Convection Heat Transfer, Wiley, 3rd ed., Wiley (2004).
2. Burmeister, L. C., Convective Heat Transfer, 2nd ed., Wiley (1993).
3. Heat convection , Latif M.Jiji, Springer
4. Convective heat and mass transfer, S. Mostafa Ghiaasian,Cambridge Univ Press

AE XXXX Design and Modeling of Rocket Propulsion System

3-0-0-3

Elements of rocket propulsion- Nozzle design, characteristic parameters, heterogeneous flow analysis – Aerothermochemistry of combustion, dissociation, equilibrium composition, adiabatic temperature, and combustion product equilibrium flow nozzle expansion- Elements of solid propellant system- Internal ballistics and design of solid propellant - Grain design and optimization- Elements of liquid propulsion system- Design and selection of Injectors, combustion chambers, nozzle, cooling system, feed systems and tanks- Combustion Instability, low and high frequency instability and scaling – Overall and optimized rocket performance- Ideal velocity gain, gravitational losses, optimal mass ratio for multistage rockets, trajectory analysis, vertical flight of staged rocket, thrust programming along the path

References:

1. Rocket Propulsion, Barrere, M., Jaumotte A., De Veubeke, B., F., Vandekerckchove, J., Elsevier Publishing Company (1960)
2. Rocket Propulsion, Ramamurthi, K., 2nd edition, Trinity Press (2015)
3. Modern Engineering for Design of Liquid-Propellant Rocket Engines, Huzel, D.K., Huang, D. H., Prog. in Astronautics and Aeronautics, Vol. 147 (1992)
4. Rocket Propulsion Elements, Sutton & Biblarz, 7th Edition Wiley (2001)
5. Mechanics and Thermodynamics of Propulsion, 2nd Edition, Hill & Peterson, Pearson (1992)
6. Orbital Mechanics for Engineering Students, Curtis, H.D., 5th edition, Butterworth-Heinemann, Elsevier Aerospace Engineering Series (2026)

AE XXXX Elements of Aerospace Engineering

3-0-0-3

History of aviation – types of flying machines – anatomy of an aircraft; fundamental aerodynamic variables – aerodynamic forces – lift generation –Airfoil numbering system - airfoils and wings – aerodynamic moments – airplane performance - control surfaces; loads acting on an aircraft – load factor for simple maneuvers – Vn diagrams; mechanism of thrust production – propellers – jet engines and their operation – elements of rocket propulsion; aerospace materials; introduction to aerospace structures; basic orbital mechanics – satellite orbits; launch vehicles and reentry bodies; Overview of UAV propulsion systems

References:

1. Anderson, J. D., Introduction to Flight, 7th ed., McGraw-Hill (2011).
2. Anderson, D. F. and Eberhardt, S., Understanding Flight, 2nd ed., McGraw-Hill (2009).
3. Szebehely, V. G. and Mark, H., Adventures in Celestial Mechanics, 2nd ed., Wiley (1998).
4. Turner, M. J. L., Rocket and Spacecraft Propulsion: Principles, Practice and New Developments, 3rd ed., Springer (2009).

5. Fahlstrom P.G., Gleason T.J., Sadraey M.H., Introduction to UAV Systems, 5th ed., John Wiley (2022).

AE XXXX Finite Element Method with Applications to Heat Transfer and Fluid Flow

3-0-0-3

Introduction – Direct approach to FEM – Variational approach: elements of calculus of variations, Euler-Lagrange equation – Rayleigh-Ritz method – Weighted residual methods: point collocation method, subdomain collocation method, least-square method – Galerkin method – Finite element method: one-dimensional finite element analysis, types of elements, shape functions – Element and global stiffness matrices – Heat transfer problems – fluid flow problems.

Two-dimensional elements: coordinate systems – Field problems governed by second-order PDE, classification of PDE, boundary conditions – Two-dimensional finite element equations– Applications (torsional bar) – Applications to heat transfer and fluid mechanics problems –Acoustic vibrations.

Higher-order elements and shape functions – Lagrangian interpolation – Isoperimetric elements – Numerical integration: Gauss quadrature – Axisymmetric field problems –Axisymmetric elements.

