Course-Plan [Autumn-2024]

School: **Engineering**
Department: **Energy**
Course Code: **EN 562**
Course Name: **Heat Transfer**
Instructors: **Vikas Verma (**vikas@tezu.ernet.in**;** Intercom: 5310**)**

1. **Abstract**:

Comprehensive analysis of all the three modes of heat transfer (conduction, convection and radiation) will be taught in this course. The numerical tools and techniques, used to estimate the transfer of heat for all the three modes, are elaborately discussed. The dependency of heat transfer on material and environmental factors/properties are critically discussed with examples. Broader understanding is ensured incorporating practical examples of heat transfer.

2. **Objectives:** (*what the course seeks to do*)

a) Enable the learners to identify appropriate mechanism(s) of heat transfer and understand it.
b) Enable the learners to apply the understanding of heat transfer on design and management of heat transfer appliances (This is essentially required for different energy conservation and management practices).

3. Prerequisites of the course: (*What are the basic skills expected from the students or the courses s/he must have completed while opting for the course*.)

Basic knowledge on thermo-dynamics, 3-D geometry, differential calculus and SI units are required.

4. Course outline and suggested reading:

Units/Modules	Topics	Lecture no.
Unit 1: Heat transfer: An introduction	• Overview of heat transfer: conduction, convection and radiation • Heat transfer and its importance: in relation to energy technology • Introduction to course outlines: books, journals, study materials • Units and dimensions	1
Unit 2: Theory of heat conduction	• Physical mechanisms of heat conduction • Development of rate equation (one dimensional), numerical examples	2
	• Thermal properties of matter in solid and fluid state • Thermo-physical properties of material: transport and thermodynamic; volumetric heat capacity, thermal diffusivity and Insulation concept	3
	• Determination of temperature field using Heat Diffusion Equation in Cartesian coordinates, Cylindrical coordinates and Spherical coordinates • Boundary and initial conditions	4
	• Numerical examples on (i) rate equation, (ii) thermo-physical properties, (iii) heat Diffusion Equation	5
Unit 3: Two dimensional heat conduction problems with and without internal heat generation and extended surfaces: Mathematical and numerical analysis	• Two dimensional steady state heat conduction problems : analytical solution for bodies without internal heat generation	6
	• Two dimensional steady state heat conduction problems : numerical solution for bodies without internal heat generation	7
	• Two dimensional steady state heat conduction problems : • analytical & numerical solution for bodies with internal heat generation	8
	• Heat transfer from extended surfaces: general representation of mathematical model and discussion on special cases	9
Unit 4: Transient and periodic state heat	• Two dimensional transient state heat conduction problems: • Spatially uniform temperature distribution – lumped capacitance method	10

conduction: mathematical and numerical analysis	and its validity checking	
	• Two dimensional transient state heat conduction problems: • Spatially non-uniform temperature distribution – approximate and exact solution	11
Unit 5: Convective heat transfer & boundary layer theory	• Concepts of convection heat transfer in natural and forced convection – practical examples	12
	• Velocity boundary layer & thermal boundary layer	13
	• Boundary layers: characteristics of laminar and turbulent flow, concepts of Reynolds number	14
	• Development of convection transfer Equations in velocity boundary layer	15
	• Development of convection transfer Equations in thermal boundary layer	16
	• Velocity (momentum transfer) and thermal (energy transfer) boundary layer equations – simplifications for special cases,	17
	• Normalized equations and functional form of solutions of convective heat transfer equation	18
	• Physical significance of some important dimensionless parameters concerning boundary layers	19
Unit 6: Heat transfer in fins/extended surface	• Introduction of fins and applications (commercial and industrial)	20
	• Convection correlations, laminar flow in circular tubes, turbulent flow in circular tubes and numerical examples	21
Unit 7: Boiling, Condensation and Heat Exchanger	• Boiling modes (Pool boiling and flow boiling) and variations of heat transfer coefficient	22
	• Condensation- laminar film condensation and turbulent film condensation, film condensation	23
	• Condensation- film condensation inside horizontal tubes , dropwise condensation	24
	• Heat exchanger: classifications & Design consideration	25
	• Estimation of heat transfer for parallel flow, counter flow and cross flow arrangements	26
	• Heat exchanger effectiveness – LMTD and NTU method	27
Unit 8: Radiative heat transfer	• Fundamental concept of thermal radiation: volumetric vs. surface phenomenon, directional nature of radiation, emissive power, irradiation and radiosity	28
	• Fundamental concept of thermal radiation: directional nature of radiation, emissive power, irradiation and radiosity	29
	• Numerical example demonstrating concepts of intensity of emission, solid angle, and rate of intercepted radiation by objects located at different positions	30
	• Laws of radiative heat transfer. Numerical examples	31
Unit 9: Radiation heat transfer between black and grey bodies:	• Concepts of Surface absorption, reflection, transmission, black surface vs. gray surface. Numerical examples concerning radiation heat transfer in furnace.	32
	• Radiation exchange between surfaces: concept of view factor.	33
	• View factors of some common two and three dimensional geometries	
	• Blackbody radiation exchange and real surface	34
	• Radiation exchange between diffuse, gray surfaces inside enclosure	35
	• Multimode heat transfer: solution of numerical examples concerning heat transfer in radiative Superheater, Concept of view factors	36
	Revision & Practices of Numerical problems	37
Semester End term (Entire Syllabus)		

Suggested reading materials

Text Book

[1] Incropera F. P., DeWitt D. P., Bergman T. L. and Lavine A. S. (2011) *Introduction to Heat Transfer,* Fifth Edition, John Wiley
[2] Özışık M. N. (1985); *Heat transfer: A basic approach*, McGraw Hill

Reference Book

[1] Lienhard V J. H. and Lienhard IV J. H. (2011); *A Heat Transfer Textbook,* Fourth Edition, Dover Publication
[2] Holman J. P. (1992); *Heat Transfer*, Seventh Edition, McGraw Hill
[3] Gupta V. (1995); *Elements of Heat and Mass Transfer*, New Age International
[4] Ghajar A. J. and Cengel Y. A. (2011); *Heat and Mass Transfer*, Tata McGraw Hill
[5] Dutta B. K. (2009); *Heat Transfer: Principles and Applications*, First Edition, Prentice Hall India

5. (a) **Time-Plan**

As provided in the lesson plan in Section 4 above

(b) **Evaluation plan** (to be as per the University calendar)

Tests	Date*	Marks	Time
Sessional Test-I	As per CoE notification	25	*
Mid Term Examination		40	*
Sessional Test-II		25	*
End Term Examination		60	3 hr.
Total		150	

**As per University Calendar & Notification*

6. Pedagogy:

Lectures and discussion with the aids of Blackboard and Power point presentation will be followed.

7. Course Outcomes

CO1: Understanding heat transfer modes for solution of thermal energy applications
CO2: Design and analysis of the performance of heat transfer devices
CO3: Determine the optimal parameters through numerical solution of heat transfer problems