GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: PROCESS HEAT TRANSFER
(Course Code: 3340501)

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	4th Semester

1. 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.

2. COMPETENCY

The course should be taught and curriculum should be implemented with the aim to develop required skills so that students are able to acquire following competency:

- **Supervise operation and maintenance of various heat transfer equipments.**

3. COURSE OUTCOMES

The theory should be taught and practical should be carried out in such a manner that students are able to acquire required learning out comes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

i. Classify Modes of heat transfer
ii. Derive equations of steady state heat transfer through wall, cylinder and sphere
iii. Explain shell and tube heat exchangers
iv. Explain heat transfer with phase change
v. Calculate radiation based on radiation laws

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	200
4	0	4	8	70	30	40	60	

Legends: L - Lecture; **T -** Tutorial/Teacher Guided Student Activity; **P -** Practical; **C -** Credit; **ESE** - End Semester Examination; **PA** - Progressive Assessment

5. COURSE DETAILS

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I Fundamental of Heat Transfer	1a. Define Heat Transfer & write its' importance	1.1 Definition and importance of heat transfer in process Industries
	1b. Classify Modes of heat transfer	1.2 Modes of heat transfer (a) Conduction (b) Convection (c) Radiation
	1c. Differentiate steady state and unsteady state heat transfer	1.3 Steady state and unsteady state heat transfer
Unit – II Heat Transfer by Conduction	2a. Explain Fourier's Law	2.1 Fourier's law of heat conduction with Concepts of (a) Heat transfer rate (b) Heat flux (c) Temperature gradient
	2b. Describe thermal conductivity.	2.2 Thermal conductivity and its variation with temp.
	2c. Derive equations of steady state heat transfer through wall, cylinder and sphere 2d. Calculate heat transfer rate	2.3 Steady state (S.S.) heat conduction through composite wall 2.3.1 S.S. heat conduction through composite cylinder up to three layers 2.3.2 S.S. heat conduction through composite sphere up to three layers 2.4 Simple problems by direct use formula
	2e. Explain Thermal Conductivity of solids, liquids and gases	2.5 Thermal Conductivity of solids, liquids and gases
	2f. Describe insulation 2g. Calculate critical radius of insulation	2.6 Hot and cold Insulation (a) Optimum thickness of insulation (b) Lagging of steam pipe 2.7 Derivation of equation for critical radius of insulation and calculations
Unit – III Heat Transfer by Convection	3a. Describe types of convection	3.1 Types of Convection 3.1.1 Free convection 3.1.2 Force convection
	3b. Explain Newton's Law	3.2 Newton's Law of convective heat transfer
	3c. Derive equation of overall heat transfer coefficient	3.3 Individual and Overall heat transfer coefficient
	3d. Calculation for convection	3.4 Simple Problems of Convection
Unit – IV Heat exchangers	4a. Classify heat exchanger 4b. Describe Double pipe heat exchanger 4c. Explain shell and tube heat exchangers 4d. Describe plate type heat exchanger 4e. Describe finned type exchanger 4f. Explain heat transfer in different medium.	4.1 Types of heat exchanger based on flow pattern, function and construction 4.2 Double pipe heat exchanger (a) Counter current (b) Co-current 4.3 Shell and tube heat exchanger : (a) 1-1 Pass (b) 1-2 Pass (c) 2-4 Pass 4.4 Plate type heat exchanger 4.5 Finned type(extended surface) heat exchanger

