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

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: MASS TRANSFER-I
(Course Code: 3340502)

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

1. RATIONALE

The operations which involve changes in composition of solutions, are known as the mass-transfer operations. Mass transfer operations are required for preliminary purification of raw materials or final separation of products from by-products. Mass transfer operations are major and important activity in most of the chemical plants. Hence the course has been designed to develop the following 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 of various equipments for, the mass-transfer operations in chemical process plants.**

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. Discuss fundamentals of mass transfer operation.
ii. Evaluate diffusivity of gases by using empirical equation and explain effect of pressure and temperature on diffusivity.
iii. Explain Equilibrium and resistance concept related to mass transfer at fluid surface
iv. Calculate numerical for absorption based on material balance
v. Solve problem based on material balance with different condition on ternary diagram
vi. Explain various equipment uses for liquid extraction
vii. Explain different states of operation and equipment used for leaching.
viii. Discuss various membrane types and membrane modules

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 (Outcomes in cognitive domain)	Topics and Sub-topics
Unit – I **Fundamental of Mass Transfer**	1a. Describe Importance of ass transfer operation	1.1 Introduction of Mass transfer operations
	1b. Classify mass transfer operations based on direct contact of two immiscible phases 1c. Explain Membrane separation operations	1.2 Operations based on direct contact of two immiscible phases 1.3 Membrane separation operations
	1d. Distinguish direct and indirect operations 1e. Describe selection of appropriate separation method	1.4 Direct and indirect operations 1.5 Choice of separation method
	1f. Explain fundamental design principles of Mass Transfer	1.6 Fundamental design principles of Mass Transfer
Unit – II **Molecular Diffusion in Fluids**	2a. Differentiate Molecular and Eddy diffusion 2b. Calculate the rate of diffusion in Fluids 2c. Distinguish Molar flux, diffusivity and concentration gradient in Fluids 2d. Apply the diffusion principal in Fluids	2.1 Molecular and Eddy diffusion 2.2 Rate of diffusion in Fluids 2.3 Molar flux, diffusivity and concentration gradient in Fluids 2.4 Applications of diffusion in Fluids.
	2e. Derive diffusivity equation 2f. Describe the effect of various factors on diffusivity 2g. Explain molecular diffusion in fluids for laminar flow	2.5 Derivation of diffusivity equation ($D_{AB}=D_{BA}$) 2.6 Effect of concentration, Temperature and pressure 2.7 on diffusivity 2.8 General equation for steady state molecular diffusion in fluids for laminar flow
	2h. Describe Molecular diffusion in gases 2i. Derive Equation for Steady state diffusion 2j. Evaluate diffusivity of gases using empirical equation	2.9 Molecular diffusion in gases 2.10 Derive Equation for Steady state diffusion of (a) Component A through non diffusing B and simple numerical (b) Equimolar counter current diffusion of A and B with simple numerical Empirical equation of diffusivity of gases
Unit – III **Interphase Mass Transfer**	3a. Explain Equilibrium 3b. Describe Diffusion between phases 3c. Describe various mass transfer coefficients using resistance concept 3d. Distinguish mass transfer co-efficients	3.1 Concept of equilibrium 3.2 Diffusion between phases (two resistance concept) 3.3 Local and overall two phases mass transfer co-efficient and their uses 3.4 Average overall mass transfer co-efficient
	3e. Define stage, stage efficiency and cascade	3.5 Stage and stage efficiency and types of Cascade
Unit – IV	4a. Apply concept of absorption	4.1 Industrial application of Absorption

Unit	Major Learning Outcomes (Outcomes in cognitive domain)	Topics and Sub-topics
Gas Absorption	4b. Describe the physical properties of gases 4c. Explain Raoults law	4.2 Equilibrium solubility of gases in liquids and effect of temperature and pressure. 4.3 Ideal solution and Raoult's law
	4d. Select appropriate solvent	4.4 Solvent for absorption
	4e. Explain Material balance in different condition 4f. Select liquid-gas ratio for absorber	4.5 Material balance for one component transfer 1. counter current flow 2. co-current flow 3. counter current multistage operation 4.6 Minimum liquid-gas ratio for absorber
	4g. Define various Efficiencies	4.7 Real Tray & Tray efficiency- point efficiency, Murphy efficiency, Overall Tray efficiency
	4h. Explain tray tower and packed tower 4i. Evaluate various packing	4.8 Tray tower and packed tower 4.9 HETP
	4j. Calculate absorption based on material balance	4.10 Raoult's law and material balance applied in gas absorption
Unit – V **Liquid Extraction**	5a. Apply the liquid extraction	5.1 Industrial application of Liquid Extraction
	5b. Describe the three component system 5c. Explain equilibrium using triangular co-ordinates 5d. Describe the effect of temperature and pressure	5.2 Equilibrium for three component system 5.3 Equilateral triangular co-ordinates system 5.3.1 System of three liquids-one pair partially Soluble 5.3.2 System of three liquids-two pair partially Soluble 5.4 Effect of temperature and pressure on solubility
	5e. Select appropriate solvent	5.5 Criteria for choice of solvent
	5f. Distinguish various types of extraction 5g. Describe the material balance for various stages 5h. Calculate Material balance in different conditions	5.6 Single stage extraction and multistage cross current extraction on ternary diagram 5.7 Material balance for single stage, multistage- cross current/counter current system 5.8 Problems based on material balance
	5i. Define Various equipment use in liquid extraction	5.9 Equipment Single stage extractor, agitated vessel, flow mixer and settler, spray tower, packed tower and centrifugal extractor
Unit – VI **Leaching**	6a. Describe Industrial applications	6.1. Industrial applications of leaching
	6b. Prepare solids Explain the factors affecting leaching	6.2. Preparation of solid 6.3. Temperature of leaching
	6c. Describe different states of operation and equipments	6.4. Methods of operation and equipment for (a) Unsteady state operation I. In place operation II. Heap leaching III. Percolation tanks

