GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)
Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester-6
Course Title: Advance Separation Technology
(Course Code: 4360506)

Diploma programme in which this course is offered	Semester in which offered
Chemical Engineering	6

1. 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 semester Diploma students.

2. COMPETENCY

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competencies:

- Understand advance separation processes and apply in industry.

3. COURSE OUTCOMES (COs):

Student will be able to_

a) Understand basics of separation processes.
b) Select different membrane separation processes.
c) Illustrate different adsorption and chromatography techniques.
d) Describe different novel separation techniques.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits L+T+(P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	0	3	30	70	0	0	100

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate the integration of COs, and the remaining 20 marks are the average of 2 tests to be taken during the semester for assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

Legends: CI-Class Room Instructions; T – Tutorial/Teacher Guided Theory Practice; P - Practical; C – Credit, CA - Continuous Assessment; ESE - End Semester Examination.. Legends: L-Lecture; T – Tutorial/Teacher Guided Theory Practice; P -Practical; C – Credit, CA - Continuous Assessment; ESE - End Semester Examination.

5. SUGGESTED PRACTICAL EXERCISES

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
NOT APPLICABLE			

S.No.	Sample Performance Indicators for the PrOs	Weightage in %
NOT APPLICABLE		

6. MAJOR EQUIPMENTS/ INSTRUMENTS REQUIRED

S. No.	Equipment Name with Broad Specifications	PrO. No.
NOT APPLICABLE		

7. AFFECTIVE DOMAIN OUTCOMES

The following sample Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned Cos. More could be added to fulfill the development of this course competency.

a) Work as a leader/a team member.
b) Follow ethical practices
c) Practice environmentally friendly methods and processes (environmental related).

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

The major Underpinning Theory is formulated as given below and only higher level UOs of *Revised Bloom's taxonomy* are mentioned for development of the COs and competency in the students by the teachers. (Higher level UOs automatically include lower level UOs in them). If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit – I **Introduction to Separation Processes**	1. Understand the basics of separation processes at different levels 2. Explain the equilibrium and rate-governed separation processes 3. Apply advance separation. techniques for chemical processes	1. Fundamentals of separation techniques 2. General separation technique ● separation by phase creation ● separation by phase addition ● separation by barrier ● separation by solid agent ● separation by force field 3. Separation factor 4. Equilibrium and rate-governed separation processes 5. Applications of separation processes in the chemical industry
Unit– II **Membrane Separation Processes**	1. Understand membrane separation processes 2. Describe different types of membrane separation processes 3. Explain the working principles of various membranes 4. Classify membrane module 5. Apply membrane separation processes in the industry	1. Introduction to membrane separation processes 2. Classification of membrane separation processes 3. Classification of membrane module 4. Principle, working, application & advantages of ● Reverse osmosis (RO) ● Ultra filtration (UF) ● Nanofiltration (NF) ● Pervaporation ● Microfiltration 5. Membrane Reactor: Concept & working, Various types of membrane used for membrane reactor, Membrane bioreactor.

Unit– III **Adsorption and** **Chromatography**	1. Explain the basics of adsorption 2. Identify different types of adsorbents 3. Describe adsorption isotherms 4. Understand thermal swing adsorption (TSA) and pressure swing adsorption (PSA) 5. Describe different types of chromatography 6. Apply adsorption and chromatography in the chemical industry	1. Introduction to adsorption 2. Different types of adsorbents 3. Adsorption isotherms 4. Thermal swing adsorption (TSA) 5. Pressure swing adsorption (PSA) 6. Classification of chromatography techniques 7. Principle & Operation of ● Chromatographic column ● Ion exchange chromatography ● Liquid chromatography ● Gas Chromatography
Unit– IV **Novel Separation Processes**	1. Explain the principles of special separation processes 2. Apply novel separation processes in real-world scenarios 3. Describe applications in the chemical engineering industry	1. Concept ,Working principle and application of ● Supercritical fluid extraction (SFE) ● Short path distillation ● Reactive & catalytic distillation 2. Other novel separation processes- Concept ,Working principle and application of ● Cryogenic Distillation ● Freeze Crystallization ● Pressure Swing Distillation