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
		4.6 Heat transfer in agitated vessels
	4g. Derive equation and Calculate L.M.T.D.	4.7 L.M.T.D. : derivation of equation and simple calculations
	4h. Calculate overall heat transfer co-efficient and area of heat exchangers	4.8 Overall heat transfer co-efficient of heat exchangers and heat exchanger area
Unit – V Heat Transfer with Phase Change	5a. Explain heat transfer with phase change	5.1 Heat transfer with phase change
	5b. Explain dimensionless groups	5.2 Significance of dimensionless groups (a) Prandtl No. (b) Reynold No. (c) Grashoff No. (d) Nusselt No.
	5c. Describe boiling	5.3 Phenomena of Boiling (a) Pool and Nucleate boiling
	5d. Describe condensation and condensers	5.4 Phenomena of Condensation (a) Drop wise and film wise Condensation (b) Commonly used Condensers
Unit – VI Thermal Radiation	6a. Explain radiation facts	6.1 Fundamental facts of radiation
	6b. Define radiation terms	6.2 Concepts of radiation (a) Emission of radiation (b) Wavelength of radiation (c) Emissive power (d) Black body (e) Gray body (f) White body (g) Opaque body (h) Monochromatic wave length
	6c. Describe radiation laws	6.3 Radiation laws (a) Kirchhoff's Law (b) Plank's Law (c) Stefan Boltzmann Law (d) Wein's law
	6d. Calculate radiation based on radiation laws	6.4 Simple calculations of radiation between black surfaces
Unit – VII Evaporation	7a. Define evaporation	7.1 Introduction of evaporation
	7b. Explain characteristics of liquid	7.2 Characteristics of liquid for evaporation
	7c. Differentiate single and multi effect evaporation	7.3 Single and multi effect evaporation with flow arrangement
	7d. Classify evaporators	7.4 Types of evaporators (a) Short tube evaporator (b) Agitated film evaporator (c) Long tube vertical evaporators (i) Forced circulation (ii)Upward flow [Climbing film] (iii)Downward flow [Falling film] (iv) Triple Effect Evaporator
	7e. Explain evaporator capacity	7.5 Evaporator capacity and economy
	7f. Solve simple evaporation problem	7.6 Direct use of formula for solving simple evaporation problems
	7g. Describe duhring's rule	7.7 Duhring's rule and its importance.

6. SUGGESTED SPECIFICATION TABLE WITH HOURS & MARKS (THEORY)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals of Heat Transfer	2	1	2	0	3
II	Heat Transfer by Conduction	12	3	4	7	14
III	Heat Transfer by Convection	6	2	2	4	8
IV	Heat Exchangers	12	4	4	7	15
V	Heat Transfer with Phase Change	8	2	3	5	10
VI	Thermal Radiation	8	2	3	5	10
VII	Evaporation	8	2	3	5	10
Total		**56**	**16**	**21**	**33**	**70**

Legends: R = Remember; U = Understand; A = Apply and above levels (Bloom's revised 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.

7. SUGGESTED LIST OF EXERCISES/PRACTICAL

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills **(outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

Note*: Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of* ***Course Outcomes*** *related to affective domain. Thus over all development of* ***Programme Outcomes*** *(as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical/Exercise (Outcomes in Psychomotor Domain)	Apprx. Hrs. Required
1	II	Determine the thermal conductivity of Metal Rod	4
2	II	Determine the thermal conductivity of composite wall	4
3	III	Determine critical radius of insulating material	4
4	III	Determine the specific heat of Air	4
5	IV	Determine the overall heat transfer co-efficient in Agitated vessel	4
6	IV	Determine the overall heat transfer co-efficient for air to water heat exchanger	4
7	IV	Determine the liquid-liquid overall heat transfer co-efficient for shell and tube heat exchanger	4
8	IV	Determine the overall heat transfer co-efficient for	4

S. No.	Unit No.	Practical/Exercise (Outcomes in Psychomotor Domain)	Apprx. Hrs. Required
		horizontal double pipe heat exchanger.	
9	IV	Determine the overall heat transfer co-efficient for vertical double pipe heat exchanger.	4
10	V	Calculate the rate of condensation in Drop-wise condensation	4
11	V	Calculate the rate of condensation in Film-wise condensation	4
12	VI	Determine the emissivity using Stefan Boltzmann apparatus	4
13	VII	Determine economy of open pan evaporator.	4
14	VII	Study and compare different types of Evaporators.	4
Total Hours			**56**

8. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities. These could be individual and group based.

i. Prepare course/topic based presentation for seminars,
ii. Visit websites of reputed companies making heat exchangers.
iii. Teacher guided self learning activity
iv. Organise MCQ/Quiz.

9. SPECIAL INSTRCTIONAL STRATEGY (If Any)

i. Animated videos and drawings/models of heat exchangers and heat exchange phenomenon should be shown

10. SUGGESTED LEARNING RESOURCES

A. List of Books:

Sr. No.	Title of Books	Author	Publication
1	Unit Operations of Chemical Engineering	McCabe, Warren L., Julian C. Smith	McGraw Hill Publication, New York 2004 (Seventh Edition)
2	Introduction to Chemical Engineering	L.Badger, Julius T. Banchero	McGraw Hill Publication, New York 2004 (Seventh Edition)
3	Engineering heat transfer	Gupta & Prakash	Nem Chand & Brothers, New Delhi, 1999 (Seventh Edition)
4	Process heat transfer	D.Q.Kern	Tata McGraw Hill Publication, New Delhi, (Reprint 2008)
5	Unit Operation –II	Gavhane, K.A.	Nirali Prakashan, Pune 2009
6	Introduction to chemical engineering	Ghosal Salil k.	Tata McGraw Hill Publication, New Delhi, (Reprint 2006)