Unit	Major Learning Outcomes (Outcomes in cognitive domain)	Topics and Sub-topics
		IV. Filter press leaching V. Agitated vessel VI. Leaching by Shanks system (b) Steady state operation I. Leaching during grinding II. Leaching in door type agitator III. Leaching in door balanced tray thickener IV. Continues counter current decantation with flow sheet V. Leaching of vegetable seeds 1. Rotacel 2. Kennedy extractor 3. Bollman extractor 4. Continuous horizontal extractor
	6d. Explain Material balance	6.5. Material balance for single stage system
Unit – VII **Membrane Separation**	7a. Describe Membrane Separation Process	7.1 Introduction and Basic Principle of Membrane Separation
	7b. Classify membrane process	7.2 Types of Membrane Processes
	7c. Describe advantages and disadvantages 7d. Uses membrane separation processes	7.3 Advantages and disadvantages of membrane processes 7.4 Various applications of membrane separation.
	7e. Draw the diagram of various membrane modules	7.5 Various types of membrane and membrane Modules with diagram a. Plate and frame b. Tubular c. Spiral wound d. Hollow fiber

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	Fundamental of Mass Transfer	04	03	02	00	05
II	Molecular Diffusion in Fluids	07	02	04	03	09
III	Interphase Mass Transfer	05	02	02	02	06
IV	Gas Absorption	11	02	04	08	14
V	Liquid Extraction	10	02	03	08	13
VI	Leaching	11	02	03	08	13
VII	Membrane Separation	08	02	04	04	10
Total		**56**	**15**	**22**	**33**	**70**

Legends: R = Remember; U= Understand; A= Apply and above levels (Bloom's revised taxonomy)
Note: This specification table shall be treated as only as a guideline for students and teachers. The actual distribution of marks in the question paper may vary 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)	Approx. Hrs. Required
1	II	Determine diffusivity of gas-liquid system at room temperature	4
2	II	Determine diffusivity of gas-liquid system with respect to temperature	4
3	II	Determine diffusivity of liquid-liquid system at room temperature	4
4	II	Determine diffusivity of liquid-liquid system at different temperature	4
5	IV	Find out rate of absorption in a tray or packed tower	4
6	V	Determine the efficiency of single stage extraction	4
7	V	Determine the efficiency of two stage cross current extraction	4
8	V	Determine the efficiency of continuous counter current extraction	4
9	V	Prepare ternary diagram for a system of three liquids	4
10	VI	Obtain tie-line data for Acetic Acid, Benzene and water	4
11	VI	Measure recovery of salt using sand-salt mixture in single stage leaching	4
12	VI	Measure recovery of salt using sand-salt mixture in two stage leaching	4
13	VI	Calculate efficiency of Leaching by shanks system	4
14	VII	Study and Compare different types of membrane module with detailed diagram.	4
Total Hrs			**56**

8. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities such as:

i. Visit nearby industries and observe the working of mass transfer equipments and collect their specifications

ii. Visit the website of reputed mass transfer equipment manufacturers and prepare a report on these equipments.

9. SPECIAL INSTRUCTIONAL STRATERGY (if any)

i. Show animated videos and drawings of mass transfer equipment

10. SUGGESTED LEARNING RESOURCES

A. List of Books:

Sr. No.	Title of Books	Author	Publication
1	Mass Transfer Operations	Robert E. Treybal	Mc Graw- Hill, 3rd Edition, 1981
2	Unit Operation of Chemical Engineering	McCabe, Warren L., Julian C. Smith	McGraw Hill Publication, New York 2004, 7th Edition
3	Separation Process Principles	Ernest J. Henley, J. D. Seader, D. Keith Roper	Wiley India, 2nd Edition, 2005
4	Unit Operations-II	K. A. Gavhane	Nirali Prakashan, Pune, 2009
5	Unit Operations of Chemical Engineering, Volume-1	P. Chattopadhyay	Khanna Publishers, New Delhi, 1995
6	Chemical Engineering, Volume-2	Coulsion and Richardson	Butterworth-Heinemann; 5th Edition, 2002
7	Introduction to Chemical Engineering	L.Badger, Julius T. Banchero	McGraw Hill Publication, New York, 7th Edition, 2004

