GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Summer Internship-I
(Course Code: 4330001)

Diploma programme in which this course is offered	Semester in which offered
All Branches of Diploma Engineering(Except Automobile, Bio Medical, ICT, Power)	Third

1. RATIONALE

Idea of Embedded Internships- AICTE has made 7-10 weeks summer internships mandatory in the new curriculum which will equip the students with practical understanding and training about industry practices in a suitable industry or organization. To make education holistic, sports, physical activities, values and ethics have been embedded in the curriculum.

We must agree that all Branches of Diploma Engineering are changing rapidly. New technologies are adding fast which effects can be seen in our society. Summer internship is a good option by which students to get flavor of such emerging technology and familiar with industry environment to identify scope and focus of their career development opportunities. Main objective of summer internship is hand-on practice to expose students for thinking about professional career by observing, understanding working mechanism of ongoing work of industry and to obtain various types of skills throughout internship program.

This two week mandatory internship is to equip the students with practical knowledge and provide them exposure to real time industrial environments. Further, in these internships, the option is provided to do internship in Government Agencies/ skill centers/ social sector/ Govt. initiated social schemes/ NGOs etc. The duration of internship will be two weeks. It will be after completion of 2nd Semester and before the commencement of Semester 3rd. Any options from following can be chosen by the students:

1. **Offline internship in industry** - Student is supposed to produce joining letter for starting and relieving letter once the internship is over in case of Offline internship in any industry.
2. **Online internships –** Student can select from any of approved /supported / recommended by the All India Council of Technical education for Internship (like Internshala/ NEAT/ Gujarat Knowledge Society Initiative etc.) or Approved by the state government or University approved
3. **A Mini Project** - On some suitable topic related to respective branch. It can be small fabrication / experimental results/ simulations/ Application development / Design and / or Analysis of System(s) etc. depending on the branch of the student. Preferably a single student should carry out a mini-project.

2. COMPETENCY

The purpose of this course is to help the student to attain flavor of the following industry identified competency through summer internship experiences:

- **Develop multiple types of skills such as planning, communication, collaboration, decision making / Problem solving and management skills along with selected technical knowledge.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

a) Learn and adopt the engineer's role and responsibilities with ethics.
b) Get exposure to the industrial environment for professional activities.
c) Get possible opportunities to learn, understand and sharpen the technical skills required for technical advancement.
d) Develop managerial skills required for professional career.
e) Attain skill for writing technical report and prepare poster for presentation.

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	
0	0	0	1	0	0	25	25	50

1. **Offline internship in industry:** CA will be carried out based on submitted progress card by Industry resource person and ESE / Assessment will be carried out by institute resources person.
2. **Online internships:** CA will be carried out based on submitted certificate and ESE/ Assessment will be carried out by institute resources person.
3. **A Mini Project:** CA will be carried out based on project work by institute resources person.

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

List of Documents to be prepared for Submission:

- Detail report duly signed and approved by the internal/external mentor
- Presentation softcopy approved by the internal/external mentor
- Poster of summer internship activities approved by the internal/external mentor.

Sample forms for Registration and Evaluation of Summer Internship-I –SI-I are given below:

1) Both forms are mandatory to be filled at the commencement and completion of SI respectively.
2) It is mandatory to file and map SI-I Registration and Evaluation with respective forms of SI-II (Later in Semester 5) so that students get enough exposure of industry / technology. (Mapping doesn't mean same industry/ company/ project-it can be independent/ different also.)
3) Mapping will be done to ease CA and ESE Evaluations.
4) A Seminar / Webinar can be arranged so that students coming from different industry / institute / project background can share experiences and learnings to their peers / all students of the same department.
5) Attached formats for Registration, Completion and Evaluation are suggestive. But, adhering to these formats is anticipated.

Summer Internship-I Registration Form

Note: Students needs to submit this registration form after finalizing mode of internship.

Student Details												
Enrollment Number												
Student Name												
Student Details	Mobile Number :											
	Email Address:											
Branch												
Code of the Institute	Name of the Institute											
Mentor Details (Institute)	Name:											
	Designation:											
	Mobile No:											
	Email Address:											
Industry Details	Name:											
	Address:											
	Email:											
	Phone:											
	Website:											
Mentor Details (Industry)	Name:											
	Designation:											
	Mobile No:											
	Email Address											
Mode of Internship Carried Out	Online / Offline/ Mini Project											
Title of the Project/ Internship carried out												
Nature of Work Carried Out	Web Design / Application development (Web / Mobile), Experimental results/ simulations/ Analysis of System(s) etc… Other please Specify_____											

Student Signature Faculty Signature

Summer Internship-I -Suggested Letter for Completion

[Company or Institute letter head]

No: Date

TO WHOM SO EVER IT MAY CONCERN

This is to certify that, Mr. /Mrs._____

Enrollment No._____ Student of_____

Has successfully completed a two week Internship in the field of_____

From the date:_____ to date:_____.

[90% Attendance is mandatory for completion of Internship]

During the period of his/her summer internship program with us, He / She were exposed to following different processes and were found sincere and hardworking.

1. _____

2. _____

3. _____

4._____

Mentor Signature **Head of Department**

Stamp Stamp

Summer Internship-I -Evaluation Rubrics for Institute

Evaluation Rubrics (Institute)

Enrollment No: _____ Branch: _____

Name of the Students: _____

Date of Evaluation: _____

Internal Evaluation – 25 Marks PA(I) (To be carried out by the mentor in consultation with Industry) Minimum Passing Marks: 13					
Parameter	**Excellent**	**Good**	**Average**	**Not up the level of Satisfaction**	**Obtained Marks**
Mark range	**4-5**	**3-4**	**2-3**	**Below 2**	
Knowledge acquisition in specific domain. **5 marks**					
Skill and attitude attainment in specific domain. **5 marks**					
Feedback and suggestions given are incorporated? **5 marks**					
Quality of the prepared report and poster. **5 marks**					
Quality of the presentation. **5 marks**					
Total Marks Obtained Out of 25 PA(I)					

Signature: _____ Institute Resource Examiner Name: _____

Suggested Evaluation Rubrics for Industry

Evaluation Rubrics (Industry)

Enrollment No: _____ Branch: _____

Name of the Students: _____

Date of Evaluation: _____

External Evaluation – 25 Marks ESE(V) (To be carried out by the Industry Supervisor) Minimum Passing Marks: 13					
Parameter	**Excellent**	**Good**	**Average**	**Not up the level of Satisfaction**	Obtained Marks
Mark range	**4-5**	**3-4**	**2-3**	**Below 2**	
Student regularity during the Internship period and proactive ness/responsiveness towards the given tasks (**5 Marks)**					
Work Plan, Execution and quality of work in forms of Outcome achieved (**5 Marks)**					
Engineering Tools and Techniques (**5 Marks)**					
Quality of poster design and presentation (**5 Marks)**					
Quality of the report and Skill **(5 Marks)**					
Total Marks Obtained Out of 25 ESE(V)					

Signature: _____ Industry resource/ Examiner Name: _____

Common Note:

1) For Summer Internship / Projects / Seminar etc. Evaluation is based on work done, quality of report, performance in viva-voce, presentation etc. The internal / external assessment is based on the student's performance in viva-voce /work record respectively.
2) In case Industry Supervisor is not available / Institute Mentor/ Faculty can fill up both.

5. AFFECTIVE DOMAIN OUTCOMES

The following 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 as role of Engineer.
b) Practice environmentally friendly methods and processes.
Follow safety precautions and ethical practices.

6. SUGGESTED STUDENT ACTIVITIES

Following are the suggested student-related curricular, **co-curricular** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should perform following activities and prepare reports and give presentation in front of students and faculty members. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement interviews:

a) Perform various tasks given by industry resources person during offline internship.
b) Perform various tasks given during online internship.
c) Perform various task required to complete mini project work under guidance of faculty member.
d) Summer Internship program Interns are required to give a presentation before review committee consisting of a group of academic staff members.
e) The review committee gives feedback and suggests possible improvements in the work.
f) At the end of the program all the Summer Internship program Interns make a poster presentation of the work carried out. The poster presentation is open to the public. It is also evaluated by faculty members.
g) A completion certificate will be issued to all Summer Internship program Interns only after the completion of internship tenure.

7. SOFTWARE / LEARNING WEBSITES

An internship is a short term work program usually offered to students by companies and institutes who require staff for assistance at junior levels. Thus for the students undergoing internship a professional learning experience is provided to benefit them in their skills as well as career. It will brush existing skills and provide exposure to new skills. Generally it is provided ay entry level in the industry.

Here is a suggestive list for reference only.

- https://www.internshala.com
- https://swayam.gov.in
- https://nptel.ac.in/
- https://neat.aicte-india.org/
- https://www.edx.org/
- https://www.coursera.org/
- https://www.udemy.com/
- https://www.linkedIn.com
- https://www.stumags.com
- https://www.letsintern.com
- https://www.internship.com
- https://www.glassdoor.com

8. PO-COMPETENCY-CO MAPPING

Semester III	Summer Internship (Course Code:4330001)						
	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	**Use principles of basic electronics to maintain various electronics circuits And equipment**						
CO1) Learn and adopt the engineer's role and responsibilities with ethics.	2	1	1	1	1	1	1
CO2) Get exposure to the industrial environment for professional activities.	1	1	1	1	1	1	1
CO3) Get possible opportunities to learn understand and sharpen the technical skills required for technical advancement.	2	1	2	2	1	1	1
CO4) Develop managerial skills required for professional career.	1	1	2	1	1	1	1
CO5) Attain skill for writing technical report and prepare poster for presentation.	1	1	-	1	1	1	1

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

9. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Sr. No.	Name and Designation	Institute	Contact No.	Email
1	Jiger P. Acharya	GP, Ahmedabad	9429462026	jigeracharya@gmail.com
2	Alpeshkumar R. Thaker	GP, Ahmedabad	9879709675	alpeshrthaker@gmail.com
3	Umang D. Shah	GP, Ahmedabad	9427686364	umang.shah111gp@gmail

BoS Resource Persons

Sr. No.	Name and Designation	Institute	Contact No.	Email
1	Shri U. V. Buch- BoS Member and Subject in-charge (EC)	G P Ahmedabad	9825346992	uvbuch@gmail.com

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Mechanical Operation
(Course Code: 4330501)

Diploma programmer in which this course is offered	Semester in which offered
Chemical Engineering	Third

1. RATIONALE

The operations of chemical plants require use of material handling and size reduction equipments, screens, agitator, mixers, centrifuges, cyclones, filters, storage & conveying of solids and other mechanical separation equipments. Therefore students must have information about the principles, construction, working and application of these equipments so that they can plan for their efficient use in plants. In this course the students would also learn simple calculations to judge the performance of these equipments.

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:

- **Plan and supervise operation of mechanical operation equipments.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

a) Use fundamentals of mechanical operation.
b) Apply concept of size reduction, separation, agitation-mixing, Storage and Conveying of Solid & Fluid.
c) Operate size reduction equipment, separators, agitators, mixers and conveyors.
d) Calculate properties of solid particles, power consumption, and resistance, crushing law constants, efficiency and material balance.

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	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 practical/exercises should be properly designed and implemented with an attempt to develop different types of practical skills **(Course Outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies **(Programme Outcomes).** Following is the list of practical exercises for guidance.

Note: Here only Course Outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of Programme Outcomes/Course Outcomes in affective domain as given in a common list at the beginning of curriculum document for this programme. Faculty should refer to that common list and should ensure that students also acquire those Programme Outcomes/Course Outcomes related to affective domain.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Option	Approx. Hrs. Required
1.	Measure volume surface mean diameter, mass mean diameter, number of particles using a sieve shaker.	I		**4**
2.	Perform differential and cumulative screen analysis	III		**4**
3.	Test Kicks law for crushing in Jaw crusher.	II		**4**
4.	Test Bond's law for crushing in a Roll crusher.	II		**4**
5.	Test Rittinger's law for grinding in a Ball mill and measure critical speed.	II		**4**
6.	Measure efficiency and cut diameter of Cyclone Separator.	IV		**4**
7.	Determine rate of settling by Sedimentation.	IV		**4**
8.	Measure rate of filtration, filter medium & cake resistance in Gravity filtration.	IV	**Any three**	**4**
9.	Measure rate of filtration, filter medium & cake resistance in Vacuum filtration.	IV		**4**
10.	Measure cake resistance, filter media resistance in Pressure filtration.	IV		**4**
11.	Measure rate of filtration, cake resistance, filter media resistance in Centrifuge.	IV		**4**
12.	Measure efficiency of separation in froth flotation cell.	III	**Any two**	**4**
13.	Measure efficiency of separation in Magnetic separator.	III		**4**
14.	Measure efficiency of separation in Electrostatic separator.	III		**4**

15.	Evaluate mixing index in mixer.	V		**4**
16.	Measure power consumption in baffled and unbaffled Agitation vessel.	V		**4**

Note

*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.*

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipments with broad specifications for the PrOs is a guide to procure them by the administrators to use in uniformity of practical's in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Sieve shaker – Sieve dia – 100 mm to 200 mm, no of sieve – 6-8 and Pan, Opening – as per standards (micro or coarse particle)	1,2
2	Jaw crusher – 10-50 kg/hr capacity, Suitable for operation on 415V, 50Hz, 3 Phase, AC supply with energy meter	3
3	Laboratory Roll crusher – 5-25 kg/hr capacity, Suitable for operation on 415V, 50Hz, 3 Phase, AC supply with energy meter	4
	Laboratory Ball mill - 5kg capacity, Suitable for operation on 415V, 50Hz, 3 Phase, AC supply with energy meter	5
4	Cyclone separators – Product Particle as per requirement, Suitable for operation on 220V, Power: 1000W with energy meter	6
5	Batch Sedimentation Set up (Lab Scale Model using Glassware)	7
6	Gravity filter (Lab scale model using Glassware)	8
7	Vacuum Filter (Lab scale model using Glassware and Vacuum pump)	9
8	Laboratory filter Press - Suitable for operation on 220V, Power: 1000W	10
9	Basket centrifuge - Suitable for operation on 415V, 50Hz, 3 Phase, AC supply	11
10	Froth flotation Cell, 5-15 kg/hr capacity, Suitable for operation on 220V, Power: 1000W with energy meter	12
11	Magnetic separator suitable for operation on 220V, Power: 1000W	13
12	Electrostatic separator.	14

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
13	Double cone mixer - Suitable for operation on 220V, Power: 1000W	15
14	Ribbon Blender- Suitable for operation on 220V, Power: 1000W	15
15	Sigma Mixer- Suitable for operation on 220V, Power: 1000W	15
16	Agitation vessel setup – Suitable for operation on 220V, Power: 1000W with energy meter (with removable baffles)	16

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 course competency.

a) Follow ethical practices.
b) Practice good housekeeping.
c) Demonstrate working as a leader/a team member during brainstorming.

