BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE - PILANI, HYDERABAD CAMPUS
INSTRUCTION DIVISION
SECOND SEMESTER 2023-2024

COURSE HANDOUT: PART - II

Date: 02.01. 2024

In addition to Part- I (a general handout for all courses appended to the time-table), this handout provides the specific details of this course.

Course No.	**:**	ME G631
Course Title	**:**	Advanced Heat Transfer
Instructor-in-charge	**:**	SANTANU PRASAD DATTA

1. Course Description

Heat conduction equations; Eigen value problems; analytical solution of heat conduction equation by Laplace transform, Duhamel's theorem, Fourier transform and separation of variables techniques; contact resistance; transient heat conduction - conduction with moving boundary, solidification and melting; problems with periodic boundary conditions; inverse heat conduction, micro-scale heat transfer; integral equation for radiative exchange; view factors; radiative exchange between surfaces: black surfaces, gray, diffuse partially specular surfaces; radiative properties of participating media: introduction to gas properties, wide band models, total emissivity, particle properties; radiative transfer through participating media: gray, plane-parallel slab; approximate methods; non-gray media.

2. Scope and Objective

To introduce and familiarize students with various analytical methods used as tools to analyse a wide range of engineering applications involving heat transfer by conduction and radiation. Emphasis will be given to understanding and the use of various mathematical techniques needed to develop the exact analytical and appropriate solutions for a broad class of heat conduction and radiation problems. Examples will be discussed to illustrate the applications of various exact solution techniques. In the first half, basics conduction heat transfer equations and analytical methods to the solutions of transient conduction heat transfer with and without heat generation, with moving heat source and phase change will be discussed. In the second half, the theory of radiation heat transfer and analytical methods to the solution of radiation heat exchange between different surfaces with and without participating media will be discussed.

3. Text Books (TBs)

(a) TB1: M. Necati Ozisik, "Heat Conduction", John Wiley & Sons, 2nd edition, 1993.
(b) TB2: A. Bejan, Convective Heat Transfer, Wiley India Pvt. Ltd, Third Edition, 2004.
(c) TB3: Michael F. Modest, Radiative Heat Transfer, Academic Press, 2nd edition, 2003.

4. Reference Books (RBs)

(a) RB1: Latif M. Jiji, "Heat Conduction", Springer, 3rd edition, 2009.
(b) RB2: Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incropera, David P. DeWitt, "Fundamentals of Heat and Mass Transfer",Wiley, 7th edition, 2011.
(c) RB3: W.M. Kays, M. E. Crawford, and B. Weigand, Convective Heat and Mass Transfer, McGraw-Hill Int. Edition, Fourth Edition, 2005.
(d) J.G. Collier, and J.R. Thome, Convective Boiling and Condensation, Oxford University Press, Third Edition, 1996.
(e) RB4: John R. Howell and Robert Siegel, "Thermal Radiation Heat Transfer", Taylor & Francis, 4th Edition, 2002.
(f) S. Kakac, Heat Exchangers: Selection, Rating, and Thermal Design, 2nd, CRC Press, 2002

5. Course Plan

Lecture No.	Learning Objectives	Topics to be covered	Chapter Nos.
1-5	Heat conduction equations with different geometry, boundary conditions, solution methodology	Fundamental of conduction heat transfer (CHT) - steady and transient CHT, boundary conditions, 2-D Steady Heat Conduction and Separation of Variables	Ch. 1-3 (TB1)
6-9	Mathematical modelling of moving heat source and heat sink problems	Application of transient conduction heat transfer (TCHT) - stationary and moving heat source/sink, : Conduction in Semi-infinite and infinite Regions: The Similarity Method	Ch. 3-4 (RB1)
10-12	Heat conduction through porous media	Introduction about porous media, steady state and transient heat transfer through porous media	Ch. 5 (RB1)
13-17	Phase-change problems with variable boundary wall	Application of TCHT - moving boundary problems (melting and solidification)	Ch. 6 (RB1)
18-19	An overview of nonlinear conduction problems	Source of nonlinearity, Taylor series method, Kirchhoff Transformation, Boltzmann Transformation	Ch. 7 (TB1)
20	Approximate solution: Integral method	Integral method approximation and accuracy of integral method	Ch. 8 (RB1)
21	Perturbation solutions	Perturbation solution procedure and example, Variable thermal conductivity	Ch. 9 (RB1)
22	Fundamental Principles	Conservation equations, Rules of scale analysis, and Heat lines for visualization.	TB:2 1.1 – 1.6
23-25	Laminar Boundary Layer Flow	Concept of boundary layer, Velocity and thermal boundary layers, Integral solutions, Similarity solutions, Other wall heating conditions, and Flow past a wedge and stagnation flow.	TB:2 2.1 – 2.7
26-27	Laminar Duct Flow	Hydrodynamic entrance length, Fully developed flow, Hydraulic diameter and Pressure drop, Heat transfer to fully developed duct flow and developing flow.	TB:2 3.1 – 3.5
28-29	External Natural Convection	Natural convection as a heat engine in motion, Laminar boundary layer equations, Scale analysis, Integral solution, Similarity solution, Uniform wall heat flux, Mixed convection, and Heat transfer results including the effect of turbulence.	TB:2 4.1 – 4.6; & 4.10 – 4.11
30	Internal Natural Convection	Transient heating from the side and Enclosures heated from below.	TB:2 5.1; & 5.4 – 5.5
31-32	Boiling and Condensation	Film Condensation on a Single Horizontal Tube, Film Condensation in Tube Bundles, Condensation inside Tubes, Flow Boiling	TB:2 10.1 – 10.2
33-34	Fundamentals of radiation, basic laws, some definition of radiative heat transfer	Fundamental of radiation heat transfer (RHT) – radiation characteristics of matter, radiative properties of surfaces	Ch. 1 & 3 (TB3)
35-36	Definition and method to evaluate view factor	View factors	Ch. 4 (TB3)
37-39	Radiative heat exchange between different surfaces	Radiative heat exchange between gray, diffusive, partially-specular and non-gray surfaces, radiation network, radiation shield	Ch. 5-7 (TB3)
40-42	Equation of radiative transfer in participating media	Radiative heat transfer with participating media – absorbing, emitting and scattering	Ch. 9 (TB3)

6. Evaluation Scheme

Evaluation Component	Duration (min.)	Weightage (%)	Date & Time	Nature of Component
Midsem	90	25%	To be announced	Closed Book
Term-project/Assignment	-	10%	Continuous	Open Book
Laboratory Experiment	-	10%	Continuous	Open Book
Class Assessment	-	20%	To be announced by I/C	Open Book
Comprehensive Exam	180	35%	To be announced	Closed Book

7. Chamber Consultancy Hour

To be announced by I/C in the class.

8. Notices

Students are advised to visit regularly *CMS* (institute's web based **C**ourse **M**anagement **S**ystem) for all notices and updates.

9. Make-up Policy

Make-up request for tests shall be granted only for the genuine cases with sufficient evidence. Request letter duly signed by the student should reach the under signed well in advance.

10. Academic Honesty and Integrity Policy:

Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

Instructor-in-charge (I/C)
(ME G631)