Approved in 44th BoA Meeting (24-11-2021)

Course Number	**:**	**ME518**
Course Name	**:**	**Conduction and Radiation**
Credits Distribution	**:**	**3-0-0-3**
Intended for	**:**	**MTech/MS/PhD in engineering streams.**
Prerequisites	**:**	**None**
Mutual Exclusion	**:**	**None**

1: Preamble: The concepts involved in all three modes of heat transfer are beyond to deliberate in a single course of heat transfer even at the UG level. Thus, generally, the teaching of the concepts in heat transfer have been bifurcated into two parts and grouped conduction and radiation modes of heat transfer in one course, and convective mode of heat transfer in another course. Thus, this course covers the detailed topics in conduction and radiation modes of heat transfer.

2: Course modules with quantitative lecture hours:

- **Module 1**: Derivation of Heat Conduction Equation for Heterogeneous, Isotropic Materials in Cartesian Coordinates. Heat conduction equation for homogeneous, isotropic materials in Cartesian, Cylindrical and Spherical Coordinates. Heat transfer from a fin of uniform and variable cross-section. Two-dimensional Steady State Heat Conduction: Solution by Method of Separation of Variables, time constants, thermal boundary layer, Steady 2D Conduction in Cylindrical Coordinates - Fourier-Bessel Series Solution. [8hrs]
- **Module 2:** Treatment of variable conductivity by Kirchhoff transformation.Unsteady State Conduction: Applications. Biot Number and its Physical Significance. Lumped System Analysis: Time Constant and its Physical Significance. Semi-Infinite Solid: Definition. Solution by Laplace Transform and Similarity technique. Time-dependent Boundary Conditions-Duhamel's Superposition Principle. Derivation of the integral. Solidification and Melting: Introduction. Stefan problem, enthalpy method. [8hrs]
- **Module 3:** Inverse heat conduction and microscale transport: Determination of unknown boundary conditions from interior measurement; Stefan problem, enthalpy method, Experimental determination of thermal conductivity and heat capacity. Microscale heat transfer: hyperbolic heat conduction, speed of propagation of thermal waves, time lag, solution for a thin slab. [6hrs]
- **Module 4:** Introduction To Radiation heat transfer. Physical Mechanism. Laws of Thermal Radiation: Planck's Law. Wien's Displacement Law. Stefan-Boltzmann Law. Intensity of Radiation. Diffuse and Specular Surfaces. Absorptivity, Reflectivity and Transmissivity. Monochromatic and Total Emissivity. Definition of an ideal gray body. Monochromatic and Total Absorptivity. Kirchhoff's Law.

Restrictions of Kirchhoff's law. View Factor. Hottel's Crossed-strings Method:. Radiation Exchange in a Gray Enclosure. [5hrs]

- **Module 5:** Two-Surface Enclosure: Network, Expression for the net radiation exchange. Radiation Shields. Radiation Effects in Temperature Measurement (Conduction effects negligible). Integral equation approach. Spectrally diffuse enclosure surfaces; band approximation. Treatment of specularly reflecting surfaces; specular and diffuse reflectivities, modified definition of radiosity, method of images. [5hrs]
- **Module 6:** The equation of radiative heat transfer in participating media. Solution methods. Non-Gray Radiative properties of molecular gases. Introduction to HITEMP DATABASE. Approximate solution methods for one-dimensional media: The optically thin approximation. The optically thick approximation (Diffusion Approximation). [5hrs]
- **Module 7:** Gas Radiation: Introduction. Beer's law: Monochromatic transmissivity, absorptivity and emissivity of a gas. Mean Beam Length. Gas emissivity charts. Correction factor charts. Heat Exchange between gas volume and black enclosure: Calculation of gas absorptivity using charts. Heat exchange between two black parallel plates at different temperatures. Heat exchange between gas volume and gray enclosure: Hottel's Expression. [5hrs]

3. Text Books

1. Hahn, D. W., and Ozisik, M. N., Heat Conduction, John Wiley and Sons, 2012.
2. Modest, M.F., Radiative Heat Transfer, 3rd Edition Academic Press, 2013.

4. Reference Books

1. Arpaci, V. S., Conduction Heat Transfer, Longman Higher Education 1967.
2. Siegel, R., and Howell, J., Thermal Radiation Heat Transfer, Taylor and Francis, 2015.
3. Schneider, P., Conduction Heat Transfer, Addison-Wesley Pub. Co, 1974.
4. Kakac et al., Heat Conduction, CRC Press, 5st ed, 2018.
5. Myers, Analytical Methods in Heat Conduction, AMCH, 2nd Ed 1998.

5: Similarity Content Declaration with Existing Course

S.N	Course Code	Similarity Content	Approx. % of Content
1	ME613	Radiation properties of real surfaces, Methods to calculate view factor, The equation of radiative heat transfer in participating media. Solution methods	20-25%

6: Justification for new course proposal if cumulative similarity content is > 30 %

Not Applicable