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)	Topics and Sub-topics
Unit – I Fundamental of Mechanical Operation	1a. Define Unit Operation and Unit Process 1b. Differentiate Unit Operation and Unit Process	1.1 Fundamentals of Unit Operation and Unit Process 1.2 Examples of Unit Operation and Unit Process
	1c. Describe specific properties of solids	1.3 Define & Calculate ● Particle density and Bulk density

		● Sphericity ● Equivalent diameter ● Specific surface area ● Volume surface mean diameter ● Mass mean diameter ● Shape factor ● Number of particles in solid
Unit– II Size Reduction	2a. Explain size reduction with applications	2.1 Principles of Size reduction and its application
	2b. Select Size reduction equipments	2.2 Factors for selection of size reduction equipment
	2c. Calculate Energy and power requirement in comminution	2.3 Energy and power requirement in comminution
	2d. Explain Empirical laws of size reduction and work Index	2.4 Laws of size reduction: (i) Rittinger's law (ii) Bond's law (iii) Kick's law 2.5 Calculate Power required for size reduction using empirical laws and calculation of work Index.
	2e. Explain Different Size reduction equipments	2.6 Principle, construction, working and Application of ● Jaw crusher ● Gyratory crusher ● Roll Crusher ● Ball mill ● Hammer mill
	2f. Compute Angle of nip for Roll Crusher	2.7 Derive equation of angle of nip 2.8 Calculation of angle of nip for Roll crusher
	2g. Calculate Critical speed of Ball mill	2.9 Derivation of equation of critical speed for Ball Mill 2.10 Calculation of operating speed and critical speed for Ball Mill
	2h. Explain Open and Close circuit grinding	2.11 Difference between open circuit and close circuit grinding
Unit– III Solid-Solid separation	3a. Explain Screening 3b. Compare types of screen analysis 3c. Derive formula for	3.1 Basics of Ideal and Actual Screen 3.2 Types of Screen Analysis ● Cumulative analysis ● Differential analysis 3.3 Capacity and effectiveness of

	effectiveness of screen 3d. Calculate capacity and effectiveness of screen 3e. Explain different screening equipment	screen ● Derivation of formula for overall effectiveness of screen ● Calculation of capacity and effectiveness of screen 3.4 Principle, Construction, Working & Application of ● Trommel, grizzlies, vibrating screen
	3b. Explain different Solid separation equipments	3.5 Principle, Construction, Working & Application of ● Hydraulic Jig ● Double cone classifier ● Electrostatic precipitator ● Magnetic separator ● Froth flotation cell
	3c. Select solid separation equipment	3.6 Factors affecting selection of equipment for solid separation
Unit– IV Solid- fluid Separation	4a. Describe filtration and Differentiate constant rate and constant pressure filtration 4b. Characterize filter media 4c. Explain filter aids and its application 4d.Explain cake resistance, filter media resistance for various conditions 4e. Classify equipments for liquid-solid separation	4.1 Basics of filtration ● Constant Rate filtration ● Constant Pressure filtration 4.2 Filter media and its characteristics 4.3 Filter Aid & its application 4.4 Cake Resistance, Filter medium Resistance ● Constant Rate filtration ● Constant Pressure filtration 4.5 Principle, construction, working and application of ● Filter Press ● Rotary Drum Filter ● Leaf Filter ● Basket Centrifuge
	4f. Explain sedimentation 4g. Draw batch sedimentation curve 4h. Explain Gravity Thickener	4.6 Basic of Sedimentation ● Hindered settling ● Free settling 4.7 Batch Sedimentation Experiment ● Interphase height Vs Time curve for batch sedimentation 4.8 Principle, construction,

		working and application of Gravity Thickener
	4i. Explain Terminal settling velocity	4.9 Terminal settling velocity
	4j. Describe Cyclone Separator	4.10 Principle, construction, working and application of Cyclone Separator
	4k. Calculate Cut diameter and efficiency of cyclone	4.11 Cut diameter and Efficiency ofCyclone Separator
Unit– V Agitation and mixing	5a. Describe agitation and mixing 5b. Classify impellers 5c. Compare various impellers 5d. Explain vortex formation and prevention 5e. Explain factors affecting agitation 5f. Calculate power consumption 5g. Describe Agitated vessel	5.1 Define agitation and mixing 5.2 Classification of Impellers and brief explanation 5.3 Vortex formation and swirling 5.4 Methods for Prevention of Vortex 5.5 Factors affecting on agitation and Mixing 5.6 Calculation of Mixing index & Power Consumption 5.7 Principle, construction, working and application of Agitated vessel
	5h. Explain different Types of Mixers	5.8 Principle, construction, working and application of ● Ribbon blender ● Kneaders ● Banbury mixer ● Muller mixer
Unit VI Storage & Conveying of Solid and Fluid	6a. Describe different Storage of Solids	6.1 Angle of repose 6.2 Bulk storage 6.3 Storage in bins and silos
	6b Explain different types of Conveyor	6.4 Types of Conveyors ● Screw conveyors ● Belt conveyors ● Bucket elevators ● Pneumatic conveyor ● Hydraulic Conveyor

***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 QUESTIONPAPER DESIGN

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamental of Mechanical Operation	04	2	2	3	07
II	Size Reduction	10	4	5	8	17
III	Solid-Solid Separation	07	3	4	4	11
IV	Solid-Fluid Separation	10	4	5	8	17
V	Agitation and Mixing	07	3	5	3	11
VI	Storage and Conveying	04	2	3	2	07
Total		**42**	**18**	**24**	**28**	**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.
e) 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. Prepare a chart/model of Size reduction equipments along with their Principle and applications.
2. Prepare chart/model for various types of impellers used in Industry.
3. Interpret results of Cumulative Analysis and Differential Analysis using Microsoft excel.
4. Prepare chart for Vortex formation and swirling and Methods for their prevention.
5. Draw suitability chart for various factors for selection of various mechanical equipment.
6. Prepare 15-20 slides power point presentation showing classification, construction and working of any mechanical equipment.
7. Compare Screen Effectiveness by Manual & Mechanical Method using Literature/ experimental data by the use of Microsoft excel.
8. Prepare Laboratory set up for Batch Sedimentation.
9. Prepare Working model of any mechanical operation equipment.
10. Prepare a demonstrative model of any mechanical operation equipment.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Unit Operations of Chemical Engineering	McCabe and Smith	McGraw Hill Publications, New Delhi

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
2	Introduction to Chemical Engineering	Badger W. L. and Banchero J. T	McGraw Hill Publications, New Delhi
3	Unit Operation –I	Gavhane K. A.	Nirali Prakashan, Pune
4	Mechanical Operations	Swain A.K., G.K.Roy	Tata McGraw Hill Publications, New Delhi
5	'Chemical Engineering' Vol.- II,	J.M. Coulson & J.F. Richardson 'Chemical Engineering' Vol.- II,	6th Ed. Elsevier, 2003
6	Transport Processes and Separation Process Principles'	C.G. Geankopolis	4th Ed, Prentice Hall India, 2003.

14. SOFTWARE/LEARNING WEBSITES

a. https://ndl.iitkgp.ac.in
b. https://onlinecourses.nptel.ac.in
c. https://swayam.gov.in/explorer
d. www.cheresources.com

15. PO-COMPETENCY-CO MAPPING

Semester-III	Mechanical Operation (Course Code:4330501)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ develop-ment of solutions	PO 4 Engineering Tools, Experimen-tation & Testing	PO 5 Engineering practices for society, sustainabilit y & environment	PO 6 Project Manage-ment	PO 7 Life-long learning
Competency	***Select and Operate Mechanical Operation equipment in the Chemical industry.***						
Course Outcomes CO a) Use fundamental of mechanical operation.	2	-	-	-	-	-	-
CO b) Apply concept of size reduction, separation, agitation-mixing, Storage and Conveying of solid and Fluid.	2	2	2	2	2	2	2

CO c) Operate size reduction equipment, separators, agitators, mixers and conveyors. .	3	2	2	2	3	2	2
CO d)Calculate properties of solid particles, power consumption, and resistance, crushing law constants, efficiency and material balance	2	2	2	3	2	-	1

*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

Sr. No.	Name and Designation	Institute	Contact No.	Email
1.	Mrs. Bhoomi Luckvindersingh Guleria	Government Polytechnic Gandhinagar	8128349140	bhoomitrivedi87@gmail.com
2.	Mrs. Bhumika Bhavin Makwana	Shri K.J. Polytechnic, Bharuch	9662032947	bhmkrn@gmail.com

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Fluid Flow Operation
(Code: 4330502)

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	3rd Semester

1. RATIONALE

Knowledge of fluid mechanics is essential for the chemical engineer because the majority of chemical-processing operations are conducted either partly or totally in the fluid phase. This course deals with basic concepts and principles in hydrostatics and hydrodynamics and their application in solving fluid - mechanics problems. Using various theoretical and practical concepts of fluid mechanics, power requirement for pumps, blowers and compressors can be determined and friction losses through pipes and fittings can also be calculated.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- To maintain flow of different fluids in the chemical plants according to the process requirement.

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:

1. Calculate the pressure difference using fundamental concept of fluid statics and carry out dimensional analysis.
2. Solve various fluid flow problems using governing equations.
3. Calculate Friction losses from changes in velocity or direction
4. Understand the concept of fluidization.
5. Select the metering equipments and fluid moving machinery for appropriate chemical engineering operations.

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	7	30*	70	50	50	200

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-projectto 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.	Estimate pressure drop using U-tube manometer	I	4
2.	Identify types of flow by using Reynolds's apparatus	II	4
3.	Use Bernoulli's apparatus for mechanical energy balance	III	4
4.	Estimate viscosity of water using Hagen-Poiseuille's equation	III	4
5.	Estimate friction losses through pipe, fittings and valves	IV	4
6.	Estimate friction losses through packed bed	IV	4
7.	Conduct a performance test on reciprocating pump and plot the operating characteristics	V	4
8.	Conduct the performance test on centrifugal pump and plot the operating characteristics	V	4
9.	Estimate friction losses due to sudden expansion and contraction in flow area	IV	4
10.	Determine the Co-efficient of discharge for venturi meter	VI	4
11.	Determine the Co-efficient of discharge for orifice meter	VI	4
12.	Determine the Co-efficient of discharge of the Rotameter and obtain the calibration error	VI	4
13.	Determine the Co-efficient of discharge for notches	VI	4
14.	Measure minimum fluidization velocity through fluidized bed	VII	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	Weightage 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 of them by the administrators/management of the institutes. This will ensure the conduction of practice in all institutions across the state in a proper way so that the desired skills are developed instudents.

