GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160507
Semester – VI
Subject Name: Advanced Separation Processes

Type of course: Professional Elective

Prerequisite: Basic Concepts of unit operations including mass transfer.

Rationale:
The course is intended to familiarize the students of chemical engineering with the new, emerging and non-traditional separation techniques and their potential applications in chemical and allied process industries. The course will provide exposure to membrane based techniques, chromatographic separation, super critical fluid extraction and various other technologies.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Contents	Total Hrs
1	Fundamentals of separation processes, separation factor, chemical potential in interface mass transfer,equilibrium and rate governed separation, drawbacks of the conventional separation processes, need for advanced separation processes. Major areas of applications of advanced separation processes.	5
2	Membrane Separation Processes: Membrane types, materials, synthesis and characterization; Different membrane modules; Working principle, operating parameters, membranes used, transport processes/mechanisms and industrial applications for individual membrane processes such as (i) Reverse osmosis, (ii) nanofiltration, (iii) ultrafiltration,(iv) microfiltration (v) dialysis	8
3	Membrane gas separations, Fundamental mechanism, governing factors, principle of designing of gas separator membrane using complete mixing model. Gas separation membranes, applications of membrane gas separation. Introduction to pervaporation: principle, membranes used and application. Hybrid distillation-pervaporation system, Membrane Reactor: Concept & working, Various types of membrane used for membrane reactor, Membrane bioreactor.	8
4	Reactive and catalytic distillation Concept, advantage & disadvantages, BALE & KATMAX packing Manufacturing of MTBE and ETBE and its comparison with conventional techniques, Concept & working of short path Distillation Unit (SPDU),	6

5	Supercritical extraction: Working Principal, unique properties and solubility behavior of supercritical fluids, Advantages of supercritical extraction, Decaffeination, ROSE process for purification of crude oil, hydrothermal oxidation, and Commercial applications of supercritical extraction.	**6**
6	Chromatographic separation: Principle and operation, Chromatographic column Ion exchange chromatography, Gel filtration and affinity chromatography; Thin layer and paper chromatography Liquid chromatography, Advantages and disadvantages of chromatographic separations.	**6**
7	Electrophoretic separations: Principle of electrophoresis, Factors affecting electrophoresis, Gel membrane and paper electrophoresis, applications of electrophoresis.	**6**

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
14	26	23	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. Transport Processes and Separation Process principles, Christie J Geankoplis Prentice-Hall of India Private Ltd, New Delhi, 4th Edition 2006.
2. Membrane Separation Processes, Second Edition, by Kaushik Nath, PHI Learning Pvt. Ltd, New Delhi,2017
3. Munir Cheryan, UF Applications Handbook, Technique Publishing Co, Lancaster, USA (1986).
4. Separation Process Engineering, Philip C. Wankat, Prentice-Hall, 4th Edition, 2016.
5. Introduction to process Engineering & Design" by S.B. Thakore & B.I Bhatt,Tata McGraw-Hill Ltd.,2007
6. Separation Process Principles, J.D. Seader and E.J.Henley, Wiley, 2nd Edition 2004
7. Perry Chemical Engineers Handbook' 7thEdition by R.H Perry and D. Green.
8. Ullman's Encyclopedia of Industrial Chemistry, 7th edition, Wiley-VCH
9. Natural Extracts using supercritical carbon dioxide, M. Mukhopadhyay, CRC Press

Course Outcomes: At the end of the course, the students will be able to

Sr. No.	CO statement	Marks % weightage
CO-1	Ability to identify an appropriate separation technique for intended problem	20
CO-2	Understand the principle of membrane separation for various aqueous systems	35
CO-3	To conceptualize the reactive and catalytic distillation	20
CO-4	Ability to recognize the selection criteria between advanced separation techniques and conventional separation techniques.	25

List of Open Source Software/learning website:

Preparation of power-point slides, which include videos, animations, Pictures, graphics for better understanding theory – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus of Advanced separation processes is covered.

Suggested list of experiments to be performed (8 to 10 experiments are to be given)

1. Determination of the water permeability of a given polymeric membrane.
2. Determination of permeation flux of a membrane in flat-sheet module (Dye-water solution may be used as feed). (RO/NF/UF membranes can be used)
3. The experiment (2) can be performed with various other modules such as spiral wound or hollow fiber.
4. Study of the effect of trans membrane pressure on permeatetion flux of a given membrane in a given module.
5. To determine rejection coefficient of the given membrane for a particular feed waste-water. (RO/NF/UF membranes can be used)
6. Determination of the swelling/sorption characteristics of a given polymeric membrane in a given pure solvent and its mixture of different concentrations.
7. Determination of permeate flux and separation factor for the separation of a given organic-aqueous mixture using pervaporation module.
8. Determination of membrane permeability, selectivity and diffusivity for the separation of a given organic-aqueous mixture using pervaporation.
9. To separate a mixture of dyes using thin layer chromatography

10. Separation of metallic ions by paper chromatography
11. Separation of plant pigments (chlorophylls and carotenoids) from green leaves by column chromatography.
12. Determination of ion exchange capacity of a given cation or anion exchanger
13. Numerical/design assignment of various membrane processes e.g. Reverse Osmosis, Ultra Filtration, Pervaporation etc.
14. Numerical/design assignment based on reactive and catalytic distillation.

In the beginning of the academic term, students may be allotted at least one Open-ended Project / Study Report /Latest outcome in technology. 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. These can be done in a group containing maximum three students in each. 4.

List of Open Source Software/learning website: Software:

Students can refer to video lectures available on various websites including NPTEL. ¬ Students can refer to the CDs which are available with some reference books for the solutions of problems using softwares. Students can develop their own programs for the solutions using excel, Chemical and other simulation softwares.