



# GUJARAT TECHNOLOGICAL UNIVERSITY

**Bachelor of Engineering**

**Subject Code: 3160501**

**Semester –VI**

**Subject Name: Mass Transfer Operations II**

**Type of course:** Professional Core course

**Prerequisite:** Mass Transfer Operations- I

**Rationale:** The objective of this course is to apply principles of mass transfer operations for detail study and for solving problems pertaining to conventional unit operations such as distillation, humidification, adsorption, drying etc. for separation

**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)	
4	0	2	5	70	30	30	20	150

**Content:**

Sr. No.	Content	Total Hrs
1	<p><b>Distillation:</b> Introduction, Vapor-liquid Equilibria, P-x-y T-x-y diagrams, concept of relative volatility and effect of Pressure and Temperature on equilibrium data, Ideal solutions, Raoult's law as applied to distillation operations, Deviation from ideality, steam distillation, 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, q line, Feed tray location, Concept of minimum, total and optimum reflux ratio, Reboilers, Use of open steam, , Partial condensers, cold reflux, etc., Azeotropic Distillation, Extractive Distillation, Vacuum distillation etc.</p> <p><b>Multicomponent distillation :</b> key components, minimum and total reflux, short cut method: FUG (Fenske-Underwood-Gilliland) method, Rigorous methods: Lewis-Matheson calculations, Thiele and Geddes method, etc.</p>	26
2	<p><b>Humidification Operations:</b></p> <p>VLE and Enthalpy for a pure substance, Saturated and unsaturated vapour-gas mixtures and related terminologies such as absolute humidity, dry bulb temperature, dew point, wet bulb temperature, percentage &amp; relative saturation, adiabatic saturation temperature, humid heat, humid volume etc. Psychrometric chart &amp; Psychrometric relations for air-water system, adiabatic saturation curves, wet bulb temperature theory, Lewis relation, Adiabatic operations, cooling towers.</p>	11
3	<p><b>Adsorption and Ion exchange:</b></p> <p><b>Adsorption:</b> Definitions and industrial applications, Types of adsorption, nature of</p>	13



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	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 liquid solution, Material balance and application of Freundlich's equation for single stage operation, multistage cross-current operation and multistage countercurrent operation, Equipments for adsorption such as fluidized bed & Teeter beds, steady state moving bed & unsteady state fixed-bed adsorbers, concepts of adsorption wave, break-through curve, Pressure swing adsorber, elution and chromatography etc. <b>Ion-Exchange</b> : Principles, Techniques, Applications, Equilibria and Rate of ion exchange	
4	<b>Drying:</b> Equilibrium relationship & hysteresis, various types of moisture in drying, Batch drying, rate of batch drying, time of drying, Cross-circulation drying, Through-circulation drying, concept of $N_{tOG}$ and $H_{tOG}$ , Drying at low temperature, Freeze drying etc. Batch & continuous drying equipments-Tray dryer, Tunnel dryer, Rotary dryers, Spray dryers, Fluidized bed dryer, etc.	10

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	25	25	10	-	-

**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. R. E. Treybal, Mass transfer operations, 3rd edition, Mc-Graw Hill international, New Delhi, 1983.
2. J. F. Richardson, J H Harker, Coulson and Richardson's Chemical Engineering, Volume2, 5th edition, Butterworth Heinemann, 2002.
3. Binay K. Dutta, Principles of mass transfer and separation processes, 2nd edition, Prentice Hall of India, 2007.
4. W. L. McCabe, J.C .Smith & Harriott, Unit Operations of Chemical Engineering, 7th edition Mc-Graw Hill international, India, 2014.
5. C. J. Geankoplis, Transport processes and unit operations, 3rd edition, Prentice Hall of India, 1993.

### Course Outcomes: Students should be able to

Sr. No.	CO statement	Marks % weightage
CO-1	Explain concepts and applications of distillation, humidification, adsorption and drying.	15
CO-2	Describe theories, derivations and equipments of distillation, humidification, adsorption and drying.	35
CO-3	Solve problems of frequently encountered separation systems using	35



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	conventional mass transfer operations.	
CO-4	Compare among various mass transfer operations for desired separation.	15

### List of Experiments:

1. To measure the vapor pressure of acetone and calculate its latent heat of vaporization.
2. To study the humidification operation and calculate all psychometric parameters for air – water system.
3. To study the characteristics of adsorption of moisture on Silica gel.
4. To study and verify the Freundlich's adsorption isotherm for aqueous oxalic acid – charcoal system.
5. To verify Rayleigh's Equation for Differential Distillation.
6. To find out the critical moisture content of a given material using rate of drying curve.
7. To study the distillation with rectification in bubble cap distillation column
8. To verify the Equilibrium Relationship for n-Butanol-Water System.
9. To validate the basic principles of steam distillation.
10. To determine pressure drop data and values of  $K_G$  for various air and liquid velocities in a counter current cooling tower.

### Major equipments:

Distillation column, Adsorption column, Cooling tower, dryer etc.

### Open Source Software/learning website:

1. Students can refer to video lectures available on the websites including NPTEL.
2. Students can perform experiments on Virtual lab by IITs.
3. FOSSEE –DWSIM <https://dwsim.fossee.in/>