ADVANCED HEAT TRANSFER

Course Code: 15ME2303

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

CO1: Explain the general heat conduction equation, fin heat transfer, solution of two-dimensional steady state equation, and conduction shape factor

CO2: Describe the solution of transient heat conduction equation by analytical methods and by Heisler's charts, and laminar heat transfer for flow over a flat plate

CO3: Analyze heat transfer in laminar and turbulent flows through pipe, liquid metal and high speed flow, and describe pool and flow boiling

CO4: Compare external and in-tube film condensation, and explain working of a heat pipe

CO5: Explain radiation properties and apply radiation networks to calculate radiation exchange between surfaces, and gas radiation

UNIT-I (10-Lectures)

General heat conduction equation: Heat conduction equation in Cartesian, cylindrical, and spherical coordinates.

One-dimensional steady state heat conduction: Heat transfer from extended surfaces – infinitely long fin - rectangular and triangular fins – boundary conditions - fin performance.

Two-dimensional steady state heat conduction: Steady state two-dimensional heat conduction equation – boundary conditions – numerical solution by finite difference method.

Definition of conduction shape factor – conduction shape factor for a three-dimensional wall and for different other geometries.

UNIT-II (10-Lectures)

Unsteady-state heat conduction: Lumped heat capacity system - transient heat conduction in a semi-infinite rod - transient heat

conduction in an infinite plate with convection boundary condition at the surface.
Transient heat conduction in an infinite cylinder exposed to a convection environment - transient heat conduction in a sphere - Heisler's charts.
Forced convection-I: Laminar boundary layer on a flat plate – Von Karman analysis through integral equations for hydrodynamic boundary layer thickness – energy balance equation and thermal boundary layer on a flat plate, turbulent boundary layer – mixing length and eddy viscosity.

UNIT-III (10-Lectures)
Forced convection-II: Heat transfer in laminar tube flow – turbulent flow in a tube, heat transfer in high speed flow – liquid metal heat transfer – high speed heat transfer for a flat plate.
Boiling: Regimes of saturated pool boiling – Rohsenow's correlation for nucleate pool boiling, flow boiling: external flow boiling, internal flow boiling, two-phase flow regimes.

UNIT-IV (10-Lectures)
Condensation: Nusselt's analysis for laminar film condensation on a vertical plate – condensate Reynolds number – film condensation inside horizontal tubes.
Heat pipe: Heat pipe components, materials and working fluids – Applications of heat pipe – Cooling of electronic components.

UNIT-V (10-Lectures)
Radiation heat transfer: Radiation properties – Kirchhoff's law – Wien's displacement law – Planck's distribution law – black body - gray body. Radiation heat exchange between black isothermal surfaces - radiation shape factor, Irradiation–radiosity– space resistance – surface resistance – radiation networks – radiation between two hot plates enclosed by a room.
Gas radiation: Radiation exchange between a gas and a heat transfer surface - absorption in a gas layer - radiation network for an absorbing and transmitting medium, interaction of radiation with conduction and convection.

TEXT BOOKS:

1. Holman, J.P., "*Heat Transfer*", 10th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2010.
2. David Reay and Peter Kew, "*Heat pipes – Theory, Design and Applications"*, 5th Edition, Butterworth and Heinemann (Elsevier), 2006.

REFERENCES:

1. M. Thirumaleswar, "*Fundamentals of Heat and Mass Transfer"*, 2nd Edition, Pearson Education, New Delhi, 2009.
2. Incropera, F.P., Dewitt, D.P., Bergman, T.L., Lavine, A.S., Seetharamu K.N. and Seetharam T.R., "*Fundamentals of Heat and Mass Transfer*", 1st Edition, Wiley India, 2013.
3. Sachdeva, T.R., "*Fundamentals of Engineering Heat and Mass Transfer" (SI UNITs)*, 4th Edition, New Age International, 2010.