References:

1. Segerlind, L. J., *Applied Finite Element Analysis*, 2nd ed., John Wiley (1984).
2. Fish, J. and Belytschko, T., *A First Course in Finite Elements*, Wiley (2007).
3. Liu, G. R. and Quek, S. S., *The Finite Element Method: A Practical Course*, 2nd ed., Butterworth-Heinemann (2013).
4. Lewis, R. W., Nithiarasu, P., and Seetharamu K. N., *Fundamentals of the Finite Element Method for Heat and Fluid Flow*, Wiley (2004).
5. Donea, J. and Huerta, A., *Finite Element Methods for Flow Problems*, John Wiley (2002).

AE XXXX Heat transfer in Aerospace applications

3-0-0-3

Review of concepts in Heat Transfer, Governing Equations for Momentum, Mass, and Energy Transport; Ablation; Aerodynamic Heating; Heat Transfer at High Speeds; Low-Density Heat Transfer: Rarefied Gas Heat Transfer; Microchannel Applications; Aerospace Heat Exchangers, General Design Considerations for Aerospace Heat Exchangers; Heat Pipes for Aerospace Application; Microgravity Heat Transfer.

References

1. Sundén, B., & Fu, J. (2016). Heat transfer in aerospace applications. Academic Press.
2. Meseguer, J., Pérez-Grande, I., & Sanz-Andrés, A. (2012). Spacecraft thermal control. Elsevier.
3. Gilmore, D. G. (Ed.). (2002). Spacecraft thermal control handbook: cryogenics (Vol. 2). Aiaa.
4. Miao, J., Zhong, Q., Zhao, Q., & Zhao, X. (2021). Spacecraft thermal control technologies (p. 27). Singapore: Springer.

AE XXXX Introduction to Human Space Flight

3-0-0-3

History of Human Spaceflight Spacecraft; Overview Space Environment; Life Support Requirements; Physiological Effects and Countermeasures; Operational Space Medicine; Spaceflight Analogs and Human Factors; Life Support Systems; Habitability and Crew Accommodations; Astronaut Selection and Training; Psychology of Spaceflight - Group Dynamics, Stress, and Coping Space Accidents and Anomalies Working in Space; Extra Vehicular Activity - Physiology and Space Suit Design.

References

1. Harrison, A. A. (2002). *Spacefaring: The human dimension*. Univ of California Press.
2. Chamitoff, G. E., & Vadali, S. R. (Eds.). (2021). *Human spaceflight operations: Lessons learned from 60 years in space*. American Institute of Aeronautics and Astronautics, Inc..
3. Sgobba, T. (2017). *Space safety and human performance*. Butterworth-Heinemann.
4. Hawkins, F. H., & Orlady, H. W. (2017). *Human factors in flight*. Routledge.

AE XXXX Non-Intrusive Diagnostics for Thermal and Fluid Flow

3-0-0-3

Introduction to Non-intrusive Diagnostics in Thermal-Fluid Systems – Fundamentals of Light-Matter Interaction – Planar Imaging Systems – Optical Flow Visualization Techniques – Velocity Measurement – Temperature Measurement – Density Fields – Scalar Field Measurement – Multiphase Flow Diagnostics – Heat Transfer & Surface Diagnostics – Microfluidics & Small-Scale Flows – Error analysis – Safety Procedures

Textbook:

1. Laser Diagnostics For Combustion Temperature and Species - Alan C. Eckbreth; Publisher - Taylor & Francis
2. Spectroscopy and Optical Diagnostics for Gases - Ronald K. Hanson, Spearrin & Goldenstein; Publisher - Springer
3. Physical Chemistry - Atkins; Publisher - Oxford University Press
4. Optical Measurements: Techniques and Applications – Franz Mayinger & Oliver Feldmann (Eds.) - Springer

References:

1. Applied Combustion Diagnostics - Kohse-Hoinghaus & Jeffries; Publisher - Taylor & Francis
2. Particle Image Velocimetry - Raffel, Willert, Wereley & Kompenhans; Publisher – Springer
3. Optical Diagnostics for Reacting and Non-Reacting Flows: Theory and Practice - Adam Steinberg and Sukesh Roy