B. List of Major Equipment/ Instrument with Broad Specifications

i. **Gaseous diffusion system:**
Thermostatic bath 2 litre; Temperature controller 0-100 ^{0}C; Vernier 0-100 mm(0.1 mm resolution); Magnetic stirrer with heater 2 MLH; Air blower 0.25 HP

ii. **Liquid diffusion system:**
1 liter glass beaker, Magnetic stirrer 1 MLH, electrical conductivity sensor & meter to measure conductivity in MHO

iii. **Packed column absorber :**
75 mm ID, 1 m Glass column, Rasching ring packing; CO_2 cylinder with pressure regulator and rotameter; NaOH circulation system with pump, sump and rotameter

iv. **Continuous extractor :**
Glass column ID 75mm, OD 87mm, Height 1000mm; Supply tanks(three)-SS 304, 40 litre; Rotameters(two)-0.3 to 3 lpm-Glass tube, SS316 float; 0.25 HP motor with SS 304/316 shaft and blades

v. **Leaching apparatus :**
Leaching bag-Polypropylene; Glass column Dia. 40 mm, height 400mm with SS 304 cap at both end; Solvent tank SS304-25 litre with 1 KW immersion heater; Collection tank SS 304, 30 litre; Pump- MOC-Polypropylene, 15 lpm flow rate

vi. **Glass Separating funnels**
-250ml, 500ml ; **Burettes**-25 ml, 50 ml; **Pipettes** - 10 ml, 25 ml; **Conical flasks**- 250 ml, 500 ml; **Beakers** - 250 ml, 500 ml

C . List of Software/Learning Websites

i. www.unitoperation.com
ii. www.nptel.com

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. Harsh B. Shukla**, Lecturer in Chemical Engineering, Shri K.J. Polytechnic, Bharuch
- **Prof. Upasana T. Singh**, Lecturer in Chemical Engineering, Shri K.J. Polytechnic, Bharuch
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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

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: CHEMICAL PROCESS TECHNOLOGY-II
(Code: 3340503)

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

1. RATIONALE

This course provides the essential link between chemistry and the chemical industry. It is vital to develop the comprehensive understanding about the fundamental knowledge and manufacturing process for various chemical products. This course develops the skill to understand and arrange the treatment, reaction and separation steps in a flow diagram of chemical production process. 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:

- **Prepare flow diagram for the manufacturing of various chemical products**.

3. COURSE OUTCOME

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.

- Explain Manufacture of Vegetable oil, Sugar from sugar-cane, Starch from maize and Dextrin from starch
- Describe manufacturing of pulp and paper industries with major engineering problems
- Prepare flow diagram and Explain manufacturing of fuel gases
- Prepare flow diagram and Explain manufacturing of Ethyl alcohol by fermentation, lactic acid from corn sugar, citric acid from molasses and vinegar by Frings' method
- Explain manufacturing of rubber chemicals
- Explain manufacturing of various pharmaceutical products.
- Describe manufacturing process of pesticides
- Explain Production of bromine from sea water

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 0	208 06	70 70	30 30	40 20	60 30	

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 **Natural Product Industries**	1a. Define oil and fat	1.1 Basics of oil and fat
	1b. Describe physical properties of oil	1.2 Physical properties of oil
	1c. Describe carbohydrates	1.3 Introduction to Carbohydrates
	1d. Draw flow diagram explain manufacturing process of (i)Vegetable oil (ii) Hydrogenated products of oil (iii) Sugar from sugar-cane (iv) Starch from maize (v) Dextrin from starch	1.4 Manufacturing Process of (i) Vegetable oil (ii) Hydrogenated products of oil (iii) Sugar from sugar-cane (iv) Starch from maize (v) Dextrin from starch
	1e. Distinguish chemicals available from the sea	1.5 Chemicals from sea
	1f. Draw flow diagram describe manufacturing process of bromine from sea water.	1.6 Production of bromine from sea water
Unit – II Pulp and Paper Products	2a. Explain pulp and paper	2.1. Fundamentals of Pulp and paper
	2b. Distinguish methods of pulp production 2c. Describe various steps of pulp production 2d. Draw flow diagram explain manufacturing of paper using Fourdrinier machine	2.2. Methods of pulp production 2.3. Sulphate (Kraft) pulp process 2.4. Manufacturing of paper using Fourdrinier machine
	2e. Identify major engineering problems of paper manufacturing	2.5. Paper manufacturing
Unit – III **Fuel and Industrial Gases**	3a. Classify fuels 3a1. List types, sources, uses of fuels	3.1 Fuels:
	3b. List types, sources, uses of industrial gases	3.2 Important industrial gases: types, sources, uses
	3c. Draw flow diagram explain manufacturing process of fuel gases	3.3 Production of fuel gases (i) producer gas (ii) water gas (iii) coke oven gas (iv) natural gas
	3d. Describe industrial electrolytic process	3.4 Industrial electrolytic processes
	3e. Describe Cryogenic for producing industrial gases	3.5 Cryogenic
Unit – IV Fermentation Industries	4a. Classify fermentation 4a1.List types of fermentation	4.1. Fermentation
	4b. Draw flow diagram explain manufacturing (i) Ethyl alcohol by fermentation (ii) Lactic acid from corn sugar	4.2. Manufacture of (i) Ethyl alcohol by fermentation (ii) Lactic acid from corn sugar (iii) Citric acid from molasses

