GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: MASS TRANSFER-II
(COURSE CODE: 3350502)

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	5th Semester

1. RATIONALE

Diploma Chemical engineer have to supervise the preliminary purification of raw materials or final separation of products from by-products. They have to deal with changes in composition of solutions known as the mass-transfer operations. The large numbers of towers used for petroleum refining are examples of mass transfer operations. A substantial number of the unit operations of chemical engineering are concerned with the problem of changing the compositions of solutions and mixtures through methods involving chemical reactions. Hence the course has been design to develop these competencies and its associated cognitive, practical and effective domain learning out comes.

2. LIST OF COMPETENCY

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

- **Perform separation operations for purification of raw materials and products**

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. Operate equipments for gas-liquid operations.
ii. Perform distillation operations.
iii. Calculate the product rate and number of trays for binary distillation.
iv. Calculate various terms associated with humidity.
v. Operate drying systems.
vi. Use the concept of adsorption and ion exchange.
vii. Operate various crystallisers.

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 CONTENT DETAILS

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I Equipment for Gas Liquid Operations	1a. Describe importance of Gas-Liquid operations 1b. Classify equipments for Gas-Liquid operations 1c. Describe construction of equipments with diagram of 1.3 & 1.4 1d. Explain working principle and operation of equipments with sketches of 1.3 & 1.4	1.1 Importance of Gas-Liquid operations
		1.2 Classification of equipments for Gas-Liquid operations
		1.3 Gas dispersed 1.3.1 Sparged vessel 1.3.2 Mechanically Agitated Vessel 1.3.3 Tray tower 1.3.3.1 Types of trays 1.3.3.2 Operating problems in tray tower 1.3.3.3 Tray efficiency 1.4 Liquid dispersed 1.4.1 Venturi scrubber 1.4.2 Wetted wall column 1.4.3 Spray tower 1.4.4 Packed tower and its operating problems
	1d. Distinguish different types of packing with diagram	1.5 Types of packing (a) Random (b) Regular
Unit – II Distillation	2a Describe applications	2.1 Distillation as a versatile separation method
	2b Describe the steps to Plot VLE, Constant pressure, Constant temperature equilibria	2.2 Vapor Liquid Equilibria 2.2.1Constant pressure equilibria 2.2.2 Constant temperature equilibria
	2c Explain Relative volatility and laws - Raoult's, Henry's 2c.1 State their uses	2.3 Relative volatility 2.4 Raoult's law, Henry's law, and their uses
	2d Differenetiate azeotropes	2.5 Maximum and minimum boiling azeotropes
	2e Explain -Flash vaporisation, Differential distillation, Continuous rectification 2f Calculate amount and composition for Flash vaporization 2g Calculate product composition for Differential distillation	2.6 Flash vaporization 2.6.1 Material balance 2.6.2 Calculation of amount and composition 2.7 Differential distillation 2.7.1 Derivation of Rayleigh's equation 2.7.2 Calculation of product composition 2.8 Continuous rectification of binary solution 2.8.1 The fractionation operation 2.8.2 Overall material and enthalpy balances
	2f. Apply McCabe-Theile method for multistage tray tower for enriching and stripping section 2f.1 Calculate product rates, minimum reflux ratio and number of trays for the given data	2.9 McCabe and Thiele method for enriching and stripping section 2.9.1 Introduction of Feed and Location of the feed tray 2.9.2 Total reflux ratio, Minimum reflux ratio, Optimum reflux ratio 2.9.3 Calculations of product rates, minimum reflux ratio and number of trays
	2g. Compare distillation techniques viz (a) Steam distillation (b)Vacuum and molecular distillation (c)Azeotropic and extractive distillation	2.10 Important distillation techniques (a) Steam distillation (b)Vacuum and molecular distillation (c)Azeotropic and extractive distillation
	2h. Distinguish Reboilers	2.11 Reboilers and their use

