

# GUJARAT TECHNOLOGICAL UNIVERSITY

## CHEMICAL ENGINEERING (05) ADVANCED SEPARATION TECHNIQUES

**SUBJECT CODE:** 2160507

B.E. 6<sup>th</sup> SEMESTER

**Type of course:** Chemical Engineering.

**Prerequisite:** None.

**Rationale:** Separation techniques are integral unit operation in most of the modern chemical, pharmaceutical and other process plants. There are many standard and conventional separation techniques available in the market and these techniques are quite common and the relevant technologies as well as well developed and well studied. On the other hand, newer separation processes, like, membrane based techniques, chromatographic separation, super critical fluid extraction, etc., are gaining importance in modern days plants. The present course is designed to emphasize on these novel separation processes. The course is designed for an elective subject of final year undergraduate students.

### Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P		Theory Marks			Practical Marks			
			ESE (E)	PA (M)		ESE (V)		PA (I)		
				PA	ALA	ESE	OEP			
4	0	2	6	70	20	10	20	10	20	150

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit; ESE- End Semester Examination; PA- Progressive Assessment

### Content:

Sr. No.	Topic	Teaching Hours	Weightage (%)
1.	<b>Super Critical Extraction</b> Working Principal, Advantage & Disadvantages of supercritical solvents over conventional liquid solvents, Advantage & Disadvantages of supercritical extraction over liquid- liquid extraction, Decaffeination, ROSE process, Commercial applications of supercritical extraction.	06	08
2.	<b>Short path Distillation:</b> Concept & working of short path Distillation Unit (SPDU), Difference between short path Distillation & molecular distillation, applications of SPDU.	06	08
3.	<b>Reactive &amp; Catalytic Distillation:</b> Concept, Advantage & Disadvantages, BALE & KATMAX packing Manufacturing of MTBE and ETBE and it's comparison with conventional techniques.	07	10

4.	<b>Pressure Swing Distillation:</b> Concept & Working, Advantage & Disadvantages of PSD over azeotropic and Extractive Distillation, Applications	04	6
5.	<b>Membrane separation technique:</b> Principles, mechanisms, cross flow, membrane materials and various membrane modules used in membrane separation processes, Classification, application & advantages of membrane separation processes.	08	11
6.	<b>Pressure Swing Adsorption:</b> Concept & Working, Advantages & Disadvantages of PSA over cryogenic distillation, four step PSA, six step PSA, Purification of hydrogen, oxygen, Nitrogen & other commercial applications of PSA.	07	10
7.	<b>Melt crystallization:</b> Concept, phase equilibrium, different techniques, commercial applications	06	8
8.	<b>Reverse Osmosis:</b> Concept of osmosis and reverse osmosis, different types of membrane modules and membrane material for R.O., Advantages and commercial applications of R.O.	06	9
9.	<b>Ultrafiltration and nano filtration:</b> Concept & working principal ultrafiltration Vs Conventional filtration, Ultrafiltration membranes and modules, Commercial applications of ultrafiltration and nano filtration.	08	10
10.	<b>Pervaporization:</b> Working principal, Advantages, Production of absolute alcohol and other commercial applications.	05	7
11.	<b>Membrane Reactor:</b> Concept & working, Various modules of membrane used for membrane reactor, Advantages & Disadvantages, applications under research	05	7
12.	<b>Membrane or Osmotic Distillation:</b> Working Principal, Various applications, etc.	04	6

**Text Books:**

1. "Membrane separation Processes" by Kaushik Nath, PHI Pvt. Ltd., 2008
2. "Introduction to process Engineering & Design" by S.B. Thakore & B.I Bhatt, Tata McGraw-Hill Ltd., 2007

**Reference Books:**

1. Perry Chemical Engineers Handbook' 7<sup>th</sup> Edition by R.H Perry and D. Green.
2. Ullman's Encyclopedia of Industrial Chemistry.
3. "Encyclopedia of Chemical Engineering" by Kirk & Othmer.
4. "Natural Extracts using supercritical carbon dioxide" M. Mukhopadhyay

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
14	21	21	7	7	0

**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.

**Course Outcome:** After learning the course the students should be able:

1. To built advanced concepts of separation techniques used in chemical industries.
2. To understand the principles and functioning advanced separation techniques.
3. To utilize the advanced separation technique in problem solving where conventional techniques are not fruitful and require replacement.
4. To understand the applications of advanced separation techniques as per industrial requirement..
5. To recognize the selection criteria between advanced separation techniques and conventional separation techniques.

### 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.**

### List of Practical:

1.	Perform separation techniques using reactive distillation.
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2.	Perform separation using membrane modules.
3.	Perform separation techniques using supercritical extraction
4.	Preparation of membrane modules for reverse osmosis.
5.	Perform separation techniques using short path distillation.

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

Open Ended projects in Advanced analytical techniques may include:

1. Review chart of application of advanced separation techniques in process industries.
2. Fabrication of reactive catalytic distillation unit.
3. Fabrication of short path distillation.
4. Fabrication and performance evaluation of different types of filtration membranes,
5. Fabrication of membrane module

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

- 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.

**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.