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
	(iii) Citric acid from molasses (iv) vinegar by Frings'method	(iv) vinegar by Frings' method
	4c. Describe use of biotechnology in chemical engineering	4.3. Biotechnology in Chemical Engineering
Unit – V **Rubber Chemicals**	5a. Define rubber 5b. Describe production of natural rubber 5b1.List properties and uses of natural rubber 5c. Classify synthetic rubbers 5c1. List uses of synthetic rubber	5.1 Fundamentals of rubber 5.2 Natural rubber 5.3 Synthetic rubbers
	5d. Explain compounding procedure for rubber	5.4 Compounding of rubber
	5e. Draw flow diagram for manufacturing of (i) styrene butadiene rubber (ii) poly butadiene rubber (iii) chloroprene (iv) nitrile rubber	5.5 Manufacturing of (i) styrene butadiene rubber (ii) poly butadiene rubber (iii) chloroprene (iv) nitrile rubber
Unit – VI **Pharmaceuticals**	6a. Classify pharmaceutical products on the basis of use (with examples)	6.1. Pharmaceutical products
	6b. Distinguish Important drugs	6.1. Important Drugs (i) Antipyretic (ii) Anaesthetic (iii) Analgesic (iv) Anti-malarial (v) Anti-TB drugs (vi) Antibiotics (vii) Antihistamine (viii) Vitamins
	6c. Draw flow diagram and explain manufacturing of (i) Antibiotics, (ii) Aspirin, (iii) Paracetamol	6.3(i) Antibiotics, (ii) Aspirin, (iii) Paracetamol
Unit-VII **Pesticides**	7a. Describe the important Pesticides	7.1 Important pesticides: (i) Algiscide, (ii) Bactericide, (iii) Fungicide, (iv) Herbicide, (v) Insecticide (vi) Biopesticide
	7b. Formulate pesticides	7.2 Formulation of Pesticide
	7c. Draw block diagram and explain manufacturing of (i) methyl bromide (ii) 2-4 Dichlorophenoxy acetic acid	7.3 Manufacturing process of (i) methyl bromide (ii) 2-4 Dichlorophenoxy acetic acid

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

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total
1.	Natural Product Industries	11	04	06	04	14
2.	Pulp and Paper Products	06	02	04	01	07
3.	Fuel and Industrial Gases	08	03	05	02	10
4.	Fermentation Industries	08	02	06	02	10
5.	Rubber Chemicals	08	02	06	02	10
6.	Pharmaceuticals	09	04	06	02	12
7.	Pesticides	06	02	03	02	07
	Total	**56**	**19**	**36**	**15**	**70**

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

Note: This specification table shall be treated as a 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)	Approx. Hrs. Required
1	I	Estimate Acid value in oil sample	04
2	I	Estimate iodine value in oil sample	04
3	I	Prepare starch from maize	04
4	I	Extract vegetable oil from seed	04
5	I	Prepare Glycerine	04
6	I	Estimate NaCl content in sea water	04
7	II	Prepare pulp from bamboo	04
8	III	Estimate moisture, volatile matter and ash content in fuel	04
9	IV	Prepare alcohol	04
10	IV	Prepare citric acid	04

11	IV	Prepare vinegar	04
12	V	Analyse rubber products	04
13	VI	Prepare Aspirin	04
14	VI	Prepare Paracetamole	04
Total Hours			**56**

8. SUGGESTED LIST OF STUDENT ACTIVITIES

i. Prepare course/topic based presentations for seminars
ii. Visit websites of reputed process plant industries

9. SPECIAL INSTRUCTIONAL STRATEGY (If Any)

i. Arrange visit to nearby industries
ii. Show vides/animation films/photographs of different process plants.
iii. Give internet based assignments
iv. Give mini projects on preparing feasibility report for preparing different chemicals on commercial scale.