Note*: The UOs need to be formulated at the 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	**Unit Title**	**Teaching Hours**	**Distribution of Theory Marks**			
			R Level	**U Level**	**A Level**	**Total Marks**
I	**Introduction to Separation Processes**	5	8	4	0	12
II	**Membrane Separation Processes**	14	5	9	6	20
III	**Adsorption and Chromatography**	14	5	9	6	20
IV	**Novel Separation Processes**	9	5	7	6	18
Total		**42**	**23**	**29**	**18**	**70**

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should perform following activities in group and prepare reports of about 5 pages for each activity. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement interviews:

Following is the list of proposed student activities like:

1. Assignments
2. Technical Quiz/MCQ Test
3. Presentation on some course topic
4. I-net based assignments
5. Undertake micro-Project in team/individually
6. Students are encouraged to register themselves in various MOOCS such as: Swayam, edx, Coursera, Udemy etc to further enhance their learning

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Guide student(s) in undertaking micro-projects.
b) Diagnosing Essential Missed Learning concepts that will help for students to improve their performance.
c) Guide Students to do Personalized learning so that students can understand the course material at his or her pace.
d) Encourage students to do Group learning by sharing so that learning can be enhanced.

About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods. Guide students on addressing the issues on environment and sustainability using the knowledge of this course

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project is group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop- based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The duration of the micro project should be about **14-16 *(fourteen to sixteen) student engagement hours*** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

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
- Study report based on latest scientific development
- Technology study report
3. Prepare any Demonstrative model based on Advance separation technique.
4. Prepare Working model.
5. Preparation of Charts.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Perry's Chemical Engineers' Handbook	Robert H. Perry, Don W. Green	McGraw-Hill, New York, 2014, ISBN: 978-0-07-142294-9
2	Mass-transfer operations	Robert E. Treybal	McGraw-Hill, New York, 1980, ISBN: 0-07-066520-2
3	Transport processes and unit operations	Christie John Geankoplis	Prentice Hall, Upper Saddle River, N.J., 2004, ISBN: 0-13-101153-6
4	Unit operations of chemical engineering	Warren Lee McCabe, Julian Smith, Peter Harriott	McGraw-Hill, New York, 2005, ISBN: 0-07-284823-7
5	Separation process principles	J. D. Seader, Henry E. Henley, Dennis G. K. Anderson	John Wiley & Sons, Hoboken, N.J., 2011, ISBN: 978-0-470-46879-3
6	Introduction to Process Engineering and Design	S.B. Thakor, B.I. Bhatt	McGraw-Hill Education (India) Pvt Limited, New Delhi, 2007, ISBN: 978-0-07-147307-3
7	Membrane Separation Processes	Kaushik Nath	PHI publication, New Delhi, 1 January 2016, ISBN: 978-81-203-5112-0
8	Principles of Mass Transfer and Separation Processes	B.K. Dutta	PHI Publication, New Delhi, 1 January 2006, ISBN: 978-81-203-2927-6

14. SOFTWARE/LEARNING WEBSITES

1. https://archive.nptel.ac.in/courses/103/105/103105060/#
2. https://www.youtube.com/playlist?list=PLA15B70D88CA21EBE
3. https://www.nap.edu/read/6388/chapter/4
4. https://www.scribd.com/document/532919025/CH371-Novel-separation-process

15. PO-COMPETENCY-CO MAPPING

Semester							
	Pos						
Competency & Course Outcomes	**PO 1 Basic & Discipline specific knowledge**	**PO 2 Problem Analysis**	**PO 3 Design/ development of solutions**	**PO 4 Engineering Tools, Experimentation & Testing**	**PO 5 Engineering practices for society, sustainability & environment**	**PO 6 Project Management**	**PO 7 Life-long learning**
Competency							
a) Understand basics of separation processes.	3	-	-	-	1	2	-
b) Select different membrane separation processes.	3	2	1	-	2	2	2
c) Illustrate different adsorption and chromatography techniques.	3	2	1	-	2	2	2
d) Describe different novel separation techniques.	3	2	1	-	2	2	2

*Legend: '**3**' for high, '**2**' for medium, '**1**' for low and '**-**' for no correlation of each CO with PO.*

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

S. No.	Name and Designation	Institute	Contact No.	Email
1	Mrs. Bhoomi L. Guleria	Government Polytechnic Gandhinagar		Bhoomitrivedi87@gmail.com
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