GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester-IV

Course Title: Mass Transfer-I
(Course Code: 4340502**)**

Diploma Programme 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 domainlearning 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:

- Use chemical process plant equipments for mass transfer operation safely

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 outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

- Students will be able to

1) Understand basics of Mass Transfer operation.
2) Use concept of diffusion in Fluids & Interphase mass transfer in separation techniques
3) Select mass transfer operations (Drying & extraction) equipment for various applications.
4) Compute material balance for mass transfer operations (Drying & extraction) in different condition.

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
3	0	4	5	70	30	50	50	

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 **Fundamentals of Mass Transfer**	1a. Describe Importance of mass transfer operation	1.1 Introduction of Mass transfer operations
	1b. Classify mass transfer operations based on phases 1c. Explain Membrane separation operations	1.2 Classification of mass transfer operations 1.3 Introduction , Basic Principle & Various applications of Membrane Separation operation
	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. Methods of conducting the mass transfer operations	1.6 Different methods of conducting mass transfer operation 1) Solute recovery and fractionation 2) Unsteady state operation 3) Steady state operation 4) Stage wise operation 5) Continuous contact operation.
Unit – II **Molecular Diffusion in Fluids**	2a. Differentiate Molecular and Eddy diffusion 2b. Explain & Calculate rate of diffusion in Fluids 2c. Distinguish Molar flux, diffusivity and concentration gradient in Fluids 2d Define Fick's law & Derive diffusivity equation	2.1 Molecular andEddy diffusion 2.2 Rate of diffusionin Fluids 2.3 Molar flux, diffusivity and concentration gradient in Fluids 2.5 Fick's law & Derivation of diffusivity equation ($D_{AB}=D_{BA}$)
	2e. Describe the effect of various factors on diffusivity 2f. Explain molecular diffusion in fluids at rest & in laminar flow	2.6 Effect of concentration, Temperature and pressure on diffusivity 2.7 General equation for steady state molecular diffusion in fluids at rest & in laminar flow
	2g. Describe Molecular diffusion in gases 2h. Derive Equation for Steady state diffusion 2i. 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 2.11 Empirical equation of diffusivity of Gases
	2j. Describe Molecular diffusion in liquids	2.12 Molecular diffusion in liquids a) Steady state diffusion of A

	2k. Evaluate diffusivity of liquids using empirical equation	through non diffusing B and simple numerical b) Steady state equimolal counter diffusion and simple numerical 2.13 Empirical equation of diffusivity of liquids
Unit – III Interphase Mass Transfer	3a. Explain Equilibrium 3b. Describe Diffusion between phases 3c. Describe various mass transfer coefficients using resistance concept	3.1 Concept of equilibrium 3.2 Diffusion between phases (two resistance concept) 3.3 Local and overall two phases masstransfer co-efficient and their uses
	3e. Define stage, stage efficiency and cascade	3.5 Stage and stage efficiency and types of Cascade
Unit – IV Drying	4a. Discuss drying equilibrium and related concepts 4a.1 Define 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 Hysteresis 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 Drying equipments	4.4 Construction and working of following Drying equipments 4.4.1 Tray drier 4.4.2 Vacuum drier 4.4.3 Rotary drier 4.4.4 Spray 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 constantrate period and falling rate period
	4e. Calculate Drying time	4.7 Calculation of Drying time
Unit – V Liquid 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 materialbalance for various stages 5h. Calculate Material balance in differentconditions	5.6 Single stage extraction and multistage cross current extraction on ternary diagram 5.7 Material balance for single stage, multistage- cross current 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 6.4.1 Unsteady state operation 1. In place operation 2. Heap leaching 3. Percolation tanks 4. Filter press leaching 5. Agitated vessel 6. Leaching by Shanks system
		6.4.2 Steady state operation 1. Leaching during grinding 2. Leaching in door type agitator 3. Leaching in door balanced tray thickener 4. Continues counter current decantation with flow sheet 5. Leaching of vegetable seeds I. Rotacell II. Kennedy extractor III. Continuous horizontal extractor
	6d. Explain Material balance	6.5. Material balance for single stage & Multistage cross current system

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	06	02	05	00	07

II	Molecular Diffusion in Fluids	08	02	07	06	15
III	Interphase Mass Transfer	03	02	02	02	06
IV	Drying	08	02	06	05	15
V	Liquid liquid Extraction	10	02	08	05	15
VI	Leaching	07	03	07	02	12
Total		**42**	**13**	**37**	**20**	**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.

