



FUNDAMENTALS OF HEAT TRANSFER

PROF. SOMNATH ROY

Department of Mechanical Engineering
IIT Kharagpur

PRE-REQUISITES : Fluid Mechanics and Thermodynamics

INTENDED AUDIENCE : UG students of Mechanical Engineering and other branches

COURSE OUTLINE :

Heat is energy in transit. Understanding the fundamentals of heat transfer is essential for analysis and design of thermo-mechanical systems. Analytical skills in heat transfer is useful for study of several industrial, natural and biological systems. In this course, we will discuss the basics of different heat transfer modes. This course will also try to develop problem solving skills in the students. Few advanced topics including computational and experimental techniques for heat transfer problems will also be introduced.

ABOUT INSTRUCTOR :

Prof. Somnath Roy is currently an Associate Professor in the Department of Mechanical Engineering at Indian Institute of Technology Kharagpur. He completed his B.E. from Jadavpur University, M. Tech. from IIT Kanpur and PhD from Louisiana State University. He worked as a Research Associate and Visiting Faculty at Louisiana State University and then joined IIT Patna on February, 2011. In 2016, he moved to IIT Kharagpur. His research interest involves Computational Fluid Dynamics, Mixing, Heat Transfer, Turbulence, Micro-Air Vehicles, Biofluidics and High-Performance Computing.

COURSE PLAN :

Week 1: Modes of heat transfer (1), Introduction to conduction heat transfer (1), Fourier's law and thermal conductivity (1), Derivation of conduction equation and simplifications (1), Solution of one-d steady conduction equations (1)

Week 2: Resistance networks, critical radius of insulation (1), contact resistance, one-d steady conduction with heat generation (1), Extended surface heat transfer and solution to fin problems, array of fins (3)

Week 3: 2 D steady conduction equation and its solution using separation of variables (3), Graphical and numerical solutions (2)

Week 4: Unsteady heat conduction equations and lumped capacitance model (2), Solution using Heisler's charts (2), Semi-infinite plate heat transfer, penetration depth (1)

Week 5: Basic concepts of convection heat transfer and Newton's laws of cooling, classification of convection problems, non-dimensional numbers in convective heat transfer (1), Derivation of mass, momentum and energy equations for incompressible flow (2), Concepts of velocity boundary layer, Boundary layer equations and estimation of convective heat transfer coefficient (2)

Week 6: Laminar flow over flat plate, Blasius solution and integral method for boundary layer equation (2) Turbulent flows, Reynolds analogy (1), Forced convection over bluff body, heat transfer correlations (2)

Week 7: Forced convection through internal conduits, fully developed flow, mean temperature (3) Heat transfer correlations, solution of convective heat transfer problems (1), Experimental methods for thermal problems (1)

Week 8: Natural convection, Boussinesq approximation, vertical flat plate natural convection equation and correlations for complex geometries (2), Mixed convection and Richardson number (1), Introduction to boiling and condensation heat transfer (2)

Week 9: LMTD method for analysis of heat exchangers design vs rating problems (3), epsilon-NTU method for performance and design calculations (2)

Week 10: Basic concepts in radiation heat transfer, relevant surface properties and role of medium (1), Directional and spectral nature of radiation (1), Planck's equation, Stephan Boltzmann law, Wein's displacement law, Solar radiation (1), Black, grey and real bodies, Kirchhoff's law (1), Problems involving emission from a surface (1)

Week 11: Radiation exchange between black bodies, view factor algebra (2), Radiation exchange between grey bodies, radiosity, radiation shields (2), Radiation networks (1)

Week 12: Mass transfer through diffusion - Fick's law, mass transfer through flowing media, analogies with heat transfer (3), Introduction to heat exchangers and their classification, recuperative and regenerative heat exchangers, heat transfer augmentation