Sr.No.	Equipment Name with Broad Specifications	PrO. No.
1	**U-tube manometer:-** Metering Tube : Special Uniform bore thick walled Borosilicate Glass Tube, End Connection :Nozzle Type, Mounting : wall panel mounting, Fluid : Mercury, Range : 250-0-250 mm, Accuracy : + 0.5 % of FSD	01
2	**Reynolds's apparatus:**- Test Pipe: Acrylic, 25 mm dia., 800 mm long, Test pipe attached with water tank having capacity of 200 liter, Dye Reservoir : 500 ml	02
3	**Bernoulli's apparatus:**- Testing Duct: MOC-Acrylic , Type : Circular with divergent and convergent sections, Inlet Tank and Outlet Tank: Capacity : 20 lit., MOC : SS – 304 With provision for overflow and valve to stabilize the flow. Pump: MOC : SS body Type : Monoblock Power : 0.5 HP, Single phase Delivery Size : 1/2"	03
4	**Friction loss apparatus:**- Header pipe connected with four pipes, First pipe MS 0.5 inch provided with ball valve, gate valve, globe valve, union joint, Second pipe 0.5 inch without fittings for viscosity determination, Third pipe 02 inch and 0.5 inch connected by sudden expansion and contraction, Forth pipe 01 inch provided with rotameter(Range:3–30 LPH), All pipes and fittings provided with pressure tapping at suitable places. Manometer: Type : U tube, Length : 500 mm, Fluid : Mercury filled up to 200 mm in each limb.	4,5,9,12
5	**Packed bed apparatus:-** Packed Column : Material Borosilicate Glass with both end made of Stainless Steel Dia. 48 mm approx., Height 750 mm approx, Packing Material: glass spherical particles	06

	Size 8-10mm approx, Water tank : Material Stainless Steel, Capacity 30 Ltrs, Water Flow Measurement : By Rotameter, Pressure Drop Measurement: By Manometer, Electricity supply: 1 Phase, 220 V, 50 Hz AC, 5-15 amp combined socket with earth connection.	
6	**Centrifugal pump test rig:-** Pump: Centrifugal Type, 2800 RPM, Drive: Variable speed, Sump Tank : Made of Stainless Steel, Compatible capacity, Measuring Tank : Made of Stainless Steel, Compatible capacity, Stop Watch : Electronic Pressure Gauge : Bourdon type, Range: 0 - 4 kg/ cm^2, Vacuum Gauge : Bourdon type, Range: 0-760 mm of Hg Compound Gauge : Bourdon type, Range: -760 mm of Hg to 2 kg/cm^2, RPM measurement: RPM Indicator with Proximity sensor, Electricity supply: Single Phase, 220 VAC, 50 Hz, 5-15 Amp combined socket with earth connection	07
7	**Reciprocating pump test rig:-** Pressure Gauge:Bourdon type, RPM measurement: Digital RPM Indicator with Proximity sensor., Tanks Material:Stainless Steel, Tank Capacity:40 Liters., Sump Tank Material:Stainless Steel, Sump Tank Capacity:65 Ltrs., Pump Capacity:1 HP, Electricity Supply: Single Phase, 220 V AC, 50 Hz, 5-15amp, Head:5 kg/cm2, Type of Pump : Double Acting cylinder of RPM 320,Piston Stroke : 4cm, Piston Diameter : 4.5cm, Suction pipe : 1", Delivery pipe : 3/4",Pressure gauge : 2 kg/cm2, Vacuum gauge : 0-760mm Hg.	08
8	**Venturi and Orifice meter Apparatus:-** Sump Tank: Capacity : 80 liter MOC : SS – 304 With ½" drain valve, Collection Tank: Capacity : 50 liter, MOC : SS - 304, With self graduated glass tube level indicator & 1" drain valve,Pump: Type : Monoblock MOC : SS – 304 Power : 1 HP, Single Phase,Venturimeter: Size : Suitable for 1" pipeline Dia. Ratio : 0.6-0.64 MOC : Brass With suitable Pressure tapings Arrangement, Orificemeter: Size : Suitable for 1" pipeline Dia. Ratio : 0.6-0.64 MOC : SS 304 With suitable Pressure tapings, Rotameter: Size : Suitable for 1" pipeline Range : 3 – 30 LPH Metering tube: Borosilicate Glass Valve : Needle Valve provided integral, Manometer: MOC : Borosilicate glass tube Size : 500 mm, Fluid : Mercury filled upto 200 mm in each limb, Necessary piping and valves shall be provided to supply water to various flow meters.	10,11
9	**Discharge Over Notches Apparatus:-** Flow Channel: MOC : Rectangular Open Channel of Acrylic, Size : 600 (L) * 250 (W) * 180 (H) mm, Notches: MOC : SS – 304 (Thickness – 1.6 mm), Mounting : Interchangeable, Type: 1.Rectangular, 2. 45°V, Measuring Tank: Capacity : 40 liter, MOC : SS – 304 with self graduated glass tube level indicator, Level gauge: Type : Hook and Screw gauge, Pump: MOC : SS, Type : Monoblock, Power : 0.5 HP, Single Phase	13
10	**Fluidized bed apparatus:-** Material Borosilicate Glass with both end made of Stainless Steel Dia. 48 mm (approx.), Height 750 mm	14

	(approx.) • Packing : Glass Beads • Water tank : Material Stainless Steel, Capacity 30 Ltrs. • Water Circulation : FHP Pump, Crompton/Sharp make. • Water Flow Measurement : By Rotameter • Pressure Drop Measurement : Manometer, Electricity supply: 1 Phase, 220 V AC, 50 Hz, 5-15 amp combined socket with earth connection.	

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 (Course Outcomes in Cognitive Domainaccording to NBA terminology)	Topics and Sub-topics
Unit – I Fluid Staticsand its Applications	1a. Define Ideal fluid andReal fluid 1b. Differentiate between fluid statics and dynamics	1.1 Ideal fluid and Real fluid 1.2 Fundamentals of fluid statics and dynamics
	1c. Properties of fluid	1.3 Define pressure, Static pressure, Dynamic pressure,Vacuum, Density, Viscosity (Absolute and Kinematic), Specific gravity
	1d. Compare compressible and incompressible fluids	1.4 Compressible and incompressiblefluids

	1e. Derive and apply equation of pressure in static fluid.	1.5 Derivation of equation of pressure in static fluid
	1f. Describe different types of manometers 1g. Derive equation ofpressure difference 1h. Explain differential pressure cell	1.6 Principle construction and workingof: Simple U-tube manometer, Inclined manometer 1.7 Derive equation of pressure difference for U-tube manometer 1.8 Differential pressure cell
	1.i Solve simple numerical	1.9 Numerical based on pressure and manometer
Unit– II Fluid–Flow Phenomena and basic equations of fluid flow	2a. Explain velocity change across cross section	2.1 Velocity field, velocity gradient,shear stress and rate of shear
	2b. Explain effect of solid boundary	2.2 Boundary layer & it's formation In straight tubes
	2c. Compare Newtonian and Non-Newtonian fluids with	2.3 Newtonian and Non-Newtonian fluid
	2d. Describe Reynold'sexperiment	2.4 Reynold's experiment and Reynolds Number
	2e. Solve simple numerical	2.5 Numerical based on Reynolds Number
Unit– III Basic Equations of Fluid Flow	3a. Define velocities	3.1 Average velocity and mass velocity
	3b. Derive continuity equation	3.2 Continuity equation for mass balance in steady flow
	3c. Derive Bernoulli's equation	3.3 Bernoulli's equation and correctionsin Bernoulli's equation

Unit	**Major Learning Outcomes (Course Outcomes in Cognitive Domainaccording to NBA terminology)**	**Topics and Sub-topics**
	3d. Use Hagen-Poiseuille's Equation	3.4 Hagen-Poiseuille's Equation
	3e. Solve simple numerical	3.5 Numerical based on basic equations
Unit–IV Friction in Flowing Fluid	4a. Describe roughness of pipe	4.1 Roughness of pipe
	4b. Explain hydraulic radius and equivalent diameter	4.2 Hydraulic radius and equivalent diameter
	4c. Use friction factor chart	4.3 Friction factor chart
	4d. Explain friction losses	4.4 Friction losses from: (a) Sudden expansion of cross section (b) Sudden contraction of cross section 4.4.1 Friction loss in fittings and valves
Unit– V Transportation of fluid	5a. Compare pipe and tube	5.1 Introduction of pipe and tube 5.2 Birmingham wire gauge(BWG) and schedule no.
	5b. Describe fittings & joints	5.3 Types and uses of fittings and joints

	5c. Select valve for particular application	5.4 Construction and working of valves like: (a) Gate valve (b) Globe valve (c) Check valve (d)Butterfly valve (e) Ball valve (f) Control valve(Air to open and Air to close)
	5d. Classify pumps	5.5 Classification of pumps
	5e. Explain pumps with their startup shut and down procedure	5.6 Construction and working of centrifugal, reciprocating and rotary pump
	5f. Explain characteristics of centrifugal pump	5.7 Explain characteristics of centrifugal pump
	5g. Calculate NPSH, head and power for centrifugal pump	5.8 Developed head and power requirement in centrifugal pump
		5.9 NPSH, and Cavitation in centrifugal pump
		5.10 Numerical based on NPSH, efficiency, head and power
	5h. Explain Fan, Blower, Compressor, Vacuum pump and jet ejectors	5.11 Introduction to Fan, Blowers, Compressors, Vacuum pump and jet ejectors
Unit– VI Flow Measurement	6a. Classify flow measuring devices	6.1 Classification of flow measuring devices
	6b. Describe and select flow meters	6.2 Construction, working principles and application of flow meters like Venturi meter, Orifice meter, Rotameter, weirs, Magnetic flow meter
	6c. Derive equation of flow rate	6.3 Derivation of equation of flow rate through Orifice meter, Venturi meter.

Unit	**Major Learning Outcomes (Course Outcomes in Cognitive Domainaccording to NBA terminology)**	**Topics and Sub-topics**
	6e. Solve simple numerical	6.4 Numerical of Orifice meter, Venturi meter
Unit– VII Fluidization	7a Explain Fluidization	7.1 Fluidization and its industrial applications
	7b Discuss Drag, Drag coefficient, Stokes' law	7.2 Drag and drag coefficient Stokes' law
	7c Explain the condition of fluidization.	7.3 Condition for Fluidization
	7d Define minimum fluidization velocity	7.4 Minimum fluidization velocity

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

			Distribution of Theory Marks

Unit	Unit Title	Teaching Hours	R Level	U Level	A Level	Total Marks
I	Fluid Statics and itsApplications	06	02	03	04	09
II	Fluid–Flow Phenomena	05	02	03	02	07
III	Basic Equations of Fluid Flow	06	02	06	02	10
IV	Friction in Flowing Fluid	04	02	02	02	06
V	Transportation of Fluid	10	05	08	05	18
VI	Flow Measurement	08	04	07	04	15
VII	Fluidization	03	01	02	02	05
	Total	**42**	**18**	**31**	**21**	**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/questionsto 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, the 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 the following activities in groupand prepare small reports of about 5 pages for each activity. They should also collect/record physical evidence such as photographs/videos of the activities for their (student's) portfolio which will be useful for their placement interviews:

a) Make a survey on types of valves and pumps we use domestically.
b) Prepare a report on fluid flow through open channel in your city/village.
c) Draw and report water distribution system of chemical engineering department building.
d) Make a chart/poster on Mechanical seal and stuffing box.
e) Determine the energy consumption and efficiency of existing pumps of laboratory.
f) Collect different parts of various pumps from scrap yard.

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 are relatively simpler or descriptive are 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 are 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 a dated work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The duration of the microproject 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.

a) Prepare a model to demonstrate flow through open channels.
b) Prepare a chart on different types of vacuum pumps.
c) Prepare a chart on various types of manometers.
d) Prepare a power point presentation on classification and demonstration of valves.
e) Develop a friction factor chart experimentally.
f) Prepare a model/chart/poster on pneumatic and hydraulic conveying.
g) Prepare a chart that classifies fluid on various bases.
h) Prepare a power point presentation on blowers and compressors.
i) Prepare a power point presentation on classification and demonstration of flow measuring devices.
j) Prepare a power point presentation on various methods to join pipes and tubes.
k) Make a report on Cavitation, its identification and prevention.
l) Prepare a power point presentation pertaining to friction loss in fittings and valves.
m) Make a chart on selection criteria of pumps and valves.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Books	Author	Publication with place, year and ISBN
1	Unit Operations of ChemicalEngineering	McCabe, Warren L.,Julian C. Smith	McGraw Hill Publication, New York 2004 (Seventh Edition)
2	Introduction to ChemicalEngineering	L.Badger, Julius T. Banchero	McGraw Hill Publication, New York 2004 (Seventh Edition)
3	Unit Operations of Chemical Engineering Vol-I	Chattopadhyay, P.	Khanna Prakashan, New Delhi, 1996
4	A text book of Fluid Mechanics	Khurmi, R.S.	S. Chand Publication, New Delhi 2002
5	Unit Operation –I	Gavhane, K.A.	Nirali Prakashan, Pune 2009
6	A Textbook Of Fluid Mechanics And Hydraulic Machines	Dr. R. K. Bansal	Publisher: Laxmi Publications, 2005 ISBN 10: 8131808157 ISBN 13: 9788131808153
7	Fluid Mechanics: Fundamentals and Applications	John. M. Cimbala Yunus A. Cengel	McGraw Hill Publication, New York 2006 (1st edition) ISBN 0–07–247236–7

14. SUGGESTED LEARNING WEBSITES

a) https://ndl.iitkgp.ac.in/
b) https://www.vlab.co.in/
c) https://nptel.ac.in/
d) http://www.nzifst.org.nz/unitoperations/flfltheory.htm
e) https://www.slideshare.net/AjinkyaKhandizod/fluid-flow-operations-applications-of-fluid-mechanics-rheological-classifications-of-fluid

15. PO-COMPETENCY-CO MAPPING

Semester III	Fluid Flow Operation(4330502)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline-specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimen-tation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning

Competency	Use principles of Fluid Flow Operation in chemical engineering applications						
CO1. Calculate the pressure difference using fundamental concept of fluid statics and carry out dimensional analysis.	3	3	-	3	-	2	2
CO2. Solve various fluid flow problems using governing equations.	3	3	-	3	-	-	2
CO3. Calculate Friction losses from changes in velocity or direction	2	2	-	2	-	1	-
CO4.Understand the concept of fluidization.	2	-	-	2	-	1	-
CO5. Select the metering equipments and fluid moving machinery for appropriate chemical engineering operations	3	3	2	3	3	3	2

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

Sr. No.	Name and Designation	Institute	Contact No.	Email ID
1	Ms. Y S Patel Lecturer in Chemical Engg.	G P Gandhinagar		yaminipatel2016@gmail.com
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GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Process Calculation
(Course Code: 4330503)

Diploma programmer in which this course is offered	Semester in which offered
Chemical Engineering	Third

1. RATIONALE

Process calculation provides the fundamental information to determine the material and energy balances for all types of unit operations and unit processes across the equipment and overall chemical plant. Material and energy balance calculations are of prime importance for design and also for conservation of mass and energy to reduce the losses and cost that enhances overall economy of plant. The unit conversions, material and energy balance are the essential part in the practice of other courses such as mechanical operations, fluid flow, heat Transfer, mass transfer etc. Thus this course is a core course for chemical engineers and should be learned sincerely by students.

