GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160412
Semester –VI
Subject Name: Chemical Engineering Fundamentals-III

Type of course: Professional Core course

Prerequisite: Chemical Engineering Fundamentals-II

Rationale: The objective of this course is to study some useful mass transfer operations for specific application of separation and/or purification processes. The perspective is to provide students of biotechnology with the theoretical/analytical aspects to recognize mass transfer operation equipments and to deal with conventional problems of separations. This course also enables students to understand various instrumentation and process control aspects applied in process industries.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Distillation:** Introduction, VLE, Relative volatility, Steam distillation, Flash distillation, simple distillation, continuous rectification, Binary systems, Determination of number of stages by McCabe-Thiele method, reflux ratio, q line, Feed tray location, Azeotropic Distillation, Extractive Distillation, Vaccum distillation etc.	7
2	**Humidification:** VLE and Enthalpy for a pure substance, Saturated and unsaturated vapor-gas mixtures and related terminologies such as absolute humidity, dry bulb temperature, dew point, wet bulb temperature, percentage & relative saturation, humid heat, humid volume etc. cooling towers.	4
3	**Adsorption:** Applications, Types of adsorption, properties of adsorbent, Adsorption Equilibria, Single gases and vapors, Adsorption hysterises, Effect of temperature on adsorption, Heat of adsorption, Adsorption of solute from dilute liquid solution, Adsorption from concentrated liquid solution, 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, elution and chromatography etc.	6
4	**Drying:** Equilibrium relationship & hysteresis, various types of moisture in drying, Batch drying, rate of batch drying, time of drying, Drying at low temperature, Freeze drying etc. Batch & continuous drying equipments-Tray dryer, Tunnel dryer, Rotary dryers, Spray dryers, Fluidized bed dryer, etc.	5

5.	**Crystallization:** Saturation and super saturation, Mechanism of crystallization, Nucleation, Crystal growth and yields, , Caking of crystals, Application of crystallization, Crystallization equipment	3
6	**Membrane separation processes:** Advantages, classification, Types and applications of membrane separation processes, Membrane material and membrane modules, principles and working of various membrane separation processes such as Reverse osmosis, microfiltration, Ultrafiltration, pervaporation etc..	5
7	**Instrumentation:** ***Temperature Measurement***: Scales, Expansion thermometers, Thermoelectric temperature measurement, Pyrometers etc. ***Pressure Measurement****:* Manometers, Bourdon gauge, Bellows differential pressure gauge, Vacuum Measurement: Pirani vacuum gauge, McLeod gauge etc. ***Composition Measurement*****:** Psychomotor method for moisture in gases, hygrometer method for moisture in gases, Dew-point method, pH ion concentration measurement etc.	6
8	**Process Control:** ***Basic Concepts of Process Control*****:** Solution of linear differential equations using Laplace transforms, Response of first-order systems, physical examples of first-order systems, response of first order systems in series, higher order systems: second-order, and transportation lag. ***Linear Closed Loop Systems***: Control system, controllers and final control elements, block diagram of a control system, closed loop transfer functions.	9

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
14	35	14	7	-	-

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 Harkar, 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. Coughanowr, D. R., LeBlanc, S. "Process Systems Analysis and Control", 3rd edition, McGraw-Hill (2008).
6. S.K. Singh, Industrial Instrumentation and Control, 3rd edition, McGraw-Hill (2008).
7. R. P. Vyas, "Process Control and Instrumentation", Denett & Co.
8. Donald .P. Eckman, "Industrial Instrumentation", John Wiley & Sons Inc, New York.

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Course Outcomes: Students should be able to

Sr. No.	CO statement	Marks % weightage
CO-1	Explain concepts, applications and equipments of distillation, humidification, adsorption, crystallization, drying and membrane separation processes.	40
CO-2	Solve problems of frequently encountered separation systems using mass transfer operations.	20
CO-3	Compare among various mass transfer operations for desired separation.	10
CO-4	Explain control system by understanding the dynamic response of the processes and controllers with proper choice of instruments involved for the given bioprocess plant.	30

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 verify the Equilibrium Relationship for n-Butanol-Water System.
8. To find out crystal yield with & without seeding
9. To study Dynamic response of first and second order systems.
10. To study Dynamic response of interacting and non-interacting multi capacity systems.

Major equipments:

Distillation assembly, Adsorption column, dryer, first and second order systems, Interacting and non - interacting systems 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 IIT Bombay.
3. FOSSEE –DWSIM https://dwsim.fossee.in/