GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3163516
Semester – VI
Subject Name: Introduction to Heat & Mass Transfer

Type of Course: Open Elective

Prerequisite: A good understanding regarding basic states of matter along with fluid flow phenomena. Mathematical background is also essential in this respect in addition to basic heat transfer modes.

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 and mass transfer process. Mass transfer is also presented through analogy of heat transfer by diffusion and forced convection.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
2	0	2	3	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Conduction, Convection & Radiation** Conduction – Fourier's law, thermal conductivity and its effect on temperature, General heat conduction equation in Cartesian coordinates, Boundary conditions, Formulation of heat transfer problems through plane wall, cylinder, sphere & composite slab. Critical and Optimum thickness of Insulation. Convection: Mechanism, Thermal and velocity boundary layers, Convective heat transfer coefficient, thermal boundary layers for the cases of flow over a flat plate and flow through pipe, dimensionless numbers in heat transfer and their significance. Correlations for heat transfer in laminar and turbulent flow for external and internal flows for constant heat flux and wall temperature conditions, Analogy between momentum and heat transfer. 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 transmissivity. Concept of black and grey body, radiation intensity, Laws of black body radiation.	**10**
2	**Heat Exchangers:** Classification of heat exchangers, Fouling, concept of overall heat transfer coefficient, LMTD and its correction factor, Sizing and rating problem using LMTD method in parallel flow, counter flow exchanger, cross flow and multi -pass heat exchangers, Temperature profile for single & multipass heat exchangers, Shell and tube heat exchanger, Important parts, Double pipe heat exchangers, Heat Exchanger Scale up, Condensers, Evaporators- Single Effect & Multi effect evaporators. Boiling – Boiling	**10**

	curve, Hysteresis, Condensation – Drop and film wise condensation.	
3	**Introduction to Mass Transfer:** Molecular diffusion, Mass flux, Fick's law, Steady state molecular diffusion in Gases and liquids, Mass transfer coefficient and its correlations, Interphase Mass transfer and Overall mass transfer coefficient, Gas liquid Contacting Equipments.	**08**
4	**Mass Transfer operations** - Gas Absorption and Stripping, Design of packed tower, Applications of Gas Absorption & Stripping, Distillation – Vapor Liquid Equilibrium, Steam distillation, Batch distillation, Azeotropic distillation, Fractional distillation ,Mc-Cabe Thiele method, Extraction – Solvent selection, Material balance over extractors, Adsorption – Adsorbent properties & selection, Adsorption Isotherms, Batch adsorption and Fixed bed adsorption, Regeneration of adsorbents. Drying – Drying Equilibria, Rate of Drying and drying calculations. Crystallization – Crystal growth, Batch crystallization.	**14**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	**15**	**15**	**10**	**10**	**5**

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

Course Outcomes:

Sr.	**CO statement**	**Marks %**

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No.		weightage
CO-1	Define heat transfer mechanism of conduction with its relevant industrial applications.	22
CO-2	Summarise heat transfer process involved in Convection and Radiation.	22
CO-3	Application of basic heat transfer mechanisms for construction and operation of heat exchangers.	21
CO-4	Analyse the phenomena of diffusion for mass transfer in laminar and turbulent flow.	14
CO-5	Describe the construction & operational features of different types of absorbers & scrubbers.	14
CO-6	Explain the various mass transfer operations practiced in Industry viz. Distillation, Extraction, Adsorption, Crystallization and Drying.	7

List of Experiments:

1. Determination of thermal conductivity of solids
2. Determination of heat transfer coefficient by natural convection
3. Determination of heat transfer coefficient by forced convection: Determination of Forced convection heat transfer coefficients for flow of fluids through heated ducts
4. Determination of overall heat transfer coefficient for counter flow in laminar regime in double pipe heat exchanger
5. Determination of overall heat transfer coefficient and efficiency in shell and tube heat exchanger
6. Heat Transfer in Composite walls- Determination of effective thermal conductivity and overall resistance.
7. Determination of overall heat transfer coefficient and efficiency in finned tube heat exchanger
8. Determination of overall heat transfer coefficient and efficiency in plate type heat exchanger
9. Determination of heat transfer coefficient in turbulent flow regime in a double pipe heat exchanger
10. Estimation of diffusivity of a component in a solution.

List of Open Source Software/learning website:

- Reference to NPTEL lectures can be made for a better understanding regarding various heat transport operations and basics of Mass Transfer.