Conduction And Radiation - Video course

COURSE OUTLINE

Radiation:
Introduction, radiation from a black body, radiation properties of non-black opaque surfaces, shape factors for uniform diffuse radiation, radiation exchange in gray diffuse enclosures, fundamentals of gas radiation, the engineering treatment of gas radiation in enclosures, multimode heat transfer.

Conduction:
Introduction – energy equation in heat conduction and common types of boundary conditions, extended surface heat transfer – variable area fins, multidimensional steady conduction – 2D Cartesian, cylindrical, superposition principle, transient conduction – 1D Cartesian, cylindrical, spherical, integral method, conduction with change of phase, numerical solution of conduction problems.

COURSE DETAIL

Module No	Topics
1.	**Introduction, radiation from a black body**: Introduction to three modes of heat transfer- conduction, convection and radiation. Importance of radiation, Mechanism of radiation,Electromagnetic spectrum. Concept of black body, derivation of black body radiation laws from first principles – Planck's law, Stefan Boltzmann law, Wien's displacement law. Universal black body function, F function charts.
2.	**Radiative properties of non-black surfaces**: Spectral directional emissivity, defintion of total and hemispherical quantities, hemispherical total emissivity. Spectral directional absorptivity, Kirchoff law, directional and hemispherical absorptivity, hemispherical total absorptivity. Concept of bi-directional reflectivity, bi-hemispherical spectral reflectivity, hemispherical total reflectivity. Particiating media and concept of transmissivity, total transmissivity.
3.	**View factors**: Need for view factors, concept of view factors, mathematical definition. View factor Algebra, Hottel's crossed string method, view factors for 2D surfaces using algebra. View factors from 2D surfaces using charts.

NP-TEL

NPTEL

http://nptel.iitm.ac.in

Mechanical Engineering

Pre-requisites:

1. Thermodynamics
2. Fluid Mechanics
3. Heat Transfer

Coordinators:

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4.	**Enclosure analysis**: Radiosity Irradiation method for gray diffuse enclosures – Problems for 2 and 3 surface enclosures – parallel plate formula, radiation shields, concept of re-radiating surface.
5.	**Gas Radiation**: Introduction to gas radiation – The equation of transfer – derivation Simple solutions to the equation of transfer. Concept of mean beam length – Calculation of mean beam length for simple geometries from charts and formula. Engineering treatment of gas radiation in enclosures – modified enclosure theory – problems to illustrate the modified enclosure theory.
6.	**Introduction to conduction**: Derivation of energy equation for conduction in three dimensions – Initial and boundary conditions. Solution of simple problems in steady state conduction with analytical solutions – Concept of electrical analogy – fin heat transfer and concept of fin efficiency and fin effectiveness.
7.	**Unsteady conduction**: Concept of Biot number – Lumped capacitance formulation – simple problems – unsteady conduction from a semi-infinite solid-solution by similarity transformation method. Solution of the general 1D unsteady problem by separation of variables and charts- example problems.
8.	**2D steady conduction and phase change problems**: Laplace equation – solution by variable separable method – concept of superposition and homogeneous boundary conditions. Phase change problems – The Stefan and Neumann problems – analytical solutions.
9.	**Numerical solution of conduction problems**: Basic ideas of finite difference method – forward, backward and central differences – Discretization for the unsteady heat equation – simple problems. Basis ideas of the finite volume method – application to Laplace and Poisson equations.

References:

Conduction:

1. Conduction Heat Transfer, D. Poulikakos, Prentice Hall, 1994.
2. Heat Conduction, S. Kakac and Y. Yener, Taylor and Francis, 1994.
3. Analytical methods in Conduction Heat Transfer, G.E.Myers, McGraw Hill, 1971.
4. Conduction Heat Transfer, V.S. Arpaci, Addison Wesley, 1996 (Abridged edition Ginn press 1998)
5. Heat Transfer, A.J.Chapman, Macmillan, 1984.

Radiation:

1. Thermal Radiation Heat Transfer, R. Siegel and J.R.Howell, Taylor &

Francis, 2002.
2. Radiation Heat Transfer, E.M.Sparrow and R.D.Cess, Wadsworth, 1966.
3. Radiative Transfer, H.C.Hottel and A.F.Saroffim, McGraw hill, 1967.
4. Radiative Heat Transfer, M.F.Modest, McGraw Hill, 2003.