GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021(COGC-2021) Semester-V

Course Title: Mass Transfer - II
(Course Code: 4350501)

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	5thSemester

1. RATIONALE

Diploma Chemical engineer have to supervise the preliminary purification of raw materials or final separation of products from by-products. They have to deal with changes in composition of solutions known as the mass-transfer operations. The large numbers of towers used for petroleum refining are examples of mass transfer operations. A substantial number of the unit operations of chemical engineering are concerned with the problem of changing the compositions of solutions and mixtures through methods involving chemical reactions. Hence the course has been designed to develop these competencies and its associated cognitive, practical and effective domain learning out comes.

2. COMPETENCY

The course should be taught and curriculum should be implemented with the aim to develop required skills so that students are able to acquire following competency:

- **Perform separation operations for purification of raw materials and products**

3. COURSE OUTCOMES(COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

CO-1: Operate equipment for various gas liquid contacting operations.
CO-2: Apply concept of distillation to various process industries.
CO-3: Use concept of humidification to various process industries.
CO-4: Apply concept of Absorption in Process Industries
CO-5: Use of Ion exchange and Adsorption in Chemical Industries
CO-6: Apply concept of crystallization in process industries

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	-	4	5	30*	70	50	50	**200**

(*):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: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **CA** -Continuous Assessment; **ESE**-End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the sub-components of the COs. *Some of the **PrOs** marked **'*'** (in approx. Hrs column) are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'*.

Sr. No.	**Practical/Exercise** (Course Outcomes in Psychomotor Domain according to NBA Terminology)	Unit No.	Approx. Hrs Required
1	Demonstrate principle, construction and working of equipments for gas–liquid operations with models		4
2	Prepare vapour liquid equilibria curve at atmospheric pressure for Benzene-Xylene		4
3	Carry out simple distillation in glass assembly		4
4	Find out the effect of vacuum on distillation of liquid		4
5	Carry out continuous rectification in packed column		4
6	Find out amount of steam required in steam distillation		4
7	Find out the property of atmospheric air with the help of wet bulb and dry bulb temperature		4
8	Set desired conditions of humid air in humidity control cabin		4
9	Find out rate of absorption in a tray tower		4
10	Find out rate of absorption in a packed tower		4
11	Characterize industrial adsorbents and observe their samples		4
12	Remove colour impurities from water using charcoal		4
13	Find out the yield of crystals from saturated solution without seeding		4
14	Find out the yield of crystals of from saturated solution with seeding		4
Total			**56**

Note

i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list**.**

ii. The following are some **sample** 'Process' and '#Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.

Sr.No.	Sample Performance Indicators for the PrOs	Weight age in %
1	Handling of apparatus for precise measurements	10
2	Record observations correctly	20
3	Practice and adapt good and safe measuring techniques	10
4	Calculations, Interpretation of results and their conclusion.	20

5	Prepare report of practical in prescribed format	10
6	Solve assignment questions.	20
7	Viva-voce	10
Total		**100**

6. MAJOR EQUIPMENT/INSTRUMENTS AND SOFTWARE REQUIRED

These major equipment/instruments and Software required to develop PrOs are given below with broad specifications to facilitate procurement to them by the administrators/management to the institutes. This will ensure the conduction of practice in all institutions across the state in a proper ways other the desired skills are developing in students.

1. Distillation Assembly: 2000 ml round bottom flask, 1000 ml collection flask, joints, adapter with ¾ neck, simple/coiled glass condenser, thermometer pocket
2. Steam distillation setup: Distillation kettle - MOC-MS, dia-150 mm, height 300mm; jacket dia 175 mm height, height 300 mm, pressure gauge, steam relief valve, steam feed line with valve, drain valve, steam trap on jacket outlet, 25 mm glass wool insulation with MS cladding; Condenser – MS shell, tube copper dia-150 mm, height 250; Steam generator inner SS 304, outer MS dia 180 mm, height 270 mm; 25,5litre collecting beaker
3. VLE apparatus: Heating mantle with 1-liter flask, dimmer stat, digital temp indicator, air- and water-cooled condenser, mounted on wooden and MS frame, thermocouples
4. Humidity cabin: Double walled thick gauge chamber SS 304, heater 500 W; Cooling circuit with compressor, expansion valve, condenser and refrigerant; Steam generator SS 304; Control panel with digital temperature indicator, low water level indicator, solenoid valve
5. Batch crystallizer: Jacket 325 mm round, 155 mm deep, 3mm thick, annulus 22.5 mm; 25 mm thick glass wool insulation, Aluminum cladding; motor-stirrer 10mm rod, speed regulator
6. Benzene, Toluene, Xylene, Sand, Limestone, silica gel, Charcoal, boric acid, Sodium sulphate, Potassium permanganate