AE XXXX Inverse Heat Transfer

3-0-0-3

Introduction to Inverse Problems, Statistical Description of Errors; Optimization Formulation, Classical Techniques and Sensitivity Analysis, Parameter and Function estimation; Nonlinear Techniques, Levenberg-Marquardt Method and Tikhonov, Probability Theory and the Bayesian Framework Regularization, Probability Theory and the Bayesian Framework, Markov Chain Monte Carlo Methods, Metropolis-Hastings Algorithm and Computational Implementation, Introduction to Machine Learning for Inverse Problems, Deep Learning — ANNs, CNNs, and RNNs, Surrogate Models and Genetic Algorithms, Physics-Informed Neural Networks (PINNs) for Forward and Inverse Problems.

References

1. Balaji C, and Balaji S, — Machine Learning and Bayesian Methods in Inverse Heat Transfer (Elsevier, 2026)
2. M.Ozisik, M. N. & Orlande, H. R. B. — Inverse Heat Transfer (Taylor & Francis, 2000)
3. Goodfellow, I., Bengio, Y. & Courville, A. — Deep Learning (MIT Press, 2016)
4. Raissi, M., Perdikaris, P. & Karniadakis, G. E. — Physics-Informed Neural Networks (J. Comput. Phys., 2019)

AE XXXX Microscale and nanoscale heat transfer

3-0-0-3

Overview of macroscale thermo-fluid sciences—limitations—characteristic length and time scales—science and technology applications of microscale systems—Basics of kinetic theory and statistical mechanics—estimation of transport properties—thermodynamic relations—Boltzmann transport equations—Microscale heat conduction—basics of electron and phonon transport—thermal conductivity models—Microscale convection—Knudsen Number and flow regimes—continuum approach—slip models—Heat Transfer in Poiseuille Micro flows—single phase convection in mini and micro channel—rarefied gas flows—boiling and condensation in mini and micro channels—Microscale radiative heat transfer—Maxwell's relations—Planck's Law—Radiative properties for microscale regime—Introduction to nanoscale heat transfer—thermal property characterization—basic theory of heat transfer enhancement using nanoparticles—selected applications—experimental and numerical methods.

References

1. Zhuomin Zhang, Nano/Microscale Heat Transfer, 2nd Ed. Springer, 2020.
2. Pradipta Kumar Panigrahi, Transport Phenomena in Microfluidic Systems, John Wiley & Sons Singapore Pte. Ltd, 2016.
3. Kandlikar, S., Garimella, S., Li, D., Colin, S., and King, M. R., Heat Transfer and Fluid Flow in Minichannels and Microchannels, 2nd Edn Elsevier, 2014.
4. Sobhan, C. B. and Peterson, G. P., Microscale and Nanoscale Heat Transfer: Fundamentals and Engineering Applications, CRC Press, 2008.
5. Sears, F. W. and Salinger, G. L. Thermodynamics, Kinetic Theory, and Statistical Thermodynamics, 3rd Ed, Narosa, 1998.
6. Chan L. Tien, Microscale Energy Transfer, Taylor & Francis, 1997.
7. Arvind Pattamatta, Sarit K. Das, Fundamentals of Nano- and Microscale Heat Transport, 2nd Edn, Springer Nature Switzerland, 2025.

AE XXXX Physiological Fluid Mechanics

3-0-0-3

Introduction to Physiological Fluid Mechanics; Review of Concepts in Fluid Mechanics; Clinical Fluid Dynamic Measurements; Analysis of Total Peripheral Flow; Circulatory Bio-fluid Mechanics, Blood Rheology, Blood Composition and Structure, Flow Properties of Blood, Blood Vessel Structure; Models of Biofluid Flow, Models of Blood Flow, Applications of Poiseuille's Law for the study of Blood Flow; Introduction to Non-Newtonian Fluids, Power Law Model, Herschel-Bulkley Model, Casson Model, Non-Newtonian Flow in Elastic Tubes; Introduction to Heart Mechanics, Cardiac Geometry, Materials, and Electric System, Mechanical Cycle Events & Vent. Function Curve, Operation of Heart Valves, Blood Flow in Arteries, Shear Stress on Vessel Wall, Blood Vessel Bifurcation, Bifurcation Patterns, Uniform Shear Hypothesis.