10. SUGGESTED LEARNING RESOURCES

A. List of Books

Sr. No.	Title of Books	Author	Publication
1	Outlines of Chemical Technology	M. Gopala Rao, Marshall Sittig	Affiliated East West Press (Pvt) Ltd-New Delhi, 3rd edition
2	Shreve's Chemical Process Industries,	Austin G.T.	McGraw Hill publication – New Delhi, 5th edition
3	Chemical Technology -Vol. I and II	G.N. Pandey and Shukla	Vani Books Company -Hyderabad, 2nd edition
4	A Text Book on Petrochemicals	Rao B. K. B.	Khanna Publishers, New Delhi, 2nd edition

B. List of Major Equipment/ Instrument with Broad Specifications

i. Glassware: Conical flask, burette, pipette, RBF, measuring cylinder, beaker
ii. Glass Assembly: RBF, reaction vessel, condenser, separating vessel
iii. Burner
iv. Weight balance (minimum 0.1gm)
v. Heating and cooling bath

C. List of Software/Learning Websites

i. www.epa.gov/sectors/sectorinfo/sectorprofiles/chemical.html
ii. www.naturalproductsexpoindia.com/
iii. www.andritz.com/pulp-and-paper/pp-pulp-production.htm
iv. ewww.linde-gas.com/en/products_and_supply/gases_fuel/index.htm

v. http://chemistry.about.com/od/biochemistry/a/carbohydrates.htm
vi. www.azom.com/article.aspx?ArticleID=3580
vii. www.iisrp.com/WebPolymers/00Rubber_Intro.pdf
viii. http://www.niehs.nih.gov/health/topics/agents/pesticides/
ix. http://levine.sscnet.ucla.edu/papers/imbookfinal09.pdf

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. R. P. Hadiya**, Lecturer, Chemical Engineering, Govt. Polytechnic-Rajkot
- **Prof. S. K. Charola**, Lecturer, Chemical Engineering, Sir BPIT-Bhavnagar
- **Prof. N. N. Hansalia**, Lecturer, Chemical Engineering, Govt. 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,

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: POLLUTION CONTROL & EFFLUENT TREATMENT
(Code: 3340504)

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

1. RATIONALE

Study of environmental pollution, related to the chemical industry is must to understand various types of pollutions and its preventive and control majors. The study of this course would help engineers in operating diverse pollution control equipments for controlling gaseous, water and land pollution. They have to perform sampling and analysis of samples from various sources in the industry. 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:

- **Perform sampling, analysis and treatment of pollutants to control pollution**

3. COURSE OUTCOMES (COs)

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. Define & classify pollution and pollutant - (Air , Water , solid)
ii. Describe removal of pollutants by applying various treatment methods
iii. Identify Sources of Pollution
iv. Conduct Environmental audit and ISO 14001

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	150
3	0	2	5	70	30	20	30	

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 **Basics of Environmental Pollution**	1a. Define pollution and pollutant	1.1 Introduction of pollution and pollutants
	1b. Classify pollutants & pollution	1.2 Types of pollution and pollutants
	1c. Identify Sources of Pollution	1.3 Sources of air, water, noise, radioactive and land pollution
	1d. Explain Effect of pollution	1.4 Effects of air, water, noise, radioactive and land pollution
Unit – II **Air Pollution**	2a. Explain Sampling of air pollutants 2b. Distinguish gaseous and particulate pollutants	2.1 Ambient air sampling 2.2 Sampling of gaseous air pollutants and particulate pollutants
	2c. Describe Construction and working of Particulate control equipments	Particulate control equipments 2.3 Gravity Settling Chamber, Cyclone separator, Fabric Filter, Wet Scrubber and Electrostatic Precipitator
	2d. Describe Thermal incineration 2e. List Methods for control of Sulfur dioxide emission 2f. Apply control methods for gaseous air pollutants from Sulfur. 2g. Apply control methods for gaseous air pollutants from Nitrogen Oxides. 2h. Apply control methods for carbon monoxide 2i. Describe removal of pollutants by applying control methods for hydrocarbons	2.4 Thermal incineration 2.5 Methods for control of Sulfur dioxide emission 2.5.1 Extraction of sulfur from fuels 2.5.2 Hydrodesulphurization of coal 2.5.3 Desulphurization of fuel oils 2.5.4 Desulphurization of flue gases by Dry processes(using metal oxides and activated carbon) and wet processes(wet scrubbing methods) 2.6 Methods for control of Nitrogen Oxides 2.6.1 Absorption of NOx 2.6.2 Adsorption of NOx 2.6.3 Catalytic reduction 2.7 Control of carbon monoxide 2.8 Control of hydrocarbons
Unit – III **Water Pollution**	3a. Explain characteristics of water	characteristics of water 3.1 Dissolved oxygen, BOD,COD, VM, Suspended Matter, Dissolved solids, pH
	3b. Distinguivish Waste water sampling methods	3.2 Water sampling methods 3.2.1 Grab sampling 3.2.2 Composite sampling
	3c. Describe removal of pollutants by applying Waste water treatment methods	3.3. Waste water treatment methods 3.3.1 Primary treatment 3.3.1.a Pretreatment 3.3.1.b Sedimentation 3.3.1.c Floatation

