

Heat Transfer

Course	Code	Credits	L-T-P	Assessment		Exam Duration
				SEE	CIA	
Heat Transfer	15ME63	04	3-2-0	80	20	3Hrs

Pre-requisites: Basic and Applied Thermodynamics

Course learning objectives:

- Study the modes of heat transfer.
- Learn how to formulate and solve 1-D steady and unsteady heat conduction problems.
- Apply empirical correlations for fully-developed laminar, turbulent internal flows and external Boundary layer convective flow problems.
- Study the basic principles of heat exchanger analysis and thermal design.
- Understand the principles of boiling and condensation including radiation heat transfer related engineering problems.

Module – I

Introductory concepts and definitions: Modes of heat transfer: Basic laws governing conduction, convection, and radiation heat transfer; Thermal conductivity; convective heat transfer coefficient; radiation heat transfer combined heat transfer mechanism, Types of boundary conditions. General Heat Conduction Equation: Derivation of the equation in (i) Cartesian, (ii) Polar and (iii) Spherical Co-ordinate Systems.

Steady-state one-dimensional heat conduction problems in Cartesian System: Steady-state one-dimensional heat conduction problems (i) with and without heat generation and (ii) with and without varying thermal conductivity - in Cartesian system with various possible boundary conditions, Thermal Resistances in Series and in Parallel. **8 Hours**

Module – II

Critical Thickness of Insulation: Concept, Derivation, Extended Surfaces or Fins: Classification, Straight Rectangular and Circular Fins, Temperature Distribution and Heat Transfer Calculations, Fin Efficiency and Effectiveness, Applications

Transient [Unsteady-state] heat conduction: Definition, Different cases - Negligible internal thermal resistance, negligible surface resistance, comparable internal thermal and surface resistance, Lumped body, Infinite Body and Semi-infinite Body, Numerical Problems, Heisler and Grober charts. **9 Hours**

Module – III

Numerical Analysis of Heat Conduction: Introduction, one-dimensional steady conduction, one dimensional unsteady conduction, two-dimensional steady and unsteady conduction, the difference equation, boundary conditions, solution methods, cylindrical coordinates and irregular boundaries.

Thermal Radiation: Fundamental principles - Gray, White, Opaque, Transparent and Black bodies, Spectral emissive power, Wien's, Rayleigh-Jeans' and Planck's laws, Hemispherical Emissive Power, Stefan-Boltzmann law for the total emissive power of a black body, Emissivity and Kirchhoff's Laws, View factor, Net radiation exchange in a two-body enclosure, Typical examples for these enclosures, Radiation Shield. **9 Hours**

Module – IV

Forced Convection: Boundary Layer Theory, Velocity and Thermal Boundary Layers, Prandtl number, Governing Equations – Continuity, Navier-Stokes and Energy equations, Boundary layer assumptions, Integral and Analytical solutions to above equations, Turbulent flow, Various

empirical solutions, Forced convection flow over cylinders and spheres, Internal flows –laminar and turbulent flow solutions, Forced Convection Cooling of Electronic Devices.

Free convection: Laminar and Turbulent flows, Vertical Plates, Vertical Tubes and Horizontal Tubes, Empirical solutions. **8 Hours**

Module – V

Heat Exchangers: Definition, Classification, applications, LMTD method, Effectiveness - NTU method, Analytical Methods, Fouling Factors, Chart Solution Procedures for solving Heat Exchanger problems: Correction Factor Charts and Effectiveness-NTU Charts, compact heat exchangers.

Heat Transfer with Phase Change: Introduction to boiling, pool boiling, Bubble Growth Mechanisms, Nucleate Pool Boiling, Critical Heat Flux in Nucleate Pool Boiling, Pool Film Boiling, Critical Heat Flux, Heat Transfer beyond the Critical Point, filmwise and dropwise Condensation, heat pipes, entrainment, wicking and boiling limitations. **9 Hours**

Course Outcomes

At the end of the course, the student will be able to:

- Understand the basic modes of heat transfer.
- Compute temperature distribution in steady-state and unsteady-state heat conduction
- Understand and interpret heat transfer through extended surfaces.
- Interpret and compute forced and free convective heat transfer.
- Explain the principles of radiation heat transfer and understand the numerical formula for heat conduction problems.
- Design heat exchangers using LMTD and NTU methods.

TEXT BOOKS:

1. Principals of heat transfer, Frank Kreith, Raj M. Manglik, Mark S. Bohn, Seventh Edition, Cengage learning, 2011.
 1. Yunus A. Cengel - Heat transfer, a practical approach, Fifth edition, Tata Mc Graw Hill.

REFERENCE BOOKS:

1. Heat nd mass transfer, Kurt C, Rolle, second edition, Cengage learning.
2. Heat Transfer, M. Necati Ozisik, A Basic Approach, McGraw Hill, New York, 2005.
3. Fundamentals of Heat and Mass Transfer, Incropera, F. P. and De Witt, D. P., 5th Edition, John Wiley and Sons, New York, 2006.
2. Heat Transfer, Holman, J. P., 9th Edition, Tata McGraw Hill, New York, 2008.

E-Books/Web references:

1. A Text book of Heat Transfer, John H Lienhard, 4th Edition,
2. NPTEL Heat Transfer course for Mechanical Engineering, <http://nptel.ac.in/courses/112101097/>
3. Heat Transfer, Chris Long & Naser Sayma, Bookboon.com

MOOCs:

1. Fluid flow, Heat and Mass Transfer- <http://ocw.tudelft.nl/courses/applied-earth-sciences/fluid-flow-heat-mass-transfer/course>
2. Heat transfer course- <https://legacy.saylor.org/me204/Intro/>

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing at least one full question from each module.