

MEPC3002 HEAT TRANSFER (3-0-0)

Course Objectives:

This course provides a comprehensive understanding of heat transfer mechanisms—conduction, convection, and radiation. Students will analyze steady/transient heat conduction, convective heat transfer (forced/natural), radiative exchange, and phase-change processes. Emphasis is placed on solving engineering problems, designing heat exchangers, and applying empirical correlations for real-world thermal systems.

Module-I: (06 Hours)

Introduction: Modes of heat transfer: conduction, convection, and radiation, Mechanism & basic laws governing conduction, convection, and radiation heat transfer; Thermal conductivity, Thermal conductance & Thermal resistance, Contact resistance, convective heat transfer coefficient, radiation heat transfer coefficient, Electrical analogy, combined modes of heat transfer. Initial conditions and Boundary conditions of 1st, 2nd and 3rd Kind.

Module-II: (06 Hours)

Heat Conduction: General heat conduction in Cartesian, polar-cylindrical and polar-spherical coordinates, Simplification of the general equation for one- and two-dimensional steady transient conduction with constant/ variable thermal conductivity with / without heat generation. Solution of the one-dimensional steady state heat conduction problem in case of plane walls, cylinders and spheres for simple and composite cases. Critical insulation thickness, Heat transfer in extended surfaces (pin fins) without heat generation, long fin, short fin with insulated tip and without insulated tip and fin connected between two heat sources. Fin efficiency and fin effectiveness. Conduction in solids with negligible internal temperature gradient (Lumped heat analysis).

Module-III: (06 Hours)

Convective Heat Transfer: Introduction to convective flow - forced and free. Dimensional analysis of forced and free convective heat transfer. Application of dimensional analysis, physical significance of Grashoff, Reynolds, Prandtl, Nusselt and Stanton numbers. Conservation equations for mass, momentum and energy for 2-dimensional convective heat transfer in case of incompressible flow, Hydrodynamic and thermal boundary layers for flow over a flat plate. Critical Reynolds number: general expressions for drag coefficient and drag force Reynolds- Colbourn analogy. Thermal boundary layer; general expression for local heat transfer coefficient; Average heat transfer Coefficient; Nusselt number. Flow inside a duct-velocity boundary layer, hydrodynamic entrance length and hydrodynamically developed flow; flow through tubes (internal flow). Use of empirical relations for solving turbulent conditions for external and internal flow. Mechanism of heat transfer during natural convection, Experimental heat transfer correlations for natural convection in the following cases(a) Vertical and horizontal plates(b) Inside and outside flows in case of tubes.

Module-IV: (06 Hours)

Radiative heat exchange: Introduction, Radiation properties, definitions of various terms used in radiation heat transfer; Absorptivity, reflectivity & transmissivity. Emissive power & emissivity, Kirchoff's identity, Planck's relation for monochromatic emissive power of a black body, Derivation of Stefan-Boltzmann law and Wien's displacement law from Planck's relation, Radiation shape factor, Relation for shape factor and shape factor algebra. Heat exchange between blackbodies through non-absorbing medium. Gray bodies and real bodies, Heat exchange between gray bodies. Radiosity and Irradiation, Radiation shields.

Module-V: (06 Hours)

Heat transfer for boiling liquids and condensing vapors: Types of condensation, use of correlations for condensation on vertical flat surfaces, horizontal tube and regimes of pool boiling, pool boiling correlations. Critical heat flux, concept of forced boiling. Numerical problems.

Heat Exchangers: Introduction, Types of heat exchanger, The overall heat transfer coefficient and fouling factors, LMTD and NTU analysis of heat exchangers.

Course Outcomes:

- CO1: Remembering (Knowledge): Recall fundamental laws (Fourier's, Newton's cooling, Stefan-Boltzmann) and modes of heat transfer (conduction, convection, radiation).
- CO2: Understanding (Comprehension): Explain concepts like boundary layers, fin efficiency, and shape factors, and interpret dimensionless numbers (Reynolds, Nusselt, Grashof).
- CO3: Applying (Application): Solve problems involving steady/transient conduction, convective heat transfer, and radiative exchange using empirical correlations and LMTD/NTU methods.
- CO4: Analyzing (Analysis): Evaluate the impact of variables (e.g., insulation thickness, flow conditions) on heat transfer rates and system performance.
- CO5: Creating (Synthesis): Design heat exchangers and thermal systems by integrating conduction, convection, and radiation principles for optimal efficiency.

Reference Books:

1. Heat Transfer Incropera and Dewitt, Wiley publications
2. Heat Transfer: J.P.Holman, TMH Publications
3. Heat Transfer: P.S. Ghosdastidar, Oxford University Press
4. Fundamentals of Engineering Heat and Mass Transfer: R.C. Sachdeva, New Age International Publishers, 4th Edition.
5. Heat Transfer by P.K. Nag, TMH
6. Heat Transfer by S.P. Sukhatme, TMH
7. Heat Transfer: A.F. Mills and V. Ganesan, Pearson Education, 2nd Edition
8. Heat and Mass Transfer: Domkundwar and Arora, Danpatrai and sons
9. Heat Transfer: R. K. Rajput, Laxmi Publications
10. Heat and Mass Transfer: A Practical Approach, Y.A. Cengel, Tata Macgraw Hills Education Private Limited