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
		3.3.2 Secondary treatment 3.3.2.a Aerobic process 3.3.2.b Anaerobic process: Activated sludge process and trickling filter
	3d. Describe removal of pollutants by applying various treatment methods on suspended solids 3e. Describe removal of pollutants by applying various treatment methods on dissolved solids 3f. List treatment methods for dissolved solids 3g. Describe facultative ponds 3h. Explain oxidation and disinfection	3.4 Suspended solids treatment methods 3.4.4 Microstraining 3.4.5 Coagulation 3.4.6 Filtration 3.5 Dissolved solids and treatment methods 3.5.4 Ion exchange 3.5.5 Reverse Osmosis 3.5.6 Electrolysis 3.6 Facultative ponds 3.7 Chemical oxidation/Disinfection
	3i. .Explain Sludge processing	3.8 Thickening, Digestion, Conditioning, Dewatering, Oxidation and ultimate sludge removal
	3j. Describe Effluent treatment plant drawing schematic block diagram	3.9 Effluent treatment plant- ETP
	3k. List out norms of GPCB for potable water	3.10 Norms of GPCB for potable water
Unit – IV Solid Waste Management	4a. Define solid waste 4b. Classify solid waste	4.1. solid waste
	4c. Explain all methods of solid Waste Disposal	4.3. Methods of solid waste disposal 4.3.1 Open Dumping 4.3.2 Sanitary Land filling 4.3.3 Incineration 4.3.4 Compositing 4.3.5 Reuse, recovery and recycling
Unit – V Environmental audit and ISO 14001	5a. Describe Procedure for Environmental Audit	5.1 Environmental audit 5.1.1 Procedure for environmental audit
	5b. List ISO 14001 norms 5c. Describe Procedure for applying ISO 14001 norms	5.2 ISO 14001 5.2.1 Benefits of ISO 14001 5.2.2 ISO 14001- Assessment process

6. SUGGESTED SPECIFICATIONTABLE WITH HOURS & MARKS (THEORY)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of Environmental Pollution	08	06	08	00	14
II	Air pollution	14	04	10	08	22
III	Water pollution	12	04	10	06	20
IV	Solid Waste Management	04	02	03	02	07
V	Environmental audit and ISO 14001	04	02	02	03	07
Total Hrs		**42**	**18**	**33**	**19**	**70**

Legends: R = Remember; U= Understand; A= Apply and above levels (Bloom's revised taxonomy)
Note: This specification table shall be treated as a 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.

Sr. No.	Unit No.	Practical/Exercise (Outcomes' in Psychomotor Domain)	Approx. Hrs. Required
1	I	Prepare detail charts of various Pollutants and sources of pollution	02
2	II	Remove suspended Impurities from air using cyclone system	02
3	II	Remove suspended Impurities from air using fabric filter	02
4	III	Determine hardness (Temporary and Permanent hardness) of given water sample	02
5	III	Determine COD of the given effluent sample	02
6	III	Measure suspended particles in liquids using Turbidity	02

Sr. No.	Unit No.	Practical/Exercise (Outcomes' in Psychomotor Domain)	Approx. Hrs. Required
		meter	
7	III	Determine hydrogen ion concentration (pH) of sample using pH meter.	02
8	III	Determine BOD of given sample	04
9	III	Determine Dissolved Oxygen in effluent sample	02
10	III	Determine total dissolved solids in given effluent sample using heat treatment	02
11	III	Determine chloride concentration in given effluent sample using heat treatment	02
12	IV	Remove suspended solid by coagulation.	02
13	IV	Prepare chart for treatments of different solid waste	02
14	V	Prepare Environmental Audit report for any Chemical Industry	04
Total Hrs			**32**

8. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities such as:

i. Visit to websites of different manufacturer of effluent treatment equipments and prepare a report.
ii. Visit to websites of pollution control boards of different states/countries and study their norms and regulations

9. SPECIAL INSTRUCTIONAL STRATEGY (If any)

i. Show video film of an ETP and on other pollution control measures.
ii. Arrange visit to nearby solid waste disposal site/segregation plant/incinerator
iii. Arrange visit to nearby Pollution Control Board/Effluent treatment plants

10. SUGGESTED LEARNING RESOURCES

A. List of Books

S. No.	Title of Books	Author	Publication
1	Environmental Pollution control	Rao C. S.	New age international Pvt. Limited, 2nd edition
2	Pollution Control in Process Industries	Mahajan S. P.	Tata Mc GrawHill, New Delhi, 21st reprint, 2008
3	Text Book of Environmental Pollution and Control	Dr. Bhatia H. S.	Galgotia Publication, 1st edition, New Delhi
4	Environmental Engineering	Pandey G. N., Carney G. C.	Tata Mc GrawHill, New Delhi

B. List of Major Equipment/Materials

i. **Glassware:** Titration set up, crucible, beaker
ii. **pH meter**: pH range-2.00 to +16.00, Resolution: 0.01, Accuracy: ±0.02, mV range: ±1999 mV, Temperature range: -10 to +105°C
iii. **Turbidity mete range:** 0 - 10,000 NTU, Principle of Operation-Nephelometric, Ratio (Color Correction): Full Time ON or OFF, Accuracy: ± 2% of reading plus 0.01 NTU (0 to 1000 NTU), Response Time: less than 6 seconds ,Sample Size: 30 ml
iv. **Incubator (BOD set up):** Chamber volume:285.0 ltrs, range :+50C to 600C, controller accuracy:+/-0.50C set value of temp., PID Control: microprocessor based PID controller
v. **Cyclone separator:** 20" diameter cyclone dust collector,3" carbon steel straight wall and a 38" carbon steel cone tapering to an 8" x 8" discharge, 3" inlet and 3" exhaust. Splits in the middle for easy clean out
vi. **Weighing machine :** Digital min. measurement 1 microgram

