GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Chemical Engineering

Course / Subject Code: DI03005031

Course / Subject Name: Process Heat Transfer

w. e. f. Academic Year:	2024-25
Semester:	3rd
Category of the Course:	PCC

Prerequisite:	Student should have knowledge regarding Unit Operations and Applied Physics
Rationale:	In almost every chemical plant heat transfer takes place (sometimes it is intentional while sometimes it is unintentional). Study of heat transfer at steady state and unsteady state is therefore important. The knowledge of the basic concepts and principles of heat transfer helps smooth and proper operation of various heat exchangers, evaporators and condensers. Using the concepts of conduction, convection and radiation heat losses through pipes, equipments and storage tanks can be estimated. Hence the course has been designed to develop this competency and its associated cognitive, practical and affective domain learning outcomes

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Classify modes of heat transfer, steady state, unsteady state and types of heat transfer equipment.	R,U
02	Apply laws of heat transfer to various chemical engineering problems Without phase change.	R,U,A
03	Apply principles of heat transfer with phase change and dimensionless group.	R,U.A
04	Estimate the design parameters for heat transfer equipment.	A

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA(M)	PA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150

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Course Content:

Unit No.	Content	No. of Hours	% of Weightage
Unit – I Fundamental of Heat Transfer	1.1 Definition and importance of process heat transfer 1.2 Steady state and unsteady state heat transfer 1.3 Basic modes of heat transfer 1.4 General laws of heat transfer (a) Conduction (b) Convection (c) Radiation 1.5 Thermal conductance and thermal resistance	05	08
Unit – II Heat Transfer by Conduction	2.1 Concept of heat conduction 2.2 Thermal conductivity of materials – solids, liquids and gases 2.3 Concept of thermal storage capacity and thermal diffusivity 2.4 One dimensional steady state heat conduction through a plane wall, cylinder and sphere 2.5 One dimensional steady state heat conduction through composite plane wall 2.6 One dimensional steady state heat conduction through composite cylinder 2.7 One dimensional steady state heat conduction through composite sphere 2.8 Thermal Insulation 2.9 Derivation of equation for critical radius of insulation 2.10 Enhanced heat transfer: concept of fins (extended surface)	10	22
Unit – III Heat Transfer by Convection	3.1 Classification of Convection (a) Free convection (Natural convection) (b) Force convection 3.2 Newton's Law of convective heat transfer 3.3 Individual and Overall heat transfer coefficient 3.4 Significance of dimensionless groups (a) Prandtl No (b) Reynolds No (c) Grashoff No (d) Nusselt No	04	10
Unit – IV Heat Transfer by Thermal Radiation	4.1 Fundamental facts of radiation 4.2 Concepts of thermal radiation: (a) Absorptivity (b) reflectivity (c) Transmittivity 4.3 Concept of thermal radiation: (a) Black body (b) White body (c) Gray body (d) Opaque body (e) Transparent body 4.4 Concept of thermal radiation: (a) Emissive power (b) Emissivity(f) Monochromatic wave length 4.5 Laws of radiation (a) Stefan Boltzmann Law (b) Wien's displacement law (c) Kirchhoff's Law (d) Plank's Law	06	14

	4.6 Concept of a black body		
Unit – V Heat Transfer with Phase Change	5.1 Introduction to Heat transfer with phase change 5.2 Phenomena of Boiling 5.3 Regimes of Pool boiling 5.4 Phenomena of Condensation 5.5 Drop wise and film wise Condensation	05	12
Unit – VI Heat exchangers	6.1 Introduction of heat exchanger 6.2 Types of heat exchanger based on flow pattern, function and construction 6.3 Double pipe heat exchanger 6.4 Shell and tube heat exchanger 6.5 Plate type heat exchanger 6.6 LMTD for parallel (Co-current) flow derivation of equation and simple calculations. 6.7 LMTD for Counter current flow derivation of equation and simple calculations 6.8 LMTD correction factors. 6.9 Overall heat transfer co-efficient of heat exchangers 6.10 Effect of scale formation	10	22
Unit – VII Evaporation	7.1 Introduction of evaporation 7.2 Characteristics of liquid for evaporation 7.3 Evaporator capacity and economy 7.4 Boiling point elevation and duhring's rule 7.5 Types of evaporators (a) natural circulation (b) force circulation	05	12
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
17	**48**	**35**	---------	————————	————————

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

S.No.	Title of Book	Author	Publication with place, year and ISBN
1	Unit Operations of Chemical Engineering	McCabe, Warren L., Julian C. Smith	McGraw Hill Publication, New York 2004(Seventh Edition)
2	Engineering heat transfer	Gupta & Prakash	Nem Chand & Brothers, Roorkee, India,20007 (Eighth Edition)
3	Process heat transfer	D.Q.Kern	Tata McGraw Hill Publication, New Delhi, (Reprint 2008)
4	Unit Operation-II	K.A. Gavhane	Nirali Prakashan, Pune 2009
5	Heat Transfer	J. P. Holman	McGraw Hill Publication, New York 2010 (Tenth Edition)

(b) Open-source software and website:

1. https://ndl.iitkgp.ac.in/
2. https://www.vlab.co.in/
3. https://swayam.gov.in/
4. https://onlinecourses.nptel.ac.in
5. Literature available in any laboratory manual of Process heat transfer
6. MIT Open course lecture available on Internet etc…
7. National Digital Library of India

Suggested Practical List:

Sr. No.	Practical/Exercise (Course Outcomes in Psychomotor Domain according to NBA Terminology)	Approx. Hrs Required
1	Determine the thermal conductivity of Metal Rod	2
2	Determine the thermal conductivity of non-metal (solids) or (Insulating Material)	2
3	To determine the thermal conductivity of given liquid.	2
4	Determine the thermal conductivity of concentric sphere	2
5	Determine the thermal conductivity of composite wall	2
6	Determine critical radius of insulating material	2
7	Determine the specific heat of Air by forced convection.	2

8	To determine convective heat transfer coefficient in natural convection.	2
9	To determine convective heat transfer coefficient in forced convection.	2
10	To Measure the Emissivity of the Test plate Surface.	2
11	To determine the value of Stefan Boltzmann constant for radiation heat transfer	2
12	To study the phenomenon of boiling heat transfer and to plot the graph of heat flux versus temperature difference. (Critical Heat Flux Apparatus)	2
13	To determine overall heat transfer coefficients obtained by operating the double pipe heat exchanger	2
14	To determine LMTD of the plate type heat exchanger under parallel and counter Flow arrangement.	2
15	To calculate the overall heat transfer coefficient of the shell and tube heat exchanger	2
16	Determine economy of open pan evaporator.	2
17	Study and compare different types of Evaporators.	2

Suggested Activities for Students:

1. Assignments
2. Technical Quiz/MCQ Test
3. Preparation of non-working models of various heat exchange equipments and its importance.
4. Preparation of power-point slides, which include videos, animations of various heat exchange equipments

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