2. COMPETENCY

The purpose of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Determine material and energy balance for different unit operations and processes**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for theachievement of the following COs:

a) Apply stoichiometric principles for solving chemical engineering problems.
b) Calculate material balance for chemical process.
c) Calculate energy balance for chemical process.
d) Estimate amount of fuel and amount of air required for combustion process.

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	
4	0	0	4	30	70	0	0	100

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

Following practical outcomes (PrOs) are thesub-components of the Course Outcomes (Cos). Some of the **PrOs** marked **'*'** 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 Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	Not Applicable		

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*

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	Weightage in %
1	Question answer or Writing steps exercise	30
2	Executing of exercise	30
3	Result	40
		100

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specificationsfor the PrOsis a guide to procure them by the administrators to user in uniformity of practical's in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1.	Not Applicable	

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample***Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs andPrOs.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 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 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 **Unit Systems**	1a. Explain the importance of process calculation. 1b. Define different unit systems. 1c. Explain the importance of physical quantities of Units. 1d. Convert units among different systems.	1.1 Introduction to process calculation 1.2 Dimensions and systems of units 1.3 Fundamental quantities of units, Derived quantities 1.4 Definition and units of force, volume, pressure, work, energy, power, heat 1.5 Unit conversions in FPS, MKS and SI systems
Unit– II **Basic Chemical Calculations**	2a. Calculate important physical quantities. 2b. Calculate composition of mixtures and solutions.	2.1 Definition and calculations of mole, atomic weight, molecular weight, equivalent weight, specific gravity and API gravity 2.2 Expression of composition of mixtures and solutions 2.3 Morality, Normality, Morality, gm/lit and related simple numerical
Unit-III **Ideal Gas Law**	3a. Derive ideal gas law. 3b. State reference conditions. 3c. Calculate important quantities for ideal gas mixture.	3.1 Concept of ideal gas 3.2 Derivation of ideal gas law 3.3 STP and NTP conditions 3.4 Dalton's law, Amagat's law,Raoult's Law and Henry's Law 3.5 Relation between mole%, volume% and pressure% of ideal gases 3.6 Calculation of average molecular weight, density, mole%, weight% in gas mixture in SI/MKS systems
Unit– IV	4a. Explain law of conservation of mass.	4.1 Law of conversation of mass 4.2 Brief description and simple

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Material Balance In Processes Without Chemical Reactions	4b. Calculate mass balance of important unit operations at steady state condition. 4c. Describe purging, recycling and bypassing operations.	material balance calculation of drying, distillation, absorption, mixing, crystallization, evaporation 4.3 Single stage material balance calculation of leaching and extraction 4.4 Brief idea regarding recycling, purging and by passing operation
Unit– V **Material Balance In Processes Involving Chemical Reactions**	5a. Explain basic concepts of material balance with chemical reaction. 5b. Calculate mass balance with chemical reaction.	5.1 Definition: Limiting reactant, Excess reactant, conversion, yield and selectivity 5.2 Simple numerical for finding yield, conversion and composition 5.3 Simple calculation of material Balance based on reaction.
Unit– VI **Energy Balance**	6a. Calculate heat capacity, specific heat, heat capacity of gas mixture and liquid mixture. 6b. Explain concepts of sensible heat and latent heat. 6c. Calculate standard heat of formation and heat of reaction.	6.1 Heat capacity and specific heat 6.2 Mean heat capacity of gases 6.3 Heat capacity of gas mixture and liquid mixture 6.4 Calculations of heat capacity by integral equation up to three terms 6.5 Brief explanation of sensible and latent heat of fusion, sublimation, vaporization 6.6 Calculations of standard heat of formation from heat of combustion data 6.7 Calculations for heat of reaction from heat of formation and heat of combustion data 6.8 Hess's Law and calculations
Unit– VII **Combustion**	7a. Describe combustion. 7b. Describe calorific value. 7c. Calculate calorific value and air requirement for combustion.	7.1 Introduction of combustion 7.2 Types of fuels 7.3 Calorific values of fuels 7.4 Proximate and ultimate analysis of solid fuel 7.5 Numerical related to calorific values of fuel from composition 7.6 Numerical related to air Requirement and composition of flue gases.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks

1	**Unit Systems**	**4**	**2**	**2**	**2**	**06**
2	**Basic Chemical Calculations**	**7**	**2**	**2**	**4**	**08**
3	**Ideal Gas Law**	**7**	**2**	**2**	**4**	**08**
4	**Material Balance In Processes Without Chemical Reactions**	**10**	**0**	**6**	**7**	**13**
5	**Material Balance In Processes Involving Chemical Reactions**	**8**	**2**	**3**	**7**	**12**
6	**Energy Balance**	**12**	**2**	**4**	**8**	**14**
7	**Combustion**	**8**	**2**	**2**	**5**	**09**
TOTAL		**56**	**12**	**21**	**37**	**70**

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

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:

a) Group assignments based on mass and energy balance of equipments like heat exchanger, boilers, distillation column, evaporator, dryer, reactors, absorption column.
b) Use of MS-Excel in solving numerical.
c) Draw block diagram and write down overall and component material balance for various mass transfer operation and mechanical operations.

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/sub topics.
b) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4***means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) 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 assessedusing different assessment methods.
e) With respect to ***section No.10***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Guide students for reading data sheets.

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-projects

are 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 contribution 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:

a) Give a data of different unit operation and calculate material balance.
b) Give a data of different unit operation and calculate energy balance.
c) Prepare chart on molecular weight and equivalent weight.
d) Visit of chemical process plant: Prepare block diagram showing material balance for process equipment used in plant which you have visited.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Stoichiometry	B I Bhatt and S B Thakore	McGraw Hill Education; 5th edition (1 July 2017), ISBN: 978-0070681149
2	Basic Principles and Calculations in Chemical Engineering	Himmelablau David M.	PHI Learning, New Delhi, Year-2003, ISBN: 9789332549623
3	Stoichiometry and Process Calculations	Narayanan K.V. and Lakshmikutty B	PHI; 2nd edition,Year-2016ISBN: 8120352890
4	Introduction to Process Calculations (Stoichiometry)	K. A. Gavhane	NiraliPrakasan, Pune, 2015

14. SOFTWARE/LEARNING WEBSITES

- https://nptel.ac.in/courses/103103165
- Basic Principles & Calculations in Chemical Engg (CD Rom)
- https://www.unitoperation.com/

15. PO-COMPETENCY-CO MAPPING

Semester III	Process Calculation (Course Code : 4330503)
	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	**Test various electrical, electronic and pneumatic components and devices using relevant tools and instruments following safe work practices.**						
Course Outcomes CO 1) Apply stoichiometric principles for solving chemical engineering problems.	3	1	2	1	1	-	-
CO 2) Calculate material balance for chemical process.	3	3	3	2	1	-	-
CO 3) Calculate energy balance for chemical process.	3	2	3	2	1	-	1
CO 4) Estimate amount of fuel and amount of air required for combustion process.	3	2	3	2	1	-	1

*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.				

NITTTR Resource Persons

S. No.	Name and Designation	Department	Contact No.	Email
1.	Mr. Harsh B Shukla, Lecturer in K.J.Polytechnic, Bharuch	Chemical Engineering		shuklahb22@gmail.com
2.	Mr. Chetan Panchal, Lecturer in G.P. Gandhinagar	Chemical Engineering		chetanpanchal91@gmail.com

GUJARAT TECHNOLOGICAL UNIVERSITY(GTU)

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

CourseTitle: Chemical Process Technology
(Course Code: 4330504)

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

1. RATIONALE

The importance of this subject arises from the need of providing comprehensive and balanced understanding of essential link between chemistry and the chemical industry. It is vital to develop simple but meaningful flow diagram for each chemical product which a student can understand. This course develops skill for arranging and understanding treatment, reaction and separation steps in a flow diagram for variety of chemicals including acids, chloro-alkalis, fuels and industrial gases, cement, lime, polymer, dyes and intermediates, pharmaceutical, fermentation, pesticides, Soap and detergents, fertilizerand many other products. Diploma holders utilize this skill to read and recognize each steps of process flow diagrams during their job. The area of job may be production, R and D, design, technical services, project development, sales and marketing etc.

2. COMPETENCY

The course content should be taught and implemented with the aim to develop different types of skills leading to the achievement of the following competencies:

- Synthesize reactions and unit operations steps to develop and operate a chemical plant to manufacture important chemicals.

3. COURSEOUTCOMES(COs)

The practical exercises, the underpinning knowledge, and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

At the end of the course, a student will be able to

1) Explain the classification and properties of various chemicals
2) Apply concept of the manufacturing processes of various chemicals with neat sketch to operate chemical plant.
3) Identify major engineering problems encountered in manufacturing processes.
4) Suggest applications of various chemicals.

4. TEACHING AND EXAMINATION SCHEME

TeachingScheme (InHours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	-	2	4	30*	70	25	25	150

(*):Out of 30marks under the theory CA,10marks 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 theCOs.

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

5. SUGGESTEDPRACTICALEXERCISES

The following practical outcomes(PrOs) arethesubcomponents oftheCOs. *These PrOs need to be attained to achieve theCOs.*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Standardize Sulfuric Acid Solution	I	2
2	Preparation of Hydrated Lime	I	2
3	Preparation of Caustic Soda	I	2
4	Preparation of Potassium Chloride	I	2
5	Preparation of Phenol Formaldehyde	II	2
6	Find out Acid Value of Oil	III	2
7	Preparation of Vegetable Oil from Seed	III	2
8	Preparation of Soap	III	2
9	Preparation of Detergent Powder	III	2
10	Preparation of Alcohol	III	2
11	Find out moisture, volatile matter and ash content in fuel	IV	2
12	Determine Calorific Value of Fuel	IV	2
13	Preparation of Aspirin	V	2
14	Prepare of Nitrobenzene	V	2

Note

i. *More **Practical Exercises** can be designed and offered by the respective course teacher todevelop the industry-relevant skills/outcomes to match the COs. The above table is only a suggestive list. Course teacher can select any 14 practicals.*

i. *The f**ollowing are some sample**'Process'and'Product'related skills(more may be added/deleted depending on the course) with approximate percentage weightage that occur in the above listed **Practical Exercises** of this **course** required which are embedded inthe Cos and ultimately the competency.*

Sr.No.	*SamplePerformanceIndicatorsforthePrOs*	*Weightage in %(Approximate)*
1	*Prepare experimental set up accurately.*	*10*

2	*Use apparatus for precise measurement*s.	20
3	Practice and adapt good and safe measuring techniques.	10
4	Good Record keeping of the observations accurately.	20
5	Interpret the results and theirconclusion.	20
6	Prepare Report in prescribed format	10
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 procuremen to them by the administrators/management of the institutes.This will ensure the conduction of practice in All institutions across the state in a proper way so that the desired skills are developed in students.

Sr. No.	EquipmentNamewithBroadSpecifications	PrO.No.
1	**HotAirOven:** Temperature is controlled by digital temperature indicator cumcontroller from ambient to 250°C with ± 0.1°C Accuracy. Powersupply: 220/230V, 50Hz single phase, Capacity (Approx.): 50 – 100 liter, Type of Shelves: 03, Material of Inner Chambers: SS304, Material of Outer Chamber: MS with powder coated paint,MaterialofShelves:SS wire mesh.	All
2	**LaboratoryWeighingBalance:** Type of Laboratory Balance: Analytical, Sensitivity (mg): 1 mg,Maximum Capacity of weighing (grams): 200 g, Shape of PAN:Circular, PowerSupply: Single Phase,Display: LED.	All
3	**HotPlateWithMagneticStirrer:** NumberofstirringPositions:1,Calibration:AutomaticCalibration,Magnetic stirrer with a hot plate, Speed Control Accuracy of setspeed (+/-) (RPM): 5, Maximum Stirring capacity per position:3000ml,TopplateMaterial:Stainlesssteel	All
4	**Lab cooling bath**: 220V/50HZ, 1.5KW, 370*340*480mm	All
5	**Bomb calorimeter** Model CC01/M3,, Iso-Thermal, BS 1016: Part 5:1967 IS: 1359–1959 IP 12/63T	12
6	**Grinder**: 230V 50Hz, 950 W, 11000 rpm, 1.8 K	07
7	**Oil making machine :** 3-6 Kg/Hr, 600 W, Gear Box, 400x160x360mm	07
8	**Hand blender: 200w**	09
9	**Crucible and designator :** white ceramic melting crucible , Dish cup 55mm for high temperature refining,	11
10	**Furnace :** Digital Muffle Furnace, 220-230V, 900°C, 25x125x250mm	11

11	**Fermentator:** 22 x 40 x 38 cm (W x D x H), LDC 4 x 40 digits with backlight, Pyrex glass with 5 to 8 side necks (culture volumes from 35 ml to 6 l)	11

7. AFFECTIVE DOMAIN OUTCOMES

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

a) Work as a leader
b) Follow ethical practices
c) Observe safety measures
d) Good house keeping
e) Time management
f) Practice environmentally friendly methods and
g) processes.(Environment-related)

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

i. 'ValuingLevel'in1st year
ii. 'Organization Level'in2nd year.
iii. 'Characterization Level'in3rd year.

8. UNDERPINNINGTHEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom'staxonomy* that are formulated for development of theCOs 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	Unit Outcomes (UOs)	Topics and Sub-topics
Unit – I Inorganic Chemical Industries	1a. Classify Various Chemical Industries 1b. Describe Properties & Uses of Chemicals 1c. Prepare Flow Diagram and Explain Manufacturing Process 1d. Explain Major Engineering Problems	1.1 Classification of Chemical Industries 1.2 Physical Properties, Application, Manufacturing Process and Major Engineering Problem of 1.2.1 Sulphuric acid 1.2.2 Soda ash 1.2.3 Caustic soda 1.2.4 Cement 1.2.5 Lime 1.2.6 Urea 1.2.7 Elemental phosphorus 1.2.8 Potassium Chloride
Unit-II Polymer Industries	2a. Classify Polymer 2b. Explain application & uses of polymer 2c. Prepare Flow Diagram and Explain Manufacturing Process	2.1 Classification of Polymer 2.2 Explain Physical Properties, Application & Manufacturing Process of 2.2.1 Polyethylene 2.2.2 Styrene butadiene rubber

		2.2.3 Phenol formaldehyde
Unit -III Natural Product Industries	3a. Define fat and oil, carbohydrates, pulp & paper 3b. Describe physical properties of oil & fat 3c. Describe fermentation types 3d. Prepare Flow Diagram and Explain Manufacturing Process 3e. Explain Major Engineering Problems 3f. Explain Role of Biotechnology	3.1 Definition and Physical Properties of Fat & Oil 3.2 Manufacturing Process of Vegetable oil 3.3 Basics of Carbohydrates 3.5 Manufacturing Process of Sugar with Major Engineering Problem 3.6 Basics of Soap & Detergent 3.7 Manufacturing Process of 3.7.1 Soap 3.7.2 Detergent Powder 3.8 Definition of Pulp & Paper 3.9 Manufacturing Process of Pulp by Kraft Process with Major Engineering Problem 3.10 Manufacturing Process of Paper by Wet Process with Major Engineering Problem 3.11 Types of Fermentation 3.12 Manufacturing Process of Ethanol with Major Engineering Problem 3.13 Role of Biotechnology in Chemical Engineering
Unit –IV Fuel and Industrial Gases	4a. Classify, describe and uses of fuels 4b. Classify Coal 4c. Prepare Flow Diagram and Explain Manufacturing Process 4d. Explain Major Engineering Problems 4e. Describe Explosive and propellant 4f. Explain important of cryogenic technology in chemical engineering	4.1 Fuels: types, sources, uses 4.2 Classification of Coal 4.3 Important industrial gases 4.4 Manufacturing and major engineering problem of 4.4.1 Producer gas 4.4.2 Coke oven gas 4.5 Classify Explosive and propellant 4.6 Important of cryogenic technology in chemical engineering
Unit –V Synthetic Organic Chemical Industries	5a. Classify Pharmaceutical Drugs, Pesticides and Dyes 5b. Explain pesticides formulation 5c. Prepare Flow Diagram and Explain Manufacturing Process 5d. Explain Major Engineering Problems	5.1 Classification of pharmaceutical Drugs based on Their Uses with Examples 5.2 Manufacturing Process and Major Engineering Problem of 5.2.1 Penicilline 5.2.2 Aspirin 5.3 Classify pesticides 5.4 Pesticide formulation 5.5 Manufacturing Process and Major Engineering Problem of 5.5.1 Parathion 5.5.2 2-4 Dichlorophenoxy acetic acid

		5.6 Classification of Dyes 5.7 Manufacturing Process of Nitrobenzene 5.8 Manufacturing Process of Aniline by Reduction of Nitrobenzene

9. SUGGESTEDSPECIFICATIONTABLEFORQUESTIONPAPERDESIGN

UnitNo.	UnitTitle	TeachingHours	Distribution of TheoryMarks			
			R Level	U Level	A Level	TotalMarks
I	Inorganic Chemical Industries	09	04	07	04	15
II	Polymer Industries	05	02	03	03	08
III	Natural Product Industries	14	06	10	06	22
IV	Fuel and industrial gases	05	02	04	04	10
V	Synthetic Organic Chemical Industries	09	03	06	06	15
Total		**42**	**17**	**30**	**23**	**70**

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

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/questionsto assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels(of R, Uand A)in the question paper may slightly vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

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

a) Prepare a PowerPoint presentation or animation showing different types of chemical manufacturing Process
b) Prepare a model of different chemical product flow diagram
c) Preparation of a table showing the difference between Organic and Inorganic Compounds.
d) Market survey of different Chemical product and compare their physical and chemical properties.
e) Library survey regarding polymers and fertilizers in different industries.
f) Collect different polymers and prepare the chart/ PowerPoint based on their type,properties, and uses.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES(ifany)

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)inundertakingmicro-projects/activities.
c) Different types of teaching methods i.e. video demonstration, activity based learning,casestudy, m-learning need to be employed byteachers to develop the outcomes.
d) Some *of the topics/sub-topics* which are relatively simpler or descriptive are to begiven 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. SUGGESTEDMICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/heart the beginning of the semester.In the first four semesters,themicro-projectare 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.***

Themicro-projectcould beindustry application-based, internet-based, workshop-based, laboratory-based, or field-based. Each micro-project should encompass two or moreCOs which are the integration of PrOs, UOs, and ADOs. Each student will have to maintain a dated work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The duration of the microproject should be about **14-16** ***(fourteen to sixteen) student engagement hours*** during the course.The student sought to submit micro-project by the end of the semester (so that they develop industry-orientedCOs.

A suggestive listofmicro-projects is givenhere. This should relate highly to the competency of the course and theCOs.Similar micro-projects could be added by the concerned course teacher:

a) Prepare a chart of the properties of given product
b) Prepare a chart to demonstrate manufacturing process.
c) Prepare a report on major engineering problem of given manufacturing process
d) Prepare a chart of application of given products
e) Prepare a power pont presentation on a topic “List of chemicals manufacturing industries in India”
f) Prepare a PowerPoint presentation or animation showing different types of chemical manufacturing Process

13. SUGGESTEDLEARNINGRESOURCES

Sr. No.	Title ofBook	Author	Publication with the place,year,and ISBN

1	Outlines of Chemical Technology, 3rd edition	M. Gopala Rao, Marshall Sittig	Affiliated East West Press (Pvt) Ltd-New Delhi
2	Shreve's Chemical Process Industries, 5th edition	Austin G.T.	McGraw Hill publication – New Delhi
3	Chemical Technology – Vol. I and II, 2nd edition	G.N. Pandey and Shukla	Vani Books Company -Hyderabad
4	A Text Book on Petrochemicals, 2nd edition	Rao B. K. B.	Khanna Publishers –New Delhi

14. SUGGESTEDLEARNINGWEBSITES

1. http://www.epa.gov/sectors/sectorinfo/sectorprofiles/chemical.html
2. www.emis.vito.be/sites/default/Bref_**cement**_and_**lime_production**.pdf
3. www.docbrown.info/page04/Mextract.htm
4. http://www.contentshoppe.com/images/eLearning/sample2.swf
5. http://www.auroma.in/propertiescoal.pdf
6. www.naturalproductsexpoindia.com/
7. www.andritz.com/pulp-and-paper/pp-pulp-production.htm
8. ewww.linde-gas.com/en/products_and_supply/gases_fuel/index.htm
9. www.iisrp.com/WebPolymers/00Rubber_Intro.pdf
10. http://www.niehs.nih.gov/health/topics/agents/pesticides/

PO-COMPETENCY-COMAPPING

Semester III	**Chemical Process Technology (CourseCode: 4330504)**						
	Program Outcomes						
Competency &CourseOutcomes	**PO1 Basic& Discipline-specific knowledge**	**PO2 ProblemAnalysis**	**PO3 Design/development ofsolutions**	**PO4 EngineeringTools,Experimen-tation &Testing**	**PO5 Engineeringpractices forsociety,sustainability& environment**	**PO6 ProjectManagement**	**PO7 Life-longlearning**
CompetencyUseSynthesize reactions and unit operations steps to develop and operate a chemical plant to manufacture	3	2	-	2	2	2	1

important chemicals							
CourseOutcomes CO1:Explain the classification and properties of various chemicals	3	-	-	2	-	2	1
CO2:Apply concept of the manufacturing processes of various chemicals with neat sketch to operate chemical plant.	3	2	-	3	2	2	2
CO3:Identify major engineering problems encountered in manufacturing processes.	2	2	-	-	2	-	-
CO4:Suggest applications of various chemicals.	2	-	-	1	1	-	1

Legend:'**3'**forhigh,'**2**'formedium, **'1'**forlowand**'-'**forno correlationofeachCOwithPO.

COURSE CURRICULUM DEVELOPMENT COMMITTEEGTUResourcePersons

S. No.	Nameand Designation	Institute	ContactNo.	Email
1.	Mr. R P Hadiya Lecturer in chemical Engg	G P Rajkot	----	rphadiya@yahoo.co.in
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GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Plant Utilities
(Course Code: 4330505)

Diploma programmer in which this course is offered	Semester in which offered
Plant Utilities	Third

1. RATIONALE

Diploma chemical engineer has to ensure smooth and proper operation of utilities and auxiliaries' plants such as steam, compressed air, instrumental air, inert gases, DM water and chilled water. These utilities are essential for manufacturing different chemical products. Use of concept of energy efficiency and green chemistry are necessary for energy conservation in chemical plant for producing materials of desired quality and to maintain plant safety. Hence the course has been design to develop these competencies and its associated cognitive and effective domain learning outcomes.

2. COMPETENCY

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

- **Use different utilities in chemical process plants for various applications.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

a) Select Various Methods For Water Softening And Purification.
b) Explain Different Types of Steam Generators and Compressors along with their components.
c) Select Refrigeration For Various Applications.
d) Apply concepts of energy efficiency and green chemistry for conservation of utilities.

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	
2	0	0	2	30	70	0	0	100

(*): For this practical only course, 50 marks under the practical CA have two components i.e. the assessment of micro-project, which will be done out of 10 marks and the remaining 15

marks are for the assessment of practical. This is designed to facilitate attainment of COs holistically, as there is no theory ESE.

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

5. SUGGESTED PRACTICAL EXERCISES

Following practical outcomes (PrOs) are the sub-components of the Course Outcomes (Cos). Some of the **PrOs** marked **'*'** 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 Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	Not applicable		

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. Care must be taken in assigning and assessing study report as it is a first year study report. Study report, data collection and analysis report must be assigned in a group. Teacher has to discuss about type of data (which and why) before group start their market survey.

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipments with broad specifications for the PrOs is a guide to procure them by the administrators to user in uniformity of practical's in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1.	**Not applicable**	

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 course competency.

a) Follow ethical practices.
b) Practice good housekeeping.
c) Demonstrate working as a leader/a team member during brain storming.

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 Application level)	Topics and Sub-topics
Unit – I Water as Basic Utility	1.a Explain role of Utilities in Chemical Plant 1.a.1 List various utilities in chemical plant & uses 1.b List sources of Water 1.c Differentiate types of Water 1.d Compare Softening processes of water 1.e Explain the process of Purification of water. 1.f Classify conventional and green techniques for sterilization of water.	1.1 List and use of various utilities in chemical plant 1.2 Sources of water 1.3 Hard & Soft water 1.4 Boiler Feed water and demineralized water 1.5 Methods of water softening processes 1.5.1 Lime soda process (Hot & Cold) 1.5.2 Zeolite process 1.5.3 Ion exchange process 1.5.4 Phosphate process 1.6 Purification of water 1.6.1 Screening 1.6.2 Sedimentation 1.6.3 Coagulation 1.6.4 Filtration 1.6.5 Sterilization 1.7 Conventional techniques 1.7.1 Sterilization by chlorine 1.7.2 Sterilization using bleaching powder 1.7.3 Sterilization by chloramines solution 1.8 Green techniques 1.8.1 Sterilization using UV rays 1.8.2 Sterilization using Ozon