B. List of Major Equipment/Materials

i. **Thermal conductivity metal rod apparatus** : Bar-445 mm, Dia 25mm, test length of bar 175 mm, 9 thermocouples on bar and 4 on insulation, Nichrome heater 400 watt, Cooling jacket 90 mm dia, Temp. Indicator 0-200 ^{0}C, V-meter 0-200 V, A-meter 0-2 Amp

ii. **Thermal conductivity composite wall apparatus :** Heater Assembly-1000W, Round coil, Sandwiched, Dia-300mm; Test Specimen-Dia. 300mm, MS 20mm, Asbestos 15 mm, Wood 10mm; 8 nos. J type thermocouple, 8 Channel Digital Temperature Indicator; Assembly shall be covered with Wooden Chamber

iii. **Critical radius of insulating material apparatus :** Heater 500 W Ni-Cr 500 mm length, Test specimen MS, Dia 50 mm,500mm; Insulation over pipe; J thermocouple 12 nos., Digital temperature Indicator; The whole assembly shall be covered with wooden chamber

iv. **Specific heat of air apparatus :** 2 inch Cylindrical test section, 0.5 HP air blower, 3 phase 440 V Air heater, U-tube manometer with orifice; Thermocouples

v. **Agitated vessel:** Tank- 10 litre SS 304 ID 200mm, Height 300mm , 1.5 mm thick, Cover –SS 304, 3 mm thick; Baffles – 3 mm thick, 225 mm length, 15 mm width 4 nos., Coil- Copper, 3000 mm, ID 10 mm, OD 12.7 mm 8 turns; Heater 1 KW; Agitator- turbine, shaft 10 mm dia, speed 150 rpm max

vi. **Double pipe heat exchanger :** Inner tube SS304 -1000mm × 25mm; Outer tube – SS304, 1000mm × 25mm, 25 mm glass wool with SS304 cover; Hot and cold water tanks - inner SS304, outer MS, 50Litre, Cold water tank, Heater 3 KW; Pumps -2 nos. monoblock 0.5 HP SS304; Rotameter – 1-10 lpm, Glass tube, float SS 316

vii. **Shell and tube heat exchanger :** 1-1 pass; Shell- ID 150 mm SS, 4 baffles with 180 mm spacing, glass wool insulation, Tubes – copper 19 nos., ID 9.5 mm, 900 mm Length; Tanks -2 nos.100 litre HDPE; Pumps- 0.25 HP; Rotameters – 2nos. 1.5-15 lpm; Thermocouple -4 Nos., Digital temp. Indicator – 0-100^{0}C

viii. **Air to water heat exchanger :** Finned tube OD 20 mm ID 16 mm; 8 fins per inch, OD 45 mm; Water supply 20 lpm, Temp indicator 0-200 ^{0}C, Water inlet and drain, 0.5 HP blower for air flow, Orifice for 2 inch pipe, Butterfly valve

ix. **Emissivity apparatus:** aluminium plates, of equal dimensions. Ni-Cr heaters sandwiched in Mica sheets one plate blackbody another natural finish, Dia. 160 mm, thickness 12mm, heater 500W, Digital temp. Indicator

x. **Open Pan Evaporator :** Pan-Hemispherical SS 304 500mm dia, 3mm thick, Jacket- MS 525 mm dia, 3mm thick; Lagging- glasswool 40 mm with SS sheat cladding, 12.5 mm steam trap

C List of Software/Learning Websites

i. www.unitoperation.com

ii. www.nptel.com

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. D. H. Joshi,** Lecturer in Chemical Engineering, Government Polytechnic, Gandhinagar
- **Prof. M R Acharya,** Lecturer in Chemical Engineering, Government Polytechnic, Gandhinagar
- **Prof. N. N. Hansalia,** Lecturer in Chemical Engineering, Government Polytechnic, Rajkot

Coordinator and Faculty Members from NITTTR Bhopal

- **Dr. Abhilash Thakur.** Associate Professor, Department of Applied Sciences
- **Dr. Bashirullah Shaikh,** Assistant Professor, Department of Applied Sciences