Unit – III Humidification	3a. Analyse the VLE for a pure substance	***Humidification:*** 3.1 Vapor-pressure curve 3.2 Saturated and unsaturated vapor-gas mixtures
	3b. Explain the concepts of Absolute humidity, Relative saturation, Percentage saturation, Dew point, Dry bulb temperature, Wet bulb temperature, Adiabatic saturation temperature, Humid volume, Humid heat, Enthalpy	3.3 Concept of Absolute humidity, Relative saturation, Percentage saturation, Dew point, Dry bulb temperature, Wet bulb temperature, Adiabatic saturation temperature, Humid volume, Humid heat, Enthalpy
	3c.Evaluate the property of air using DBT and WBT 3e.1 Calculate –absolute humidity, relative saturation, percentage saturation for the given process data	3.4 Calculations of absolute humidity, relative saturation, percentage saturation
	3d. Draw psychometric chart 3d.1 List Purposes of contact of gas with pure Liquid	3.5 Psychometric charts for Air-Water system 3.6 Purposes of contact of gas with pure Liquid
	3e. Explain construction and working with diagram	3.7 Equipments 3.7.1 Cooling towers 3.7.2 Spray chambers 3.7.3 Spray ponds
Unit – IV Drying	4a. Discuss drying equilibrium and related concepts 4a.1 Define and calculation of Moisture content, Equilibrium and free moisture, Bound and unbound moisture 4a.2 Calculate - Moisture content, Equilibrium and free moisture, Bound and unbound moisture from the given data	4.1 Drying equilibrium 4.1.1 Insoluble solids 4.1.2 Hysterisis 4.1.3 Soluble solids 4.1.4 Definitions and calculation of Moisture content, Equilibrium and free moisture, Bound and unbound moisture
	4b. Classify drying & drying equipments	4.2 Batch and continuous drying 4.3 Classification of drying equipment
	4c. Describe construction and working of Drier equipments	4.4 Construction and working of following Drier equipment • Tray drier • Tunnel drier • Vacuum drier • Rotary drier • Spray drier • Fluidized bed drier • Pneumatic drier
	4d. Describe drying rate characteristics for batch drying with sketches 4d.1 Derive equation for drying time for constant rate period and falling rate period	4.5 Drying rate curve for batch drying 4.6 Derivation of equation for drying time for constant rate period and falling rate period
	4e. Calculate drying time	4.7 Calculation of drying time

Unit – V Adsorption & Ion-Exchange	5a. Define and state uses of Adsorption	***Adsorption & Ion-Exchange:*** 5.1 Definition and industrial application of Adsorption
	5b. Classify Adsorption and adsorbents 5b.1State Commonly used adsorbents	5.2 Types of adsorption 5.3 Nature of adsorbents 5.4 Commonly used adsorbents
	5d. Analyse Adsorption Equilibria 5d.1 Describe Effect of temperature on adsorption and Heat of adsorption	5.5 Adsorption Equilibria 5.5.1 Single gases and vapours 5.5.2 Adsorption hysteresis 5.2.3 Effect of temperature on adsorption and Heat of adsorption
	5e. Apply Freudlich's equation for single stage and multi stage cross-current operation 5e.1Describe adsorption from dilute and concentrated solution	5.6 Adsorption from liquids 5.6.1 Adsorption from dilute solution 5.6.2 The Freundlich's equation 5.6.3 Adsorption from concentrated solutions 5.6.4 Material balance and Freundlich's equation for single stage and multistage cross-current operation
	5f. Describe construction and working of Higgins contactor, Pressure swing adsorber	5.7 Higgins contactor 5.8 Pressure swing adsorber
	5g. Appreciate concepts of Ion Exchange 5g.1 List Applicationv of Ion Exchange	5.9 Ion-Exchange 5.9.1 Principles 5.9.2 Application 5.9.3 Equilibria 5.9.4 Rate of ion exchange
Unit –VI Crystallisation	6a. State Industrial applications of crystallization	***Crystallisation:*** 6.1 Industrial applications of crystallization
	6b. Explain equilibria mechanism for crystallisation 6b.1 State the methods to get Super saturation	6.2 Equilibria and yields 6.3 Super saturation and methods to get it 6.4 Nucleation 6.5 Crystal growth
	6c. Explain working principle and operation of Crystallization Equipment with sketch 6c.1Describe construction of Crystallization Equipment	6.6 Crystallization Equipment 6.6.1 Vacuum crystallizer 6.6.2 Swenson walker crystallizer 6.6.3 Draft tube-baffle crystallizer
	6d. State and explain Meir's theory	6.7 Meir's theory
	6e. Calculate the crystal yield	6.8 Crystallization with and without seeding 6.9 Calculations of crystal yield
	6f. List steps to Prevent caking of crystals	6.10 Caking of crystals and it's prevention

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	Equipment for Gas Liquid Operations	6	2	3	2	7
II	Distillation	15	5	7	7	19
III	Humidification	8	2	4	4	10
IV	Drying	10	4	4	5	13
V	Adsorption & Ion-Exchange	10	4	4	4	12
VI	Crystallization	7	3	3	3	9
Total		**56**	**20**	**25**	**25**	**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/course outcomes. Following is the list of practical exercises for guidance.

