

# GUJARAT TECHNOLOGICAL UNIVERSITY

## CHEMICAL ENGINEERING (05) MASS TRANSFER OPERATION-II SUBJECT CODE: 2160501 B.E. 6<sup>th</sup> SEMESTER

**Type of course:** Chemical Engineering

**Prerequisite:** Mass Transfer Operation-I

**Rationale:** The objective of this course is to apply the principles of mass transfer operations to specific applications, separation and/or purification processes. The goal is to provide students with the theoretical/analytical aspects to design mass transfer equipments and to deal with complex problems of separations.

### Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks						Total Marks
L	T	P		Theory Marks			Practical Marks			
			ESE (E)	PA (M)		ESE (V)		PA (I)		
				PA	ALA	ESE	OEP			
3	0	3	6	70	20	10	20	10	20	150

### Content:

Sr. No.	Content	Total Hrs	% Weightage
<b>1</b>	<b>Distillation:</b> Introduction, Vapor-liquid Equilibria, $P$ - $x$ - $y$ $T$ - $x$ - $y$ diagrams, concept of relative volatility and effect of $P$ and $T$ on equilibrium data, Ideal solutions, Raoult's Law as applied to distillation operations, Deviation from ideality, Minimum and maximum boiling azeotropic mixtures, Enthalpy-concentration diagrams. Flash distillation, steam distillation, simple distillation, continuous rectification, Binary systems, Batch fractionation etc., Determination of number of stages by Ponchon and Severit method and McCabe-Thiele method, Concept of minimum, total and optimum reflux ratio, Reboilers, Use of open steam, , Partial condensers, cold hot circulating reflux etc. Azeotropic Distillation, Extractive Distillation, Concept of Multicomponent distillation.	22	41
<b>2</b>	<b>Humidification Operations:</b> VLE and Enthalpy for pure substances, Saturated and unsaturated vapour-gas mixtures and related terminologies such as dry bulb temperature, dew point, wet bulb temperature, percentage & relative saturation, adiabatic saturation temperature, humid heat, humid volume etc. Psychometric chart & Psychometric relation for air-water system, adiabatic saturation curves, wet bulb temperature theory, Lewis relation, Adiabatic operation, cooling towers.	11	21
<b>3</b>	<b>Adsorption and Ion exchange:</b> Adsorption, Definition and industrial application, Types of adsorption, nature of commonly used adsorbents, Adsorption Equilibria, Single gases and vapors, Adsorption hysteresis, Effect of temperature on adsorption, Heat of adsorption, Adsorption of solute from dilute liquid solution, Adsorption from concentrated solutions, Material balance and Freundlich's equation for single	11	20

	stage operation and multistage cross-current operation, counter current operation, Equipments for adsorption such as fluidized bed & Teeter beds, Moving bed & fixed bed unsteady state adsorbers, concept of adsorption wave. Ion-Exchange Principles, Applications, Equilibria and Rate of ion exchange		
<b>4</b>	<b>Drying:</b> Equilibrium relationship & hysteresis, various types of moisture in drying, Batch drying, rate of drying, time of drying, Cross-circulation drying, concept of <i>NoG</i> and <i>HoG</i> , Drying at low temperature, Freeze drying etc. Batch & continuous drying equipments-Tray dryer, Tunnel dryer, Rotary dryers, Spray dryers, Fluidized bed dryer, etc.	10	18

### Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	20	20	10	05	--

**Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's 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.

### Reference Books:

1. "Mass transfer operation" by R. E. Treybal, Mc-Graw Hill international, 3<sup>rd</sup> edition
2. "Mass Transfer" by Sherwood, Pigford & Wilke, Mc-Graw Hill international.
3. "Chemical Engineering", Volume-2, by Coulson & Richardson, 4<sup>th</sup> edition
4. Perry's Chemical Engineers hand book, by Perry & Green, Mc-Graw.Hill international, 7<sup>th</sup> edition
5. Unit Operations of Chemical Engg. By W. L. Mc Cabe, J.C .Smith & Harriott, Mc-Graw Hill international, 6<sup>th</sup> edition

### Course Outcome:

After learning the course the students should be able to:

1. To understand the designing of mass transfer equipments used in the chemical industries.
2. To utilize the technological methods in problem solving of mass transfer operations in industries.
3. To review the practical importance and relevance of mass transfer in chemical industry.
4. To understand the applications of different mass transfer processes.
5. To recognize the selection criteria for mass transfer process and equipments required by the industries.
6. To design various mass transfer equipments.

## List of Experiments:

Minimum 5 practicals to be performed and remaining time should be allotted to open-ended projects/study reports/latest outcomes in technology study:-

1. In the beginning of the academic term, faculties will have to allot their students at least one Open-ended Project / Study Report / Latest outcome in technology.
2. Literature survey including patents and research papers of fundamental process
  - Design based small project **or**
  - Study report based on latest scientific development **or**
  - Technology study report/modeling/ simulation/collection report **or**
  - Computer based simulation/web based application/analysis presentations of basic concept field which may help them in chemical engineering.
3. These can be done in a group containing maximum **three** students in each.
4. Faculties should cultivate problem based project to enhance the basic mental and technical level of students.
5. Evaluation should be done on **approach of the student on his/her efforts** (not on completion) to study the design module of given task.
6. In the semester student should perform **minimum 5** set of experiments and complete **one small open ended dedicated project** based on engineering applications. This project along with any performed experiment should be **EVALUATED BY EXTERNAL EXAMINER.**

## PRACTICALS (ANYFIVE):

1	To study and verify the Freundlich's Adsorption Isotherm Adsorbing Oxalic Acid and Charcoal
2.	To study the Characteristics of Adsorption for Silica Gel
3.	To measure the vapor pressure of acetone and calculate latent heat of vaporization.
4.	To study the humidification operation and calculate all the terminology's used for air – water contact operation.
5.	To determine pressure drop data and values of mass transfer coefficient for various air and liquid velocities in a counter cooling tower.
6.	a. To Verify Rayleigh's Equation for Differential Distillation b. To plot Fraction of Charge of Distillates V/S Residue Compo.& temperature of distillations
7.	To verify the Equilibrium Relationship for n-Butanol Water System
8.	To verify Henry's Law for Steam Distillation.
9.	To find out the Critical Moisture Content of a given material & find out its equation for constant and filling rate period

## Design based Problems (DP)/Open Ended Problem:

**Students are free to select any area of science and technology** based on chemical engineering applications to define Projects.

Some suggested projects are listed below:

- Separation of components by using simple distillation
- Separation of components by using steam distillation
- To carry out drying by using drying apparatus
- Removal/purification of components using adsorption
- Solving examples based on design of distillation column

**Major Equipments:**

Distillation column, Dryer, Steam distillation apparatus, Dryer, Adsorption column

**List of Open Source Software/learning website:**

- 1) Literature available in any laboratory manual of Mass Transfer Operation-II.
- 2) Mass Transfer Operations for the Practicing Engineer by [Louis Theodore](#), [Francesco Ricci](#), Wiley Publishers
- 3) NPTEL
- 4) Website: academia.edu for laboratory view based e-learning portal for virtual mass transfer operations laboratory

**ACTIVE LEARNING ASSIGNMENTS:** Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.