GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3140503
Semester – IV
Subject Name: Heat Transfer

Type of course: Professional core course

Prerequisite: A good understanding regarding basic modes of heat transfer viz. conduction, convection and radiation with governing laws underlying this heat transport mechanisms. Mathematical background is also essential in this respect

Rationale: Heat transfer is a necessary process in virtually all forms of energy generation and use; from coal fired to nuclear power stations, from automobile engines to rocket motors, from refrigerating cold stores to air conditioning space vehicles. This subject is intended to make students aware about mechanisms involved in heat transfer process in many of aforementioned applications. This ultimately will enable the students to design the equipments for heat process viz., shell and tube heat exchangers, evaporators, condensers.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
4	0	2	5	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Introduction:** Overview of applications of heat transfer in different fields of engineering, modes of heat transfer- conduction, convection and radiation, heat transfer with and without change of phase. **Conduction:** Mechanism of heat conduction, Fourier's law, thermal conductivity of solids, liquids and gases, effect of temperature on thermal conductivity, General heat conduction equation in Cartesian coordinates, Boundary conditions, Formulation of heat transfer problems without generation of heat, Conduction through systems of constant thermal conductivity :- conduction through plane, cylindrical and spherical wall, combined boundary condition systems (conduction-convection systems), conduction through composite slab, cylindrical and spherical shells. Electrical analogy to heat flow, Critical and Optimum thickness of Insulation. Unsteady State heat Conduction	12
2	**Convection:** Mechanism, thermal and velocity boundary layers, boundary layer thickness, relationship between hydrodynamic and thermal boundary layer thickness for flow over flat plates, the convective heat transfer coefficient, reference temperatures, thermal boundary layers for the cases of flow over a flat plate and flow through pipe, dimensionless numbers in heat	12

	transfer and their significance. **Forced Convection:** General methods for estimation of convection heat transfer coefficient, Correlation equations for heat transfer in laminar and turbulent flow for external and internal flows for constant heat flux and wall temperature conditions- flow in a circular tube Analogy between momentum and heat transfer: Development of Reynold's and Prandtl analogy. Overview of Colburn and Von-A **Natural Convection:** Dimensional analysis, natural convection from vertical and horizontal surfaces under laminar and turbulent conditions for plates, cylinders, physical significance of Grashoff and Rayleigh numbers.	
3	**Heat transfer by radiation:** Introduction- theories of radiation, electromagnetic spectrum, thermal radiation, spectral emissive power, surface emission- total emissive power, emissivity. Radiative properties, Emission, irradiation, absorptivity, reflectivity and transmissitivity. Concept of black and grey body, radiation intensity, Laws of black body radiation, non-black surfaces- Grey, white and real surface, radiation between black surfaces and gray surfaces	**6**
4	**Heat Exchangers:** Classification of heat exchangers: Classification according to transfer processes, number of passes, surface compactness, construction features, flow arrangements, heat transfer mechanisms. Shell and tube heat exchanger, fouling, concept of overall heat transfer coefficient, LMTD, correction factor for LMTD, Sizing and rating problem using LMTD method in parallel flow, counter flow exchanger, cross flow and multi-pass heat exchangers, Temperature – distance plots for different flow arrangements in single and multi-pass heat exchangers. Determination of area, length, number of tubes required for a given duty in different configurations using LMTD method of analysis. Concept of Effectiveness- NTU method, definition of effectiveness, effectiveness NTU relations for single pass exchangers in counter-flow and parallel flow configurations. Double pipe heat exchangers: - construction, various steps for the design of double pipe heat exchangers. Plate and spiral heat exchangers, Condensers	**12**
5	**Boiling and Condensation:** Pool boiling - Boiling curve, hysteresis in the boiling curve, mechanism of nucleate boiling, Forced convection boiling - Brief over view of internal forced convection boiling. Condensation: Physical mechanisms, types of condensation, factors affecting condensation.	**8**
6	**Evaporation:** Principle of Evaporation, types of evaporators- their construction and operation, Natural circulation evaporators, short tube vertical or calendria type evaporators, basket type vertical evaporators, long tube vertical evaporators, forced circulation evaporators, falling film evaporators, climbing or rising film evaporators, agitated thin film evaporators, the plate evaporator. Single effect and multiple effect evaporators, Performance of evaporators, capacity and economy of evaporators, Overall heat transfer coefficient, effect of liquid head and boiling point elevation. Material and energy balances for single effect evaporator and the calculations on single effect evaporator. Multiple effect evaporators, Energy Balance.	**10**

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Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	**15**	**20**	**10**	**10**	**0**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Kern D Q, Process Heat Transfer, McGraw Hill Book Co. (1997).
2. Binay. K. Dutta, "Heat Transfer Principles and applications" Prentice Hall of India
3. Coulson J M and Richardson J F, Chemical Engineering Volume 1, Pergamon Press (1999).
4. Holman J. P, "Heat Transfer", McGrawHill.
5. Ozisik M. N, "Heat Transfer - A Basic Approach", McGraw-Hill.
6. Incropera F. P. and DeWitt D. P, "Introduction to Heat Transfer". John Wiley & Sons.
7. Sachdeva R.C, "Fundamentals of Engineering Heat and Mass transfer", New Age International, India
8. Rao Y.V.C, "Heat Transfer", University Press, India
9. Cengel A. Yunnus. "Heat Transfer – A Practical Approach", McGraw Hill
10. Geankopolis C J, Transport Processes and Separation Process Principles, Prentice Hall of India, 4th Edition, Eastern Economy Edition (2004)
11. Kothandaraman C.P, "Heat and Mass Transfer Data Book" New Age International, India
12. Ramesh K. Shah and Dušan P. Sekulic, Fundamentals of Heat Exchanger Design, John Wiley & Sons, Inc. 2003

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To identify different different modes of heat transfer and understand basic mechanism of conduction.	22
CO-2	To explain heat transfer under different convective regimes.	22
CO-3	To predict extent of heat flow by radiation through grey, white and real surfaces.	12
CO-4	To analyze heat transfer through different types of heat exchangers used for various applications	18

CO-5	To describe industrial applications and regimes involved in boiling and condensation	12
CO-6	To categorize different types of evaporators with their performance evaluation and to analyze material and energy balance for single and multi-effect systems	14

List of Experiments: (Minimum 10 experiments need to be performed)

1. Determination of thermal conductivity of insulating powder
2. Determination of thermal conductivity of given metal rod
3. Determination of heat transfer coefficient by natural convection
4. Determination of heat transfer coefficient by forced convection
5. Determination of overall heat transfer coefficient for counter flow in laminar regime in double pipe heat exchanger
6. Determination of overall heat transfer coefficient of shell and tube heat exchanger
7. Heat Transfer in Composite walls- Determination of effective thermal conductivity and overall resistance
8. Determination of overall heat transfer coefficient and efficiency in finned tube heat exchanger
9. Determination of overall heat transfer coefficient and efficiency in plate type heat exchanger
10. Determination of heat transfer coefficient in turbulent flow regime in a double pipe heat exchanger
11. Determination of Stephan boltzmann constant experimentally.
12. Determination of economy and capacity of open pan evaporator.
13. Determination of economy and capacity of multiple effect evaporator

Major Equipments

Thermal conductivity measurement apparatus, stefan boltzmann apparatus, composite wall apparatus, emissivity apparatus, lagged pipe apparatus, various heat exchange equipment like shell and tube heat exchanger, plate type heat exchanger, open pan evaporator, multi effect evaporator etc.

List of Open Source Software/learning website :

Reference to NPTEL lectures can be made for a better understanding regarding heat transfer under different conditions.