GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Chemical Engineering
Subject Code: BE04005021
Subject Name: Heat Transfer

W. E. F. Academic Year:	2024-2025
Semester:	4th
Category of the Course:	Professional Core Course (PCC)

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

Course Outcome:

After Completion of the Course, Student will able:

No	Course Outcomes
CO1	To understand basic mechanism of different modes of heat transfer.
CO2	To apply fundamentals of heat transfer for systems involving phase change.
CO3	To predict extent of heat transfer for with and without phase change systems.
CO4	To evaluate thermal performance of different types of heat exchangers and evaporators.

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL*	TH		ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
60	0	30	30	120	04	70	30	20	30	50	200

- ***Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.***

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, PA = Progressive Assessment, ESE = End-Semester Examination

Course Content:

Sr. No.	Content	No. of Hours
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, Dependence of thermal conductivity on various parameters, 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	**8**
2.	**Convection:** Mechanism, thermal and velocity boundary layers, boundary layer thickness, relationship between hydrodynamic and thermal boundary layer thickness for flow	**8**

	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 transfer and their significance. Forced Convection: General methods for estimation of heat transfer coefficient and dimensional analyses, 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 analogy between heat and mass transfer. 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 transmissivity. 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 grey surfaces.	**6**
4.	**Heat Exchangers:** Classification of heat exchangers: Classification according to transfer processes, geometry, surface compactness, 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, 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	**9**

	pipe heat exchangers. Plate and spiral heat exchangers. Air cooled heat exchanger, Extended surface/ fin, Temperature distribution in fin and boundary conditions, types of fin, Fin effectiveness, fin efficiency and overall efficiency.	
5.	**Boiling and Condensation:** Pool boiling - Boiling curve, hysteresis in the boiling curve, mechanism of nucleate boiling, Forced convection boiling - Brief overview of internal forced convection boiling. Condensation: Physical mechanisms, types of condensation, factors affecting condensation.	**6**
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.	**8**
Total		**45**

Suggested Specification Table with Marks (Theory):

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)

References/Suggested Learning Resources:

(a) Books:

1. "Unit Operations of Chemical Engineering", McCabe W L, Smith J C, Harriott P, Mc Graw Hill Publication, 7th Ed., 2005.
2. Kern D Q, Process Heat Transfer, McGraw Hill Book Co. (1997).
3. Binay. K. Dutta, "Heat Transfer Principles and applications" Prentice Hall of India.
4. Rao Y.V.C, "Heat Transfer", University Press, India
5. Cengel A. Yunnus. "Heat Transfer – A Practical Approach", McGraw Hill.
6. Geankopolis C J, Transport Processes and Separation Process Principles, Prentice Hall of India, 4th Edition, Eastern Economy Edition (2004).
7. Sachdeva R.C, "Fundamentals of Engineering Heat and Mass transfer", New Age International, India.
8. Ramesh K. Shah and Dušan P. Sekulic, Fundamentals of Heat Exchanger Design, John Wiley & Sons, Inc. 2003

(b) Open source software and website:

1. Students can refer to video lectures available on the websites including NPTEL.

List of Practical's: (Minimum 10 needs to be perform)

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

List of suggested activities for Problem Based Learning:

Sr. No.	Description	No. Of hours	Total Hrs.
1	Students will have to undergo industrial visit related to any one of the content mentioned in syllabus and submit the report for the same.	Visit = 5 hrs Report Preparation = 5 hrs	**10**
2	Students will have to undergo technical video based learning related to subject and have to present it or prepare a report of that learning.	Duration of video = 5 hrs Report Preparation = 5hrs	**10**
3	Students will have to submit assignment work assigned to them.	5 assignments of 2 hrs each.	**10**
4	Self learning on-line course.	Min. Duration of the course should be 10 hrs	**10**
5	Students will have to prepare poster, chart or PowerPoint presentation on technical topic related to subject content.	Duration of each activity = 6 hrs	**6**
6	Student will have to prepare working/ non-working model on technical topics.	Working = 12 hrs Non-working = 8 hrs	**12**
7	Student will have to do Group Discussion on emerging, Trending technical topics based on subject		**1hr each**

* * * * * * *