References

1. Mazumdar, J. Biofluid mechanics. World Scientific.(2015).
2. Fung, Y. C. Biomechanics: circulation. Springer Science & Business Media. (2013).
3. Ross C. E, and Craig A. Simmons, Introductory Biomechanics, Cambridge texts in Biomedical Engineering, (2007).
4. Kleinstreuer, C, Biofluid Dynamics: Principles and Applications, CRC Press, Taylor&Francis Group, (2006).
5. Waite, L. Applied Biofluid Mechanics, McGraw Hill, (2007)
6. Waite, L. Biofluid Mechanics in Cardiovascular Systems, McGraw-Hill , (2006).

AE XXXX Radiative Heat transfer

3-0-0-3

Overview of thermal radiation, radiation properties of surfaces, view factor for diffuse radiation, radiation exchange in black and diffuse gray enclosure, spectrally diffuse enclosure surfaces, secularly reflecting surfaces, Monte Carlo ray tracing, Windows, Coatings, Introduction to satellite thermal control.

Radiative transport equation in participating media, approximate solution methods for one dimensional media: Optically thick and optically thin approximations. Formal solution and one-dimensional transfer. Moment methods: diffusion and spherical harmonics. Gas Radiation: Introduction to gas radiation, Plane parallel model, Diffusion approximation, radiative equilibrium, Optically thick limit, radiation spectroscopy, Isothermal gas emissivity, band models, total emissivity method, Isothermal gas enclosures.

Radiative transfer in absorbing, emitting, and scattering media. The discrete ordinates method: spatial and angular discretization, false scattering and ray effects, the finite volume method. Handling interaction with other modes, heat radiation at micro/nanoscales.

References:

1. Radiative Heat Transfer, Michael F. Modest, Fourth edition (2021), Academic Press
2. Thermal Radiative Transfer and Properties, M.Q. Brewster, John Wiley (1992)
3. Thermal Radiation Heat Transfer, John R Howell, M. Pinar Menuguc, Robert Siegel, CRC press, 7th edition (2020)
4. Radiative heat transfer: A Statistical approach, Robert Mahan, Wiley (2002)
5. Spacecraft Thermal Control, J. Meseguer, I. Perez-Grande and A. Sanz-Andrez, Woodhead Publishing

AE XXXX Spacecraft thermal control

3-0-0-3

Review of concepts in Heat Transfer, Governing Equations for Momentum, Mass, and Energy Transport; Spacecraft Subsystems & Interfaces; Spacecraft Thermal Environments, External – Orbit and Eclipse dependence, Internal; Thermal Design Techniques, Thermal Coupling (Heat Sinks) a) Mountings and Interfaces, Thermal Contact Resistance, Thermal isolation – Thermal standoff, Thermal Surface Finishes, Thermal Insulation, Phase-Change Materials, Radiators, Heaters, Louvers, Heat Pipes; Thermal Analysis; Thermal Design Examples; Thermal Testing.

References

1. Gilmore, D. G. (Ed.). (2002). *Spacecraft thermal control handbook: cryogenics* (Vol. 2). AIAA.
2. Karam, R. D. (1998). *Satellite thermal control for systems engineers* (Vol. 181). AIAA
3. Miao, J., Zhong, Q., Zhao, Q., & Zhao, X. (2021). *Spacecraft thermal control technologies* (p. 27). Singapore: Springer.
4. Donabedian, M. (2004). *Spacecraft thermal control handbook, I & II*: AIAA

AE XXXX Spaceflight Mechanics

3-0-0-3

Vector Algebra, Diff/Integral Calculus (KE and PE), Newton's inverse square law, n-body equation, Kepler's law, Eqn of Conic, Types of conics, Vis-Viva Eqn, Flight path angle, Relation b/w true anomaly and time, Kepler's Eqn, Different Coordinate frames, Conversion of state vector to orbital elements, Two body problem, Lambert problem, True Anomaly Iteration Method, Julian date, Non Keplerian Motion- Non-spherical earth- Third Body perturbation- Atmospheric Drag- Solar Radiation Pressure, Orbit Maneuvers- Single impulse transfer-Two impulse transfers (Hohmann, Bielliptic)- Plane change maneuvers- Spherical Triangle- Rendezvous Maneuvers, inter-planetary mission trajectories