Sr. No.	**Unit No.**	**Practical/Exercise** (Outcomes in Psychomotor Domain)	**Approx.Hrs. Required**
1	I	Describe different methods for conducting mass transfer operation (study experiment)	4
2	II	Determine diffusivity of gas-liquid system at room temperature	4
3	II	Determine diffusivity of gas-liquid system showing its dependency on temperature	4
4	II	Determine diffusivity of liquid-liquid system at room temperature	4
5	II	Determine diffusivity of liquid-liquid system showing its dependency on temperature	4
6	IV	Prepare drying curve of moist sand and moist limestone	4
7	IV	Find out equilibrium moisture content and drying time of wet solid	4
8	IV	To determine the drying characteristic for rotary dryer.	4

9	V	Determine the efficiency of single stage extraction	4
10	V	Determine the efficiency of two stage cross current extraction	4
11	V	Determine the distribution coefficient for toluene- acetic acid & chloroform -acetic acid mixture	4
12	V	Prepare ternary diagram for a system of three liquids	4
13	V	Obtain tie-line data for Acetic Acid, Benzene and water	4
14	VI	Measure recovery of salt using sand-salt mixture in single stage leaching	4
15	VI	Measure recovery of salt using sand-salt mixture in two stage leaching	4
16	VI	Describe different methods for steady state leaching operations. (study experiment)	4
Total Hrs			**64**

Note

i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list**.**

ii. The following are some **sample** 'Process' and '#Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.

Sr.No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Handling of apparatus for precise measurements	10
2	Record observations correctly	20
3	Practice and adapt good and safe measuring techniques	10
4	Calculations, Interpretation of results and their conclusion.	20
5	Prepare report of practical in prescribed format	10
6	Solve assignment questions.	20
7	Viva-voce	10
	Total	**100**

8. List of Major Equipment/ Instrument with Broad Specifications

Sr.No.	Equipment & glassware Name with Broad Specifications	Practical No.
1	**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 0.25HP	**2,3**
2	**Liquid diffusion system:** 1 liter glass beaker, Magnetic stirrer 1 MLH, electrical conductivity sensor &meter to measure conductivity in MHO	**4,5**
3	**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	**6 to 8**

4	**Extractor:** Glass column ID 75mm, OD 87mm, Height 1000mm; Supply tanks(three)-SS 304, 40 litre; Rota meters(two)-0.3 to 3 lpm-Glass tube, SS316 float; 0.25 HP motor with SS 304/316 shaft and blades	**9 to 13**
5	**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 lpmflow rate	**14 & 15**
6	**Glassware** Separating funnels with stand-250ml, 500ml; Burettes-25 ml, 50 ml; Pipettes - 10 ml, 25 ml; conicalflasks- 250 ml, 500 ml; Beakers - 250 ml, 500 ml, measuring cylinder -25ml,50ml,100ml , specific gravity bottle	**2 to 15**

9. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfill the development of this competency.

a) Work as a leader/a team member.
b) Follow ethical practices
c) Observe safety measures
d) Good house keeping
e) Time management
f) Practice environmentally friendly methods and processes.

The ADOs are best developed through laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

10. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities Other than the classroom and laboratory learning 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.
iii. Attend NPTEL / MOOCS / SWAYAM platform for self learning.
iv. Refer books available in department or Central library and prepare abstract of it.

11. SPECIAL INSTRUCTIONAL STRATERGY (if any)

i. Show animated videos and drawings of mass transfer equipment

12. SUGGESTED MICRO-PROJECTS

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission.

Suggestive lists of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a) Prepare report: Prepare report of local industries where mass transfer operations are carried out.
b) Prepare model: Demonstrate liquid liquid diffusion, Prepare working model / prototype model of equipments like rotary dryer / spray dryer / extractor etc.
c) Prepare charts: Prepare charts of different mass transfer operations and phases involved in it.
d) Prepare List: Prepare the list of different mass transfer operations and equipments.

13. 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; 5thEdition, 2002
7	Introduction to Chemical Engineering	L.Badger, Julius T. Banchero	McGraw Hill Publication, New York, 7th Edition, 2004

B. List of Software/Learning Websites

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

14. PO-COMPETENCY-CO MAPPING

Semester IV	MASS TRANSFER OPERATION-I (4340502)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline-specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimen-tation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency	• Use chemical process plant equipments for mass transfer operation safely						
CO1. Understand basics of Mass Transfer operation.	3	1	-	-	-	-	1
CO2. Use concept of diffusion in Fluids & Interphase mass transfer in separation techniques	3	2	2	3	1	-	2
CO3. Select mass transfer operations (Drying & extraction) equipment for various applications.	3	2	2	2	1	-	2
CO4. Compute material balance for mass transfer operations (Drying & extraction) in different condition.	1	2	2	2	1	-	2

15. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Sr. No.	Name and Designation	Institute	Contact No.	Email ID
1	Mr. J. D. Dattani Lecturer in Chemical Engg.	G. P. Rajkot		jddattani@hotmail.com
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