7. AFFECTIVE DOMAIN OUTCOMES

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

a) Work as a leader/a team member.
b) Follow ethical practices
c) Observe safety measures
d) Good house keeping
e) Time management
f) Practice environmentally friendly methods and processes.

The ADOs are best developed through 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 given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such higher-level UOs could be included by the course teacher to focus on the attainment of COs and competency.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit I Equipment for Gas Liquid Operations	1a Describe importance of Gas-Liquid operations 1b Classify equipments for Gas Liquid operations 1c Describe construction of equipments with diagram of 1.3 &1.4 1d Explain working principle and operation of equipments with sketches of 1.3 &1.	1.1 Importance of Gas-Liquid operations
		1.2 Classification operations of equipments for Gas-Liquid
		1.3 Gas dispersed, Mechanically Agitated Vessel, Tray tower, Types of trays, Operating problems in tray tower, Real Tray & Tray efficiency- point efficiency, Murphy efficiency, Overall-Tray efficiency (only definition) 1.4 Liquid dispersed, Spray tower, Packed tower and its operating problems
	1e Distinguish different packing with diagram types of	1.5 Types of packing (a) Random (b) Regular
Unit II Distillation	2a Describe applications	2.1 Distillation as a versatile separation method
	2b Describe the steps to Plot VLE, Constant pressure, Constant temperature equilibria	2.2 Vapor Liquid Equilibria, Constant pressure equilibria and Constant temperature equilibria
	2c Explain Relative volatility and laws - Raoult's, Henry's 2c.1State their uses	2.3 Relative volatility 2.4 Raoult's law, Henry's law,and their uses
	2d Differentiate azeotropes	2.5 Maximum and minimum boiling azeotropes
	2e Explain -Flash vaporization, Differential distillation, Continuous rectification 2f Calculate amount and composition for Flash vaporization 2g Calculate product composition for Differential distillation	2.6 Flash vaporization, Material balance and Calculation of amount and composition 2.7 Differential distillation, Derivation of Rayleigh's equation and Calculation of product composition 2.8 Continuous rectification of binary solution, The fractionation operation and Overall material balances
	2h Apply McCabe-Theile method for multistage tray tower for enriching and stripping section 2i Calculate product rates, minimum reflux ratio and number of trays for the given data	2.9 McCabe and Thiele method for enriching and stripping section, Introduction of Feed and Location of the feed tray, Total reflux ratio, Minimum reflux ratio, Optimum reflux ratio, calculations of product rates, minimum reflux