C. List of Software/Learning Websites

i. http://www.cosmolearning.com/courses/fundamentals-of-environmental-pollution-and-control-401/video-lectures/
ii. http://www.answers.com/topic/air-pollution
iii. https://en.wikipedia.org/wiki/Water_pollution
iv. http://www.water-pollution.org.uk/causes.html
v. http://www.acsregistrars.com/iso14001.asp

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

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- **Prof. N. N. Hansalia**, Lecturer in Chemical Engineering, Government Polytechnic, Rajkot
- **Prof. (Mrs.) K. J. Sareriya**, Lecturer in Chemical Engineering, Government Polytechnic, Rajkot
- **Prof. (Mrs.) Parul K. Patel**, Lecturer in Chemical Engineering, Government Polytechnic, Gandhinagar

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- **Prof. Abhilash Thakur**, Associate Professor, Dept. of Applied Sciences
- **Prof. Bashirulla Shaik**, Assistant Professor, Dept. of Applied Sciences

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: SAFETY AND HAZARD MANAGEMENT IN CHEMICAL INDUSTRY
(Code: 3340505)

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

1. RATIONALE

Chemical Industries are known as the most dangerous and hazardous industries since long. Varieties of conditions are present in chemical industries which may lead to different type of industrial accidents. Bhopal MIC leak accident is a world famous industrial accident which also happened in a chemical plant of Union Carbide Company in which thousands died and many got different diseases. Most of the industrial accidents are due to the human error or ignorance and responsible for the major losses to the industries and humanity. Use and handling of certain chemicals is also found to be dangerous as it may lead to health hazards. It is therefore essential for the technician to know about hazards, accidents, safe handling of chemicals, and operation of plant equipment and transportation of chemicals. 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:

- **Handle chemicals and operate chemical plant safely**

3. COURSE OUTCOME

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. Explain Indian and International Safety standards.
ii. Identify the causes of accident and explain various engineering control methods
iii. Explain storage, handling and transportation of hazardous materials.
iv. Classify fire extinguishing agents and methods
v. Explain risk assessment methods.

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	150
3	0	2	5	70	30	20	30	

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 Introduction to Industrial Safety and Hazards	1a. Describe importance of safety in Industry	1.1 Importance of Industrial Safety
	1b. Classify the hazards	1.2 Types of hazard (a) Chemical hazard (b) Thermal hazard (c) Electrical hazard (d) Mechanical hazard (e) Vibrational hazard (f) Biological hazard (g) Radioactive hazard
	1c. Explain Indian and International safety standards	1.3 Safety and health Standards 1.3.1 Indian Standards & codes for safety & health 1.3.2 International standard: OHSAS 18001
Unit – II Chemical hazards and Their Control	2a. Classify chemical hazards & their control 2b. Explain occupational diseases and poisoning 2c. Apply preventive measures of diseases	2.1 Classification of Chemical Hazards and their control 2.2 Chemicals as a cause of occupational diseases and poisoning 2.3 Prevention of diseases due to chemical effect
	2d. Describe safety aspects in plant layout 2e. Identify different colour codes for chemical plants	2.4 Safety aspects in plant layout, Ventilation and lighting 2.5 Color codes and symbols for safety in chemical plants (a) Classification of Color codes and symbols (b) Color codes for gas cylinders (c) Color codes for pipelines
	2f. Classify Personal Protective Devices 2g. List Personal Protective Devices in each	2.6 Personal Protective Devices (PPDs) (a) Non respiratory (b) Respiratory
Unit – III Safe Handling of Hazardous Chemicals	3a. Discuss characteristics of hazardous chemicals	3.1 Important characteristics and chemical reaction of 3.2 hazardous chemicals like (a) Chlorine (b) Nitric Acid (c) Ammonia (d) Carbon Monoxide (e) Caustic Soda (f) Phosphoric Acid

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
		(g) Sulfuric Acid (h) HCl
	3b. Handle hazardous chemicals for Storage, Handling & Transportation	3.2 Storage, Handling & Transportation of hazardous chemicals
Unit – IV Fire Hazards and their Prevention	4a. Describe Fire hazards 4a1. List the causes of Fire hazards	4.1.Fire hazards & their causes
	4b. Explain fire triangle	4.2.Fire Triangle
	4c. Describe Classes of fire	4.3.Classes of fire
	4d. Describe fire extinguishers 4e. List types of extinguishers 4f. Describe Construction and working of fire extinguishers 4g. Describe Methods of their applications for fire extinguishers	4.4. Fire extinguishers 4.4.1 Classes of fire & types of extinguishers 4.4.2 Construction and working of fire extinguishers 4.4.3 Methods of their applications
Unit – V Hazard Identification and Risk Assessment	5a. Explain hazard identification methods	5.1 Hazard identification methods : a) Hazard Operability study (HAZOP), b) Hazard Analysis (HAZAN)
	5b. List risk assessment methods 5b1Explain risk assessment methods	5.2 Risk Assessment methods: a) Failure mode and effect analysis (FMEA) b) Fault Tree analysis (FTA) c) Event Tree analysis (ETA)