Text Books

1. Orbital Mechanics for Engineering Students, Curtis, H.D., 5th edition, Butterworth-Heinemann, Elsevier Aerospace Engineering Series (2026)

References

1. Introduction to Space Flight, Hale, J.F., Prentice Hall (1994)
2. Atmospheric and Spaceflight Dynamics', Tewari, A., Birkhauser, 2007
3. Fundamentals of Astrodynamics and Applications, Vallado, D.A., 4th edition, Microcosm (2013)

AE XXXX Space Vehicle Mission Design

3-0-0-3

Space mission objectives – Orbits and delta V requirements; Launch vehicle (LV) sizing and design- Restricted and optimized staging-sizing- LV trajectory simulation - Propulsion systems-liquid and solid motor design – LV subsystems design overview-Aerodynamics, Structures, Thermal Systems- Model rocketry and sounding rocket design approaches; Spacecraft sizing and design- Rigid body and satellite attitude dynamics- Spacecraft subsystems design overview -Structures, Thermal Systems, Propulsion; Interplanetary mission design- lunar - Mars missions

References

1. Integrated Design for Space Transportation Systems, Suresh, B.N., Sivan, K., Springer India (2015)
2. Orbital Mechanics for Engineering Students, Curtis, H.D., 5th edition, Butterworth-Heinemann, Elsevier Aerospace Engineering Series (2026)
3. Rocket Propulsion, Ramamurthi, K., 2nd edition, Trinity Press (2015)
4. Design of Rockets and Space Launch Vehicles, Edberg, D., and Costa, W., 2nd edition, AIAA Education Series (2022)
5. Handbook of Model Rocketry, Stine, H., and Stine, B., 7th edition, John Wiley and Sons Inc (2004)
6. Space Vehicle Design, Griffin, M.D., and French, J.R., 2nd edition, AIAA Education Series (2004)
7. Elements of Spacecraft Design, Brown, D.C., AIAA Education Series (2002)

AE XXXX Turbomachines

3-0-0-3

Introduction to turbomachinery, including dimensional analysis, similarity principles, and performance laws.-Axial flow compressors and fans: aero-thermodynamics, blade design (2D), losses, radial equilibrium, performance characteristics, multi-staging, high-Mach stages, stall and surge.-Axial flow turbines: stage analysis, work and reaction, cascade theory, losses and efficiency, subsonic to supersonic operation, multi-staging, exit conditions, and cooling.- Centrifugal compressors: components, rothalpy, slip factor, diffuser flow, performance characteristics, surging, choking, and rotating stall.- Radial turbines: thermodynamic and aerodynamic analysis, performance characteristics, losses, efficiency.

Text Books:

1. Fluid Mechanics and Thermodynamics of Turbomachinery, 7th Edition, Dixon S L, Publisher: ELSEVIER INDIA
2. Principles of Turbomachinery, Seppo A .Korpela, JOHN WILEY & SONS, INC.

References:

1. Nicholas Cumpsty, Compressor Aerodynamics, 2004, Kreiger Publications, USA.
2. Johnson I.A., Bullock R.O. NASA-SP-36, Axial Flow Compressors, 2002
3. El-Wakil, M M; Powerplant Technology, 1984, McGraw-Hill Pub.
4. NASA-SP-290, Axial Flow turbines, 2002 (re-release), NTIS, USA.
5. Lakshminarayana, B. Fluid Dynamics and Heat Transfer of Turbo machinery, John Wiley & Sons, Inc., 1996
6. Ahmed F. El-Sayed; Aircraft Propulsion and Gas Turbine Engines; CRC press, 2008
7. Turton, Robert Keith. Principles of turbomachinery. Springer Science & Business Media, 2012.