		ratio and number of trays
	2j Compare distillation techniques viz (a) Steam distillation, (b) Vacuum and molecular distillation(c) Azeotropic and extractive distillation	2.10 Important distillation technique Steam distillation, Vacuum and molecular distillation, Azeotropic and extractive distillation
	2k Distinguish Reboilers	2.11 Reboilers and their use
Unit III Humidification	3.a Analyse the VLE for a pure substance	3.1 Vapor-pressure curve 3.2 Saturated and unsaturated vapor-gas mixtures
	3.b Explain the concepts of Absolute humidity, Relative saturation, Percentage saturation, Dew point, Dry bulb temperature, Wet bulb temperature, Adiabatic saturation temperature, Humid volume, Humid heat, Enthalpy	3.3 Concept of Absolute humidity, Relative saturation, Percentage saturation, Dew point, Dry bulb temperature, Wet bulb temperature, Adiabatic saturation temperature, Humid volume, Humid heat, Enthalpy
	3.c Evaluate the property of air using DBT and WBT Calculate – absolute humidity, relative saturation, percentage saturation for the given process data	3.4 Calculations of absolute humidity, relative saturation, percentage saturation
	3.d Draw psychometric chart List Purposes of contact of gas with pure Liquid	3.5 Psychometric charts for Air-Water system 3.6 Purposes of contact of gas with pure Liquid
	3.e Explain construction and working with diagram	3.7 Equipments, Cooling towers.
Unit IV Gas Absorption	4.a Apply concept of absorption	4.1 Industrial application of Absorption Gas Absorption
	4.b Describe the physical properties of gases 4.c Explain Raoult's law	4.2 Equilibrium solubility of gases in liquids and effect of temperature and pressure. 4.3 Ideal solution and Raoult's law
	4.d Select appropriate solvent	4.4 Solvent for absorption
	4.e Explain Material balance in different condition 4.f Select liquid-gas ratio for absorber	4.5 Material balance for one component transfer 1. Counter current flow 2. Co-current flow 3. counter current multistage operation 4.6 Minimum liquid-gas ratio for absorber
	4.g Explain tray tower and packed tower 4.h Evaluate various packing	4.7 HETP

	4.i Calculate absorption based on material balance	4.8 Raoult's law and material balance applied in gas absorption
Unit V Adsorption and Ion Exchange	5.a Define and state uses of Adsorption	5.1 Definition and industrial application of Adsorption
	5.b Classify Adsorption and adsorbents 5.c State Commonly used adsorbents	5.2 Types of adsorptions, Nature of adsorbents, commonly used adsorbents
	5.d Analyse Adsorption Equilibria 5.e Describe Effect of temperature on adsorption and Heat of adsorption	5.3 Adsorption Equilibria, Adsorption hysteresis, Effect of temperature on adsorption and Heat of adsorption
	5.f Apply Freudlich's equation for single stage and multi stage cross-current operation 5.g Describe adsorption from dilute and concentrated solution	5.4 Adsorption from liquids, Adsorption from dilute solution, The Freundlich's equation, Adsorption from concentrated solutions, Material balance and Freundlich's equation for single stage operation.
	5.h Describe construction and working of Higgins contactor, Pressure swing adsorber	5.5 Higgins contactor and Pressure swing adsorber
	5.i Appreciate concepts of Ion Exchange 5.j List Application of Ion Exchange	5.6 Ion-Exchange: Principles, Application.
Unit VI Crystallization	6.a State Industrial applications of crystallization	6.1 Industrial applications of crystallization
	6.b Explain equilibria mechanism for crystallization 6.c State the methods to get Super saturation	6.2 Equilibria and yields, Super saturation and methods to get it, Nucleation and Crystal growth
	6.d Explain working principle and operation of Crystallization Equipment with sketch 6.e Describe construction of Crystallization Equipment	6.3 Crystallization Equipment, Vacuum crystallizer, Swenson walker crystallizer.
	6.f State and explain Meir's theory	6.4 Meir's theory
	6.g Calculate the crystal yield	6.5 Crystallization with and without seeding 6.6 Calculations of crystal yield
	6.h List steps to Prevent caking of crystals	6.7 Caking of crystals and its prevention

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit	Unit Title		Distribution of Theory Marks

		Teaching Hours	R Level	U Level	A Level	Total Marks
I	EquipmentforGas LiquidOperations	04	2	03	02	7
II	Distillation	12	05	06	08	19
III	Humidification	06	02	04	03	09
IV	Gas Absorption	07	02	04	08	14
V	Adsorption&Ion-Exchange	08	04	04	04	12
VI	Crystallization	05	03	03	03	09
Total		**42**	**18**	**24**	**28**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*

Note*: This specification table provides general guidelines to assist students for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions to assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may slightly vary from above table.*