Unit	Unit Outcomes (UOs) (4 to 6 UOs at Application level)	Topics and Sub-topics
Unit – II Steam, Air & Inert Gases	2.a Explain uses of utilities like Steam, Air & Inert Gases 2.b Define properties of steam 2.c Label the different part of steam generator 2.d Classify steam generator 2.e Compare steam generators 2.f List the Factors affecting selection of Boiler 2.g Describe boiler accessories and mountings for improving efficiency and conservation of energy. 2.h Discuss utility air 2.i Describe the working principle, application of Air compressors – 2.i.1 Explain energy efficient alternative 2.j Describe properties of Inert gases	2.1 Use of Steam, Air & Inert Gases as utilities 2.2 Properties of steam 2.2.1 Enthalpy 2.2.2 Wet steam 2.2.3 Saturated Steam 2.2.4 Superheated steam 2.2.5 Specific volume of steam 2.3 Steam Generator : Classification, comparison , components, steam handling, condensate removal 2.4 Factors affecting selection of Boiler 2.5 Boiler Accessories and mountings 2.5.1 Air Pre heater 2.5.2 Super heater 2.5.3 Economizer 2.5.4 Steam trap 2.6 Utility air 2.6.1 Compressed Air 2.6.2 Blower Air 2.6.3 Fan Air 2.6.4 Instrumental air 2.7 Types of Air compressors 2.7.1 Reciprocating Air compressors 2.7.2 Rotary compressors 2.8 Energy efficient air compressor 2.8.1 Multistage compressors 2.9 Inert gas - Nitrogen, Argon
Unit – III Refrigeration	3.a Explain the working principle of Refrigeration 3.b Distinguish methods of Refrigeration 3.c Describe and TOR of refrigeration 3.d Use primary and secondary Refrigerants and list out green refrigerants 3.d.1 Explain advantages of green refrigerants over conventional refrigerants	3.1 Concept of refrigeration 3.2 Methods of Refrigeration 3.2.1 Ice Refrigeration 3.2.2 Evaporative Refrigeration 3.2.3 Vapor Refrigeration System 3.3 TOR of refrigeration 3.4 Types of Primary Refrigerants 3.4.1 Ammonia 3.4.2 Halo Carbons (Freon of Different type) 3.4.3 HFC (Hydro Fluorocarbon) 3.5 Types of secondary Refrigerants 3.5.1 Water 3.5.2 Brine 3.6 Selection of Refrigerants

***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 QUESTIONPAPER DESIGN

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Water as Basic Utility	10	10	10	6	26
II	Steam, Air & Inert Gases	12	10	10	9	29
III	Refrigeration	6	4	6	5	15
Total		**28**	**24**	**26**	**20**	**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:

a) Undertake micro-projects in team/individually.
b) Encourage Students for creating and designing water treatment processes using wastematerials.
c) 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.
e) 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 contribution in the project work and give a seminar presentation of it before submission. The duration of the microproject 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:

MICRO PROJECT 1: Identify sources of water at your college premises and measure thefollowing physical properties.

1. Measure temperature of water.
2. Measure TDS of water.
3. Measure pH of water.
4. Measure turbidity of water.

MIICRO PROJECT 2: Perform basic treatment techniques for purification of water.

MICRO PROJECT 3: Prepare 15-20 slides presentation showing classification of refrigeration & refrigerants.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Chemical Plant Utilities	Sathiyamoorthy-Manickkam	Lambert Academic Publishing;India, 2016, ISBN: 978-3-659-97828-9
2	Unit operation of Chemical Engineering	McCabe, Warren L., Julian C. Smith	McGraw Hill Publication; NewYork, 7th Edition, 2004
3	Plant utilities	D. B. Dhone	Nirali Prakashan; Pune, 2ndEdition, 2012
4	Power Plant Engineering	P.K. Nag	McGraw Hill Education; India,4th edition, 2017, ISBN: 978-9339204044
5	Thermal Engineering	R.S. Khurmi, J. K. Gupta	S. Chand Publishing; India, 2008, ISBN: 9788121925730
6	Thermal Engineering	R.K.Rajput	Laxmi Publications; India, 11thedition,

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
			2020, ISBN: 978-8131808047

14. SOFTWARE/LEARNING WEBSITES

a. https://nptel.ac.in/courses/112/107/112107291/
b. https://www.thermodyneboilers.com/economisers/
c. https://www.steamtrapefficiency.com/wp-content/uploads/BITHERM-STEAM-MANUAL.pdf
d. http://www.silbert.org/MSA_WT_Manual.pdf
e. http://ppuchem.blogspot.in/2013/02/unit-1-notes.html
f. https://booksite.elsevier.com/samplechapters/9780080966595/Chapter_3.pdf

15. PO-COMPETENCY-CO MAPPING

Semester-III	Plant Utilities (Course Code: 4330505)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ develop-ment of solutions	PO 4 Engineering Tools, Experimen-tation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Manage-ment	PO 7 Life-long learning
Competency	***Use different utilities in chemical process plants for various applications.***						
Course Outcomes CO a) Select Various Methods For Water Softening And Purification.	3	2	2	1	2	1	2
CO b) Explain Different Types of Steam Generators and Compressors along with their Components.	2	1	-	-	1	1	1
CO c) Select Refrigeration For Various Applications.	3	1	2	-	2	2	3
CO d) Apply concepts of energy efficiency and green chemistry	3	2	2	1	3	2	3

*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

Sr. No.	Name and Designation	Institute	Contact No.	Email
1.	Mr. P M Gadhiya	GOVERNMENT POLYTECHNIC RAJKOT		gadhiyapiyush53@gmai.com
2.	Mr. I P Dave	GOVERNMENT POLYTECHNIC RAJKOT		ipd.fetr@gmail.com

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)
Semester – IV

Course Title: Contributor Personality Development
(Course Code: 4340002)

Diploma programme in which this course is offered	Semester in which offered
All branches of Diploma Engineering	4th Semester

Type of course: Work-Personality Development

For Year: Pre-final year for all Diploma programs

Rationale: The Contributor Program aims to accomplish the following outcomes in the lives of students–

- Improve the employability of students by giving them the right work ethic and thinking that employers are looking for.
- Build their I-Can attitude and self-confidence for their career.
- Improve their ability to engage positively to handle the challenges in career and workplaces.
- Build long-term and sustainable view of success and career that will help them make sustainable choices in a volatile and changing world of work.
- Widen their choices of career and success, so that they are able to open up more opportunities for themselves and take up unconventional career pathways.
- Awaken their aspiration to develop as Contributors in their organizations and society.

The program is focused on building foundational career values and the self-esteem of students to contribute in today's world of work.

The Contributor Program syllabus has been evolved and fine-tuned over several years, to –

a) address the changing needs and contemporary challenges being faced by industry and what employers today are looking for in the people they hire.
b) working extensively with universities and students and an appreciation of their challenges and concerns.
c) guided by the higher ideas and principles of Practical Vedanta in work.

OVERALL TEACHING AND EXAMINATION SCHEME
FOR ALL DIPLOMA COURSES

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	
2	0	0	2	30	70	25	25	150

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
-	**30**	**30**	**10**	-	-

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note:
It is the responsibility of the institute heads that marks for PA of theory & ESE and PA of practical for each student are entered online into the GTU Portal at the end of each semester within the dates specified by GTU.

Note:
1. This subject is compulsory.
2. It will carry 2 credits.

COURSE FORMAT

Class Sessions:

- Students will have to attend 3 hours of discovery-based sessions, to build new models of thinking & capacities for every module. [i.e., total 18 hours of classroom sessions in the semester]
- They will work closely with their peers to discuss and understand these new models of thinking.
- Their learning will be facilitated by trained college faculty.
- They also go through standard end-of-module, live assessments in class via a Student App, for continuous assessment of learning, which will be used for the progressive assessment component.

Project work:

- Students will have to complete projects as part of Practical work. They have one project corresponding to each module. These projects help them apply contributor thinking into their careers and life. These also help them build their confidence to communicate, ability to do systematic research and present their thinking effectively.
- For the successful completion of projects:
    - Students will be given orientation to the project and systematic guidelines on how to conduct the project by their trained college faculty in a project orientation session.
    - The projects will be done in teams and will require research. It may also need field work.
    - Student teams present their projects in the classroom in project presentation sessions.

COURSE CONTENT:

MODULE		WHAT IS COVERED	Total Hrs.
1	Part 1: Developing self-efficacy and basic inner strength	**Who is a Contributor?** Students build a vision of who they can become as a 'Contributor' in their career. They gain clarity on expectations from the future workforce, and importance of being a contributor. This enables students to transform their expectation of themselves in their career and future work.	3 hrs Lab Sessions (discovery-based facilitator led)

2		**The 'creator approach' to life & challenges** In a "caged approach", we see the career environment as full of difficulties and hurdles. We feel powerless or blame our circumstances for not having many opportunities. This makes us fearful of uncertainty and makes us settle for jobs where we remain mediocre. In this topic, students discover the "creator approach" to challenges and situations. This helps them take ownership & responsibility to shape destiny, build a new future, find answers to challenges; and stop being complainers.	Same as above
3		**Develop yourself to succeed: The I CAN Approach** Students learn to develop an "I CAN" attitude to everything. This is the base that helps them develop a Growth Identity & builds their self-esteem step by step; making them ready to deal with the dynamic demands of the future workplace.	Same as above
4	Part 2: Building ability to make more effective career choices	**Achieving Sustainable Success in their career** Students discover how to achieve sustainable or lasting success, by making themselves success worthy. Where their focus shifts to building one's "engine of success" rather than being focused on chasing the "fruits of success". This is important, because over a lifetime of work, all people go through ups and downs – where the fruits are not in their control. People who are focused on the fruits of success fall prey to disappointment, loss in motivation, quitting too early, trying to find shortcuts – when fruits don't come. Whereas people focused on building their engine of success continue to contribute steadily, irrespective of whether fruits come or not. This helps them make better choices in life, that leads to steady success & long-term career fulfillment in an uncertain world.	Same as above
5		**Career Development Pathways open to us** In this topic, students explore a range of diverse "career development models" and the possibilities for contribution that each opens up for them. This helps them open up hidden opportunities that such an environment offers. And free themselves from a herd mentality when making career	Same as above

		choices.	
6		**Unleashing our Power to Contribute** In this topic, students learn how to expand the contribution possible in any role they play. This helps them take charge of their own career growth & discover their power to contribute in any role or job.	Same as above
Project work		Project Assignments are given corresponding to each of the six topics. These projects require research and field work beyond the classroom that students are expected to do.	Beyond classroom, with student presentations in the class

Reference resources:

A. Basic reference for both students and teachers –

1. Student Resources for study comprising of key ideas learnt in the classroom in each topic and additional references to videos, articles etc. from the internet for continued exploration. These resources are made available via the Student App.
2. In-class Assessment Quizzes for each of the 6 modules that students do via the Student App.
3. Structured classroom presentations that teachers use to conduct classes systematically. This is provided via a digital delivery platform (only for teachers).
4. Guides and preparation material to help teachers prepare for the classroom sessions. This is also provided via the digital delivery platform.
5. Project Guides and support materials provided via the digital delivery platform and the Student App.

These will be made available by Illumine (www.illumine.in), Knowledge Partner for the Contributor Program.

B. Advanced reference for teachers –

1. On Contributors, Srinivas V.; Illumine Ideas, 2011
2. Awaken the Contributor Within (Contributor Ethic), Srinivas V.; Illumine Ideas, 2019
3. Becoming a Contributor Teacher (Contributor Ethic), Srinivas V.; Illumine Ideas, 2018
4. Reclaiming our intentionality: from “victims” to “creators of our destiny” (Design of Life), Srinivas V.; Illumine Ideas, 2016.
5. Examining our motives of work: can we ask more out of ourselves? (Design of Life), Srinivas V.; Illumine Ideas, 2016.
6. Building a Contributor Ethic in Organizations, Srinivas V.; Illumine Ideas, 2019.
7. Enlightened Citizenship and Democracy; Swami Ranganathananda, Bharatiya Vidya Bhavan, 1989
8. Eternal Values for a Changing Society – Vol I-IV, Swami Ranganathananda; Bharatiya Vidya Bhavan

9. Karma Yoga, Swami Vivekananda; Advaita Ashrama
10. Six Pillars of Self Esteem, Nathaniel Branden; Bantam, 1995
11. Mindset: The New Psychology of Success, Carol S. Dweck; Random House Publishing Group, 2007
12. Lasting Contribution: How to Think, Plan, and Act to Accomplish Meaningful Work, Tad Waddington; Agate Publishing, 2007
13. Why not? how to use everyday ingenuity to solve problems big and small, Barry Nalebuff, Ian Ayres; Harvard Business School Press, 2003
14. The value mindset: returning to the first principles of capitalist enterprise (Ch 8 & 9); Erik Stern, Mike Hutchinson; John Wiley and Sons, 2004
15. The Power of Full Engagement: Managing Energy, Not Time, is the Key to High Performance and Personal Renewal, Jim Loehr, Tony Schwartz; Simon and Schuster, 2003
16. Responsibility at work: how leading professionals act (or don't act) responsibly, Howard Gardner; John Wiley & Sons, 2007

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
Outcome of class sessions		
CO-1	Students are able to recognize the work ideal of a Contributor in terms of their motives for working and approach to work. They appreciate the value and importance of becoming Contributors in today's context.	10-12%
CO-2	Students are able to recognize & appreciate a "caged" approach as distinct from a "creator" approach in the way people deal with challenges and situations; and learn ways to develop a creator approach.	10-12%
CO-3	Students are able to recognize an "I Can" approach or way of thinking in situations. They learn how to apply this thinking to systematically develop themselves and their self-confidence in any area they choose.	10-12%
CO-4	Students are able to widen their understanding of success, that will help them make more sustainable career choices.	10-12%
CO-5	Students are able to recognize & appreciate different career development pathways and their value; to open up different career possibilities for themselves.	10-12%
CO-6	Students are able to recognize that any role has the potential for contribution. And they learn how to systematically expand the contributions and impact they can make in any role.	10-12%
Outcome of practical /project sessions		
	Students learn to apply the new thinking in the real world context	30%

EXAMINATION PATTERN:

End Semester Examination Pattern:

1.0 The final examination will cover all six modules included in the course content.

2.0 The examination is largely understanding and application oriented. Thus, a thorough appreciation of the key concepts of the course to recognize contributor thinking and application of the concepts in everyday life & work context, will help students to do well in the examination.