Note*: outcomes in psychomotor domain are listed here 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	I	Demonstrate principle, construction and working of equipments for gas–liquid operations with models	4
2	I	Prepare vapour liquid equilibria curve at atmospheric pressure for Benzene-Xylene	4
3	II	Carry out simple distillation in glass assembly	4
4	II	Find out the effect of vacuum on distillation of liquid	4
5	II	Carry out continuous rectification in packed column	4
6	II	Find out amount of steam required in steam distillation	4
7	III	Find out the property of atmospheric air with the help of wet bulb and dry bulb temperature	4
8	III	Set desired conditions of humid air in humidity control cabin	4
9	IV	Prepare drying curve of moist sand and moist limestone	4
10	IV	Find out equilibrium moisture content and drying time of wet solid	
11	V	Characterize industrial adsorbents and observe their samples	4

S. No.	Unit No.	Practical/Exercise (Outcomes in psychomotor domain)	Apprx. Hrs. Required
12	V	Remove colour impurities from water using charcoal	4
13	VI	Find out the yield of crystals from saturated solution without seeding	4
14	VI	Find out the yield of crystals of from saturated solution with seeding	4
Total			**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.
ii. Visit the website of reputed mass transfer equipment manufacturers and prepare a report on these equipments.
iii. Prepare chart/ Model of mass transfer equipments.
iv. Quiz, Debate

9. SPECIAL INSTRUCTIONAL STRATERGY (If Any)

i. Animated videos and drawings of equipments

10. SUGGESTED LEARNING RESOURCES

(A) List of Books:

S. 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	Unit Operations-II	K. A. Gavhane	Nirali Prakashan, Pune
4	Unit Operations of Chemical Engineering, Volume-I	P. Chattopadhyay	Khanna Publishers, New Delhi, 1995
5	Chemical Engineering, Volume-2	Coulsion and Richardson	Butterworth-Heinemann; 5^{th} Edition, 2002
7	Introduction to Chemical Engineering	L.Badger, Julius T. Banchero	McGraw Hill Publication, New York, 7^{th} Edition, 2004

B. List of Major Equipment/Materials

i. Distillation Assembly : 2000 ml round bottom flask, 1000 ml collection flask, joints, adapter with ¾ neck, simple/coiled glass condenser, thermometer pocket
ii. Packed column : Heating mantle - single phase 240 v AC, 15 amp, max 250 ^{0}C, 2litre Flask, Column- MS and Borosil glass, ID-58 mm, OD-62 mm, Packing-100 mm glass, 400 mm MS, 50 mm glass,12 mm dia rasching ring, Condenser- shell MS, tube Copper, Rotameter-0.5-5 LPH
iii. Steam distillation setup : Distillation kettle - MOC-MS, dia-150 mm, height 300mm; jacket dia 175 mm height, height 300 mm, pressure gauge, steam relief valve, steam feed line with valve, drain valve, steam trap on jacket outlet, 25 mm glass wool insulation with MS cladding; Condenser – MS shell, tube copper dia-150 mm,

height 250; Steam generator inner SS 304, outer MS dia 180 mm, height 270 mm; 25,5litre collecting beaker

iv. VLE apparatus : Heating mantle with 1 litre flask, dimmerstat, digital temp indicator, air and water cooled condenser, mounted on wooden and MS frame, thermocouples

v. Humidity cabin : Double walled thick gauge chamber SS 304, heater 500 W; Cooling circuit with compressor, expansion valve, condenser and refrigerant; Steam generator SS 304; Control panel with digital temperature indicator, low water level indicator, solenoid valve

vi. Tray dryer : Temp range 50-100/200, thick MS chamber, digital temp indicator and controller, Air circulation by induction motor, Tray about 80×40×3 cm

vii. Batch crystallizer : Jacket 325 mm round, 155 mm deep, 3mm thick, annulus 22.5 mm; 25 mm thick glass wool insulation, Aluminium cladding; motor-stirrer 10mm rod, speed regulator

viii. Benzene, Toluene, Xylene, Sand, Limestone, silica gel, Charcoal, boric acid, Sodium sulphate, Potassium permanganate

C List of Software/Learning Websites

i. www.unitoperation.com
ii. http://nptel.ac.in/courses/index.php?subjectId=103103035
iii. http://1rv07ch.files.wordpress.com/2010/05/lecture1-introduction2mass-transfer.pdf
iv. http://www.msubbu.in/ln/mt/
v. http://chemeng.ir/download/Mass-Transfer/Mass_Transfer_Operations_-_Robert_Treybal_chemeng.ir.pdf
vi. http://serve.me.nus.edu.sg/arun/file/teaching/ME6203_2013_Mujumdar.pdf

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
- **Prof. Parul K Patel**, Lecturer in Chemical Engineering, Govt. 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