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

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) Massive open online courses (*MOOCs*) may be used to teach various topics/subtopics.
b) Guide student(s) in undertaking micro-projects/activities.
c) Different types of teaching methods i.e. video demonstration, activity based learning, case study, m-learning need to be employed by teachers to develop the outcomes.
d) Some *of the topics/sub-topics* which is relatively simpler or descriptive is to be given to the students for *self-learning* but to be assessed using different assessment methods.
e) Teachers need to ensure to create opportunities and provisions for *co-curricular activities*.
f) Guide students to address issues on environment and sustainability with reference to using the knowledge of this course

g) OERs, Vlab, and Olabs may be used to teach for the teaching of different concepts.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her at 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 the integration of PrOs, UOs, and ADOs. Each student will have to maintain dated work diary consist in go find 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 (so that they develop industry-oriented COs).

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

1.	Prepare chart/model of Mass transfer operation and applications.
2.	Prepare 15-20 slides power point presentation onmass transfer operation along with their examples.
3.	Prepare 15-20 slides power point presentation on topic of mass transfer operation.
4.	Prepare Laboratory set up for distillation, absorption, crystallization, humidification, Gas liquid operation or ion exchange.
5.	Prepare a demonstrative model of any mass transfer equipment.
6.	Prepare Working model of any mass transfer equipment.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Books	Author	Publication with place, year and ISBN
1	Mass Transfer Operations	Robert E.Treybal	Mc Graw- Hill, 3rd Edition,1981
2	Unit Operation of Chemical Engineering	McCabe, Warren	McGraw Hill Publication, NewYork2004, 7th Edition
3	Unit Operations-II	K.A. Gavhane	Nirali Prakashan, Pune
4	Unit Operations of Chemical Engineering,Volume-I	P. Chattopadhyay	Khanna Publishers, NewDelhi,1995
5	Chemical Engineering,Volume-2	Coulsion and Richardson	Butterworth-Heinemann; 5thEdition, 2002
7	Introduction to Chemical Engineering	L.Badger, Julius T.Banchero	McGraw Hill Publication, NewYork, 7thEdition, 2004

14. SUGGESTED LEARNING WEBSITES

a. www.unitoperation.com
b. http://nptel.ac.in/courses/index.php?subjectId=103103035
c. http://1rv07ch.files.wordpress.com/2010/05/lecture1-introduction2mass-transfer.pdf
d. http://www.msubbu.in/ln/mt/
e. http://chemeng.ir/download/Mass-Transfer/Mass_Transfer_Operations_-Robert_Treybal_chemeng.ir.pdf
f. http://serve.me.nus.edu.sg/arun/file/teaching/ME6203_2013_Mujumdar.pdf

15. PO-COMPETENCY-CO MAPPING

Semester V	Mass Transfer -II (4350501)						
	POs						
Competency & Course Outcomes	PO1 Basic & Discipline-specific knowledge	PO2 Problem Analysis	PO3 Design/development of solutions	PO4 Engineering Tools, Experimentation &Testing	PO5 Engineering practices for society, sustainability & environment	PO6 Project Management	PO7 Life-long learning
Competency	**Supervise operation and maintenance of various Mass Transfer equipments**						
CO-1: Operate equipment for various gas liquid contacting operations.	**2.00**	**3.00**	**3.00**	**2.00**	**-**	**1.00**	**2.00**
CO-2: Apply concept of distillation to various process industries.	**2.00**	**2.00**	**2.00**	**2.00**	**-**	**-**	**1.00**
CO-3: Use concept of humidification to various process industries.	**2.00**	**1.00**	**2.00**	**1.00**	**2.00**	**-**	**-**
CO-4: Apply concept of Absorption in Process Industries	**2.00**	**2.00**	**2.00**	**1.00**	**2.00**	**-**	**-**
CO-5: Use of Ion exchange and Adsorption in Chemical Industries	**2.00**	**3.00**	**2.00**	**2.00**	**2.00**	**-**	**1.00**

CO-6: Apply concept of crystallization in process industries	**2.00**	**2.00**	**2.00**	**2.00**	**2.00**	**-**	**1.00**