3.0 The examination paper will have ~30 questions and is to be completed in 1 ½ hours.

4.0 All questions are compulsory.

5.0 Pattern of questions –

- There are four sections in the question paper.
- All questions are in multiple-choice format (MCQ).
- The questions are in the form of scenarios / situations giving options. The student is expected to choose one option out of the given options.

6.0 The total number of marks is **70 marks**. The No. of questions and maximum marks per section is given below:

Section	Type of questions & No. of questions	Marking scheme
Section A	Case with 4 MCQs (with 2 or 3 options each). Student has to choose only one option.	2 questions x 3 marks each 2 questions x 2 marks each Max. marks = 10 marks Min. marks = zero
Section B	10 MCQs (with two valid options each). Student has to choose only one option.	10 questions x 2 marks each Max. marks = 20 marks Min. marks = zero
Section C	5 MCQs (with 3 or 4 options each). Student has to prioritize/ rank the statements & choose only one option that is closest to their ranking or priority-combination.	5 questions x 2 marks each Max. marks = 10 marks Min. marks = zero
Section D	10 MCQs (with 3 options each). Student has to choose only one option.	10 questions x 3 marks each Max. marks = 30 marks Min. marks = 10 marks

Sample Question Paper Pattern:

Section A

Instructions: This section has a scenario. Read carefully before answering the subsequent questions. There are 4 questions in this section. All questions are compulsory. Each question has 3 or 2 options. Choose ONLY ONE option which you consider the most appropriate option. Read carefully before answering.

Maximum Marks: 10

E-retailer Flipkart has announced that it will use the services of Dabbawalas of Mumbai for delivering goods to customers.

The Dabbawalas have been in the profession of transporting lunch boxes with absolute accuracy for more than 120 years. Their unique delivery system has been smooth, and reliable under all conditions. Their business involves no paper or administrative team. This helps in keeping the costs down.

However the Dabbawalas are not technology savvy which can be a problem for Flipkart.

1. The biggest advantage of this partnership is that… *[3 marks]*

a] …it will reduce Flipkart's cost of delivery significantly.
b] …it is an unusual and beneficial partnership for all concerned.
c] …it will give Dabbawalas additional income.

2. Suppose a partnership fails, your learning from it would be… *[2 marks]*
   a] These things happen, don't think about it but go forward.
   b] I need to think through more carefully whom to partner with and how we work together.

Section B

Instructions: There are 10 questions in this section. All questions are compulsory. Each question has 2 statements. Select ONLY ONE statement you feel is closest to your thinking and mark it on the answer sheet given to you.

[10 Qs x 2 marks = max. marks 20]

3. An astronomer made a discovery of a new planet at a unique location in the galaxy after several years of work. This helped prove and support an already well-established theory in Physics. Will the astronomer be called a Contributor?
   a] No, not a contributor, as finally his work led to nothing substantial (the theory was already well established).
   b] Yes, he is a Contributor because he continued for long and didn't give up so that he could make a discovery.

4. a] "I won the 'Best Athlete Award' last year. I should practice well enough to win it again this year."
   b] "I won the 'Best Athlete Award' last year. For this year's sports day, I should practice to improve my stamina and speed."

Section C

Instructions: This section will have 5 questions. All questions are compulsory. Each question has some statements with a unique number (e.g. 1, 2, 3, 4) and 3 or 4 options (e.g. a, b, c, d). Each option is either a combination of statements or a specific order of the statements. Choose ONLY ONE option closest to your thinking and mark it on the answer sheet given to you.

[5 Qs x 2 marks = max. marks 10]

5. What makes a project successful? *(Rank in the order of most likely to least likely option)*
   1. An inspiring team leader who can delegate jobs to his team.
   2. Hardworking team members who complete the tasks which are assigned to them.
   3. A team who believes the project should be successful.
   4. People who think like a 'team'.

   a] 4-3-2-1 b] 2-1-4-3 c] 2-1-3-4 d] 4-3-1-2

6. What are the different I CANs required to crack a job interview?
    1. I CAN learn to articulate my thoughts in a better manner
    2. I CAN overcome the fear of others judging me
    3. I CAN train myself to build my stamina
    4. I CAN think calmly to answer difficult questions

    a] 1, 2, 3 b] 1, 2, 4 c] 1, 3, 4 d] 2, 3, 4

Section D

Instructions: There are 10 questions in this section. All questions are compulsory. Each question has 3 options. Select ONLY ONE option you feel is the most appropriate and mark it on the answer sheet given to you.

[10 Qs x 3 marks = max. marks 30]

7. Which is a Contribution to Self, that a football player can make in his role?
    a] Asking for personalized attention from the coach and better opportunities to prove himself in the team.
    b] Improving his dribbling and passing techniques and his ability to work in smooth co-ordination with other players
    c] Winning more matches and increasing the number of goals scored by him in different matches.

8. Vaibhav, a mechanical engineering student, guides his classmates in completing their lab and group project work, gives regular updates on the progress to the teacher and works with everyone so that the journals of the entire class are submitted in time for external evaluation. What roles is Vaibhav playing in his college/class?
    a] Student leader, friend, role model
    b] Student, classmate, class representative
    c] Student, mentor, coordinator, representative of the class, assisting the teacher

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Semester – IV

Course Title: Integrated Personality Development Course
(Course Code: 4340003)

Diploma programme in which this course is offered	Semester in which offered
All branches of Diploma Engineering	4th Semester

1. TYPE OF COURSE

Value-based holistic personality development course for university students.

2. RATIONALE

IPDC aims to prepare students for the modern challenges they face in their daily lives. Promoting fortitude in the face of failures, unity amongst family discord, self-discipline amidst distractions, and many more priceless lessons. The course focuses on morality and character development at the core of student growth, to enable students to become self-aware, sincere, and successful in their many roles - as an ambitious student, reliable employee, caring family member, and considerate citizen.

3. COURSE OUTCOMES

- To provide students with a holistic value-based education that will enable them to be successful in their academic, professional, and social lives.
- To give the students the tools to develop effective habits, promote personal growth, and improve their wellbeing, stability, and productivity.
- To allow students to establish a stronger connection with their family through critical thinking and devolvement of qualities such as unity, forgiveness, empathy, and effective communication.
- To provide students with soft skills that complement their hard skills, making them more marketable when entering the workforce.
- To enhance awareness of India’s glory and global values, and to create considerate citizens who strive for the betterment of their family, college, workforce, and nation.
- To inspire students to strive for a higher sense of character by learning from role models who have lived principled, disciplined, and value-based lives.

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	
2	0	0	2	30	70	25	25	150

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

5. COURSE-CONTENT:

Each lecture can be taken in a continuous two-hour session, or in two separate one-hour sessions. In addition to the core lectures, an induction and concluding lectures are recommended as shown in the below table.

Lecture No.	Module & Subject	Subject Description	Hours
IPDC-1 (First Phase/Semester)			
Intro-duction	The Need for Values	Students will learn about the need for values as part of their holistic development to become successful in their many roles - as ambitious students, reliable employees, caring family members, and considerate citizens.	2
1	**Module:** Remaking Yourself **Subject :** Restructuring Yourself	Students learn how self-improvement enables them to secure a bright future for themselves. They will learn 6 powerful thought-processes that can develop their physical, intellectual, emotional, and spiritual quotients.	2
2	**Module:** Remaking Yourself **Subject :** Power of Habit	Students will undergo a study of how habits work, the habits of successful professionals, and the practical techniques that can be used to develop good habits in their life.	2
3	**Module:** Learning from Legends **Subject :** Tendulkar & Tata	Students will learn from the inspirational lives of India's two legends, Sachin Tendulkar and Ratan Tata. They will implement these lessons through relatable case studies.	2
4	**Module:** From House to Home **Subject :** Listening & Understanding	Active listening is an essential part of academic progress and communications. Students will learn to listen with their eyes, ears, mind, and heart.	2
5	**Module:** Facing Failures **Subject :** Welcoming	This lecture enables students to revisit the way in which they approach challenges. Through the study of successful figures	2

	Challenges	such as Disney, Lincoln and Bachchan, students will learn to face difficulties through a positive perspective.	
6	**Module:** Facing Failures **Subject :** Significance of Failures	Failure is a student's daily source of fear, negativity, and depression. Students will be given the constructive skills to understand failure as formative learning experiences.	2
7	**Module:** My India My Pride **Subject :** Glorious Past - Part 1	India's ancient Rishis, scholars, and intellectuals have made tremendous contributions to the world, they developed an advanced, sophisticated culture and civilization which began thousands of years ago. Students will learn the importance of studying India's glorious past so that they could develop a strong passion and pride for our nation.	2
8	**Module:** My India My Pride **Subject :** Glorious Past - Part 2	Our ancient concepts can be used to seek revolutionary ideas and to generate inspiration. Students will develop a deeper interest in India's Glorious Past – by appreciating the need to read about it, research it, write about it, and share it.	2
9	**Module:** Learning from Legends **Subject :** A.P.J. Abdul Kalam	Dr Kalam's inspirational life displayed legendary qualities which apply to students (1) Dare to Dream (2) Work Hard (3) Get Good Guidance (4) Humility (5) Use Your Talents for the Benefit of Others	2
10	**Module:** Soft Skills **Subject :** Networking & Leadership	Students are taught the means of building a professional network and developing a leadership attitude.	2
11	**Module:** Soft Skills **Subject :** Project Management	Students will learn the secrets of project management through the Akshardham case study. They will then practice these skills through an activity relevant to student life.	2
12	**Module:** Remaking Yourself **Subject :** Handling Social Media	Students will learn how social media can become addictive and they will imbibe simple methods to take back control.	2
13	**Module:** Facing Failures **Subject :** Power of Faith	Students will learn about the power and necessity of faith in our daily lives.	2
14	**Module:** From House to Home **Subject :** Bonding the Family	Students will understand the importance of strong family relationships. They will learn how to overcome the generation gap and connect with their family more.	2

15	**Module:** Selfless Service **Subject :** Seva	Students will learn that performing seva is beneficial to one's health, wellbeing, and happiness. It also benefits and inspires others.	2

6. COURSE MATERIAL / MAIN COURSE WORKBOOK:

Workbook will be designed and presented by IPDC Team. These official workbooks would be the course-material for study of IPDC. These workbooks will solve the purpose of study, submission, viva and exams for students.

IPDC Workbook-1 (*published by Swaminarayan Aksharpith)*

7. IPDC REFERENCES:

These are the reference material for the IPDC lectures. This is not compulsory reading for the students as the essential information is contained in the workbook.

Module No.	Module	References
1	Facing Failures	1. Thomas Edison's factory burns down, New York Times Archives, Page 1, 10/12/1914 2. Lincoln Financial Foundation, Abraham Lincoln's "Failures": Critiques, Forgotten Books, 2017 3. J.K. Rowling Harvard Commencement Speech | Harvard University Commencement, 2008 4. Born Again on the Mountain: A Story of Losing Everything and Finding It Back, Arunima Sinha, Penguin, 2014 5. Failing Forward: Turning Mistakes Into Stepping Stones for Success, John C. Maxwell, Thomas Nelson, 2007 6. Steve Jobs: The Exclusive Biography Paperback, Walter Isaacson, Abacus, 2015 7. Failing Forward: Turning Mistakes Into Stepping Stones for Success, John C. Maxwell, Thomas Nelson, 2007
2	Learning from Legends	1. Chase Your Dreams: My Autobiography, Sachin Tendulkar, Hachette India, 2017 2. Playing It My Way: My Autobiography, Sachin Tendulkar, Hodder & Stoughton, 2014 3. The Wit and Wisdom of Ratan Tata, Ratan Tata, Hay House, 2018 4. The Tata Group: From Torchbearers to Trailblazers, Shashank Shah, Penguin Portfolio, 2018 5. The Leader Who Had No Title, Robin Sharma, Jaico Publishing House, 2010 6. In the Joy of Others: A Life-Sketch of Pramukh Swami Maharaj, Mohanlal Patel and BAPS Sadhus, Swaminarayan Aksharpith, 2013