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	Introduction to Industrial Safety and Hazards	06	4	4	2	10
II	Chemical hazards and Their Control	14	10	8	6	24
III	Safe Handling of Hazardous Chemicals	06	4	4	2	10
IV	Fire Hazards and their Prevention	06	4	4	2	10
V	Hazard Identification And Risk Assessment	10	8	6	2	16
Total		**42**	**30**	**26**	**14**	**70**

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

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

Sr.No.	Unit No.	Practical/Exercise (Outcomes' in Psychomotor Domain)	Apprx. Hrs. Required
1	I	Prepare a chart of Indian safety standards	02
2	I	Identify different hazards in a given chemical plant	02
3	II	Identify different chemical hazards in a given chemical plant	02
4	II	Identify colour codes for pipelines	02
5	II	Identify colour codes for gas cylinders	02
6	II	Identify different safety symbols for chemical industry	02
7	II	Demonstrate Personal Protective Devices	02
8	III	Prepare a handouts of safe handling practices for hazardous chemicals	04

Sr.No.	Unit No.	Practical/Exercise (Outcomes' in Psychomotor Domain)	Apprx. Hrs. Required
1	I	Prepare a chart of Indian safety standards	02
2	I	Identify different hazards in a given chemical plant	02
9	IV	Demonstrate Fire triangle and classes of fire	02
10	IV	Demonstrate construction and working of different fire extinguishers	04
11	V	Apply HAZOP method using a case study	02
12	V	Apply Risk Assessment method for a chemical plant	02
Total Hrs			**28**

8. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities:

i. Study of Fire extinguishers / Visit of a nearby fire station
ii. Study of personal protective equipments / visit to nearby industry
iii. Preparation of Material Safety Data Sheet of hazardous materials
iv. Visit to websites of reputed fire and safety equipment suppliers and study of features of their equipment/instruments/tools.

9. SPECIAL INSTRUCTIONAL STRATEGY (IF ANY)

i. Show different video/Animated films about functioning of different safety equipment/fire prevention equipment
ii. Discuss case studies of major industrial disasters/accidents and cause for them.

10. SUGGESTED LEARNING RESOURCES

A. List of Books

Sr. No.	Title of Books	Author	Publication
1	Manual of Chemical Technology, Chemtech-I	D.Venkateswarlu, K.R.Upadrashta, K.D. Chandrasekaran	Chemical Engineering Education Development Centre, IIT, Madras, 1975
2	Fundamentals of Industrial Safety & Health	Dr. K. U. Mistry	Siddharth Prakashan, Ahmadabad
3	Chemical Process Safety: Fundamentals with application	Daniel A. Crowl, Joshef F. Louvar	3rd Edition, 2011, Prentice Hall, USA,
4	Industrial Safety Management	N. K. Tarafdar, K. J. Tarafdar	Dhanpatrai and Co.Ltd., New-Delhi, 1st Edition, 2012
5	Industrial safety management	L M Deshmukh	Tata McGraw Hill, New Delhi, 2006
6	Industrial Safety, Health & Environment management	Sunil S. Rao, R.K. Jain	Khanna Publishers, New Delhi, 2006

B. List of Major Equipment/Materials

i. Fire Extinguishers

– CO_2 type, A, B, C type, Dry chemical powder type

Foam type- 9 litre, operation-inverted, ISS-933, Class B fire

ii. Water type-CO_2 gas pressure, 9 litre, operation-upright, ISS-940, Class A fire

iii. DCP type- 1,2,5 or 10 Kg, operation-upright, ISS-2171, Class B and C fire

iv. Soda acid type-9 litre, operation-inverted or upright, ISS-934, Class B and C fire

v. Respiratory & Non-respiratory personal protective devices:

vi. Safety goggles, face screens, Industrial safety helmets, hairnets and fire fighters helmets, Earplugs, earmuffs, Gloves, Safety boots and shoes with protective toecaps and penetration-resistant, Apron, Chemical suit

C List of Software/Learning Websites

i. https://www.osha.gov
ii. https://www.iso.org
iii. https://www.bis.org.in
iv. http://www.iffco.nic.in/applications/brihaspat.nsf
v. http://sp.ehs.cornell.edu/lab-research-safety/laboratory-safety-manual/Pages/ch8.aspx

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. Mukesh B. Dhangar**, Lecturer in Chemical Engineering, Shri N. G. Patel Polytechnic, Isroli – Afwa.
- **Prof. Manish R. Nasit**, Lecturer in Chemical Engineering, Shri N. G. Patel Polytechnic, Isroli – Afwa
- **Prof. Nitin N. Hansalia**, Lecturer in Chemical Engineering, G. P. 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