AE XXXX Two phase flow I

3-0-0-3

Review of field equations in single phase flows and heat transfer– introduction to two-phase flows – basic averaging concepts- formulation and treatment of one-dimensional homogeneous flow model – separated flow model – drift flux model –predictive methodologies for flow pattern transition in adiabatic and diabatic flows –Liquid-Vapour Phase Change Phenomenon: pool boiling – wetting phenomenon – nucleation and bubble growth– bubble dynamics –convective boiling – heat transfer in partially and fully developed sub-cooled boiling – heat transfer in saturated boiling-Condensation- condensation in the presence of non-condensable gases- Choked two-phase flows.

References:

1. J.G Collier & J.R Thome , Convective Boiling and Condensation, Oxford University Press, 1996
2. Van P. Carey , Liquid-Vapour phase-change phenomenon-An introduction to the thermophysics of vapourisation and condensation process in heat transfer equipment, Taylor and Francis, 1992
3. G. B Wallis , One-dimensional two-phase flow, Mc Graw Hill, 1969
4. S Mostafa Ghiaasiaan, Two-phase flow boiling and condensation in Conventional and Miniature systems, Cambridge Univ Press , 2017

AE XXXX Two Phase flow- II

3-0-0-3

Generalised flow field equation in two-phase flows-Eulerian averaging-modelling perspectives– one dimensional two-fluid model- modelling annular flow, slug flow and bubbly flow- fluid dispersions- flows with particles of one phase in turbulent field of another phase- gas-particle flows in rocket nozzle, Compressible two-phase flows - 1d transient two-phase flow. Cavitation, Simple modelling of cavitating flows.

Interfacial waves-dynamic behaviour of interface- linear stability analysis- Kelvin-Helmholtz instability, Rayleigh-Taylor Instability- application to typical cases-linear stability analysis in 1D two phase flows and some typical situations -Introduction to waves in fluids-analytical solution of sloshing in tank-introduction to level set and volume of fluid methods. Introduction to Interface tracking problem solving using diffuse interface methods.

Introduction to liquefaction of gases-cryogenic two-phase flows- chilldown modelling. Liquid-Vapour phase change behaviour under reduced gravity conditions.

References:

1. M.Ishii & T.Hibiki , Thermo -Fluid dynamics of two-phase flows, Springer, 2006
2. S Mostafa Ghiaasiaan, Two-phase flow boiling and condensation in Conventional and Miniature systems, Cambridge Univ Press, 2017
3. Nuclear systems II –Elements of Thermal Hydraulic design, Neil E Todreas and Mujid S Kazimi- Hemisphere Publishing corporation
4. Amir Faghri and Yuwen Zhang, Fundamentals of multi-phase heat transfer and flow, Springer, 2020
5. Jean Pierre and Jean Marie Michel, Fundamental of Cavitation, Kluwer Academic press, 2004
6. N N Filina and J G Weisend II, Cryogenic two-phase flows: Application to large scale systems, Cambridge university press, 1996

AE XXXX Viscous flow

3-0-0-3

Boundary Layer Theory, Falkner–Skan Similarity solution, Separation Criterion for Wedge Flow, Stagnation Point Flow, Laminar Mixing Layer, Plane Laminar Jet

low Reynolds number hydrodynamics, flow around, cylinder, creeping flow around spheres, Spherical harmonic solution

Temporal and Spatial Instability, Some Instability Mechanisms, waves and wave interactions, Method of solution by normal modes, Kelvin-Helmholtz, Squire's theorem and Orr-Sommerfeld Equation, Inviscid instability of parallel flows.

Turbulence fluids, statistical description, Introduction to turbulence modelling, K-Epsilon transport equation, turbulent boundary layer, turbulent jets.

References

1. Frank M White , Viscous Fluid Flow, Mc-Graw Hill, 2005
2. Pijush K. Kundu, Ira M. Cohen, David R. Dowling , Fluid Mechanics, Academic Press, 2011
3. Ronald Panton , Incompressible Flow, Wiley- India, 2006
4. Peter S Bernard, Fluid Dynamics, Cambridge univ.Press, 2015
5. Hermann Schlichting and Klaus Gersten, Boundary_layer theory, Springer, 2018
6. Peter Davidson, Turbulence: An introduction to scientists and Engineers, Oxford univ.Press, 2015
7. Tritton, D. J, Physical Fluid dynamics, Calendron press, 1988