3	My India My Pride	1. Rishis, Mystics, and Heroes of India, Sadhu Mukundcharandas, Swaminarayan Aksharpith, 2011 2. Physics in Ancient India, Narayan Dongre, Shankar Nene, National Book Trust, 2016 3. The Rise of Civilization in India and Pakistan, Raymond Allchin, Bridget Allchin, Cambridge University Press, 1982 4. The Āryabhaṭīya of Āryabhaṭa: An Ancient Indian Work on Mathematics and Astronomy (1930), Walter Eugene Clark, University of Chicago Press, reprint, Kessinger Publishing, 2006
4	Remaking Yourself	1. Power of Habit, Charles Duhigg, Random House Trade Paperbacks, 2014 2. Change Your Habit, Change Your Life, Tom Corley, North Loop Books, 2016 3. The Seven Habits of Highly Effective People, Stephen Covey, Simon & Schuster, 2013 4. Seven Habits of Highly Effective Teens, Sean Covey, Simon & Schuster, 2012 5. Atomic Habits, James Clear, Random House, 2018 6. How a handful of tech companies control billions of minds every day, Tristan Harris, TED Talk, 2017
5	From House to Home	1. "What Makes a Good Life? Lessons from the Longest Study on Happiness", R. Waldinger, Ted Talks, 2015 2. Long Walk To Freedom, Nelson Mandela, Back Bay Books, 1995 3. Outliers, Malcolm Gladwell, Back Bay Books, 2011
6	Soft Skills	1. The 17 Indisputable Laws of Teamwork, John Maxwell, HarperCollins, 2013 2. Team of Teams: New Rules of Engagement for a Complex World, Stanley McChrystal, Portfolio, 2015 3. Predictably Irrational, Revised and Expanded Edition: The Hidden Forces That Shape Our Decisions, Dan Ariely, Harper Perennial, 2010
7	Selfless Service	1. Open: An Autobiography, Andre Agassi, Vintage, 10 August 2010 2. The Physiological Power of Altruism [online], James Hamblin, The Atlantic, December 30, 2015, https://www.theatlantic.com/health/archive/2015/12/altruism-for-a-better-body/422280/ [last accessed June 10, 2020] 3. TBI Blogs: From Entrepreneurs to Doorkeepers, Everybody Serves with Love & Warmth at This Ahmedabad Café [online], The People Place Project, The Better India, May 29, 2017, https://www.thebetterindia.com/102551/small-way-serve-ahmedabad-seva-cafe/, [last accessed June 10, 2020]

GUJARATTECHNOLOGICALUNIVERSITY (GTU)

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

Course Title: Process Heat Transfer
(Course Code: 4340501)

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	4thSemester

1. RATIONALE

In almost every chemical plant heat transfer takes place (sometimes it is intentional while sometimes it is unintentional). Study of heat transfer at steady state and unsteady state is therefore important. The knowledge of the basic concepts and principles of heat transfer helps smooth and proper operation of various heat exchangers, evaporators and condensers. Using the concepts of conduction, convection and radiation heat losses through pipes, equipments and storage tanks can be estimated. Hence the course has been designed to develop this competency and its associated cognitive, practical and affective domain learning outcomes

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:

- **Use principles of heat transfer operations for safe, reliable and efficient operation of chemical plant.**

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:

a) Classify modes of heat transfer, steady state, unsteady state and types of heat transfer equipment.
b) Apply laws of heat transfer to various chemical engineering problems without phase change.
c) Apply principles of heat transfer with phase change and dimensionless group.
d) Estimate the design parameters for heat transfer equipment.

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	Determine the thermal conductivity of Metal Rod	II	4
2	Determine the thermal conductivity of concentric sphere **OR** Determine the thermal conductivity of non-metal (solids)(Insulating Material).	II	4
3	To determine the thermal conductivity of given liquid.	II	4
4	Determine the thermal conductivity of composite wall	II	4
5	Determine critical radius of insulating material	II	4
6	Determine the specific heat of Air by forced convection.	III	4
7	To determine convective heat transfer coefficient in natural convection.	III	4
8	To determine convective heat transfer coefficient in forced convection.	III	4
9	To Measure the Emissivity of the Test plate Surface.	IV	4
10	To determine the value of Stefan Boltzmann constant for radiation heat transfer	IV	4
11	To study the phenomenon of boiling heat transfer and to plot the graph of heat flux versus temperature difference. (Critical Heat Flux Apparatus)	V	4
12	To determine overall heat transfer coefficients obtained by operating the double pipe heat exchanger	VI	4
13	To determine LMTD of the heat exchanger under parallel and counter Flow arrangement.	VI	4
14	To calculate the overall heat transfer coefficient of the shell and tube heat exchanger	VI	4
15	Determine economy of open pan evaporator.	VII	4
16	Study and compare different types of Evaporators.	VII	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 of them by the administrators/management of the institutes. This will ensure the conduction Of practice in all institutions across the state in a proper way so that the desired skills are developed in students.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	T**hermal conductivity metal rod apparatus** : Bar-445 mm, Dia 25mm, test length of bar 175 mm, 9 thermocouples on bar and 4 on insulation, Ni-chrome heater 400 watt, Cooling jacket 90 mm dia, Temp. Indicator 0-200˚C, V-meter 0-200 V, A-meter 0-2 Amp	1
2	**Thermal Conductivity Of nonmetal apparatus:**, Dia 25mm, test length of bar 175 mm, 9 thermocouples on bar and 4 on insulation, Ni-chrome heater 400 watt, Cooling jacket 90 mm dia, Temp. Indicator 0-200˚C, V-meter 0-200 V, A-meter 0-2 Amp	2
3	**Thermal conductivity of liquid:** The aluminum cylinder is of size 100 mm in diameter and 100 mm in length. The thermocouples are placed to measure the oil temperature at intervals of 25 mm. The outer surface is properly insulated to avoid heat loss.	3
4	**Thermal conductivity composite wall apparatus :** Heater Assembly-1000W, Round coil, Sandwiched, Dia-300mm; Test Specimen-Dia. 300mm, MS 20mm, Asbestos 15 mm, Wood 10mm; 8 nos. J type thermocouple, 8 Channel Digital Temperature Indicator; Assembly shall be covered with Wooden Chamber	4
5	**Critical radius of insulating material apparatus :** Heater 500 W Ni-Cr 500 mm length, Test specimen MS, Dia 50 mm,500mm; Insulation over pipe; J thermocouple 12 nos., Digital temperature Indicator; The whole assembly shall be covered with wooden chamber	5
6	**Specific heat of air apparatus :** 2 inch Cylindrical test section, 0.5 HP air blower, 3 phase 440 V Air heater, U-tube manometer with orifice; Thermocouples	6
7	**Heat transfer coefficient in natural convection:** metallic tube of diameter (d) 45 mm and length (L) 450mm with an electrical heater coil along the axis of the tube. Seven thermocouples are fixed on the tube surface. Control panel instrumentation consists of multichannel digital display	7
8	**Heat transfer coefficient in forced convection:** O.D. of the pipe, Do = 38 mm I.D. of the pipe, Di = 35 mm Length of test section, L = 400 mm, Orifice diameter, d= 20 mm, Duct size = 150 mm x 100 mm, Coefficient of discharge= 0.62	8
9	**Emissivity apparatus: A**luminium plates, of equal dimensions. Ni-Cr heaters sandwiched in Mica sheets one plate blackbody another natural finish, Dia. 160 mm, thickness 12mm, heater 500W, Digital temp. Indicator	9

10	**Stefan Boltzmann apparatus :**Copper hemispherical enclosure, Non-conducting base plate made of asbestos, Thermocouples, iron – constantan type to measures temperature on the copper hemisphere T1 and T2 on the disc and T3 on specimen and T4 of hot water, Disc mounted in insulated Bakelite sleeve, made of aluminum.	10
11	**Critical Heat Flux Apparatus:** Length of Ni-chrome wire, L = 40 mm. Diameter of Ni-chrome wire, D - 0.25 mm (33 gauge) Distilled water quantity = 4 liters, Thermometer range- 0 to 100˚C, Heating coil capacity (bulk water heater)= 2 kw	11
12	**Double pipe heat exchanger :** Inner tube SS304 -1000mm × 25mm; Outer tube – SS304, 1000mm × 25mm, 25 mm glass wool with SS304 cover; Hot and cold water tanks - inner SS304, outer MS, 50Litre, Cold water tank, Heater 3 KW; Pumps -2 nos. mono block 0.5 HP SS304; Rota meter – 1-10 lpm, Glass tube, float SS 316	12
13	**Shell and tube heat exchanger :** 1-1 pass; Shell- ID 150 mm SS, 4 baffles with 180 mm spacing, glass wool insulation, Tubes – copper 19 nos., ID 9.5 mm, 900 mm Length; Tanks -2 nos.100 liter HDPE; Pumps- 0.25 HP; Rota meters – 2nos. 1.5-15 lpm; Thermocouple -4 Nos., Digital temp. Indicator – 0-100˚C	13,14
14	**Open Pan Evaporator :** Pan-Hemispherical SS 304 500mm dia, 3mm thick, Jacket- MS 525 mm dia, 3mm thick; Lagging- glass wool 40 mm with SS sheet cladding, 12.5 mm steam trap.	15

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. UNDER PINNING 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(Course Outcomes in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
Unit – I Fundamental of Heat Transfer	1a. Define Heat Transfer & Process Heat Transfer with its' importance	1.1 Definition and importance of process heat transfer
	1b. Classify Modes of heat transfer and describe laws of heat transfer	1.2 Basic modes of heat transfer and the laws governing (a) Conduction (b) Convection (c) Radiation 1.2.1 Thermal conductance and thermal resistance, (a) conductive (b) Convective (c) radiative
	1c. Differentiate steady state and unsteady state heat transfer	1.3 Steady state and unsteady state heat transfer
Unit – II Heat Transfer by Conduction	2a. Explain Concept of heat conduction	2.1 Concept of heat conduction
	2b. Describe Fourier's Law	2.2 Fourier's law of heat conduction
	2c. Describe thermal conductivity and define Thermal storage capacity and Thermal Diffusivity	2.2 concept of Thermal conductivity, Thermal storage capacity and Thermal Diffusivity
	2d. Derive equations of steady state Heat conduction through composite wall, through composite cylinder and through composite sphere,	2.3 One dimensional Steady state conduction through (a) plane and composite wall (b) plane and composite cylinder (c) plane and composite sphere
	2e. Calculate heat transfer rate	2.4 Simple problems of conduction
	2f. Describe Thermal insulation	2.5 Thermal Insulation 2.5.1 Optimum thickness of insulation
	2g. Calculate critical radius of insulation	2.6 Derivation of equation for critical radius of insulation
	2h. Explain Extended surface - fins	2.7 Extended surface - fins 2.7.1 types of extended surface
Unit – III Heat Transfer by Convection	3a. Describe types of convection	3.1 Types of Convection (a) Free convection (Natural convection) (b) Force convection
	3b. Explain Newton's Law	3.2 Newton's Law of convective heat transfer
	3c. Derive equation of overall heat transfer coefficient	3.3 Individual and Overall heat transfer coefficient
	3d. Explain dimensionless groups	3.4 Significance of dimensionless groups (a) Prandtl No. (b) Reynold No. (c) Grashoff No. (d) Nusselt No.
	3e. Calculation for convection	3.5 Simple Problems of Convection

Unit – IV Heat Transfer by Thermal Radiation	4a. Explain radiation facts	4.1 Fundamental facts of radiation
	4b. Define radiation terms	4.2 Concepts of thermal radiation (a) Absorptivity (b) reflectivity (c) Transmittivity (d) Emissive power (e) Black body (f) Gray body (g) White body (h) Opaque body (i) Monochromatic wave length (j) Emissivity
	4c. Describe radiation laws	4.3 Radiation laws (a) Stefan Boltzmann Law (b) Wien's displacement law (c) Kirchhoff's Law (d) Plank's Law
	4d. Calculate radiation based on radiation laws	4.4 Simple calculations of radiation
Unit – V Heat Transfer with Phase Change	5a. Explain heat transfer with phase change	5.1 Heat transfer with phase change
	5b. Describe boiling	5.2 Phenomena of Boiling 5.2.1 Pool boiling
	5c. Describe condensation and condensers	5.3 Phenomena of Condensation (a) Drop wise and film wise Condensation
Unit – VI Heat exchangers	6a. Classify heat exchanger	6.1 Types of heat exchanger based on flow pattern, function and construction
	6b. Describe Double pipe heat exchanger	6.2 Double pipe heat exchanger
	6c. Explain shell and tube heat exchangers and its components	6.3. Shell and tube heat exchanger
	6d. Describe plate type heat exchanger	6.4 Plate type heat exchanger
	6e. Derive equation and Calculate L.M.T.D.	6.5 L.M.T.D. : derivation of equation and simple calculations (a) Counter current (b) Co-current 6.6 L.M.T.D correction factors.
	6f. Calculate overall heat transfer co-efficient	6.7 Overall heat transfer co-efficient of heat exchangers 6.8 Effect of scale formation.
Unit – VII Evaporation	7a. Define evaporation	7.1 Introduction of evaporation
	7b. Explain characteristics of liquid	7.2 Characteristics of liquid for evaporation
	7c. Explain evaporator capacity	7.3 Evaporator capacity and economy
	7d. Describe boiling point elevation and duhring's rule	7.4 Boiling point elevation and duhring's rule
	7e. Differentiate single and multi-effect evaporation	7.5 Single and multi effect evaporation with flow arrangement
	7.f Explain short tube and long tube evaporators	7.6 short tube evaporator 7.7 long tube evaporator

9. SUGGESTEDS PECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R	U	A	Total
			Level	Level	Level	Marks
I	Fundamentals of Heat Transfer	4	2	4	0	6
II	Heat Transfer by Conduction	10	2	4	8	14
III	Heat Transfer by Convection	4	2	3	3	8
IV	Heat Transfer by radiation	5	2	4	4	10
V	Heat Transfer with Phase Change	4	2	6	0	8
VI	Heat Exchangers	9	2	6	6	14
VII	Evaporation	6	2	4	4	10
	Total	**42**	**14**	**31**	**25**	**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. SUGGESTEDSTUDENTACTIVITIES

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 are relatively simpler or descriptive are 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 a 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 student sought 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 modes of heat transfer along with their Mechanism and applications.
2 Prepare chart of law of heat transfer.
3 Prepare chart/model types of Heat exchanger and Evaporator.
4 Draw suitable chart for various heat transfer equipment
5 Prepare 15-20 slides power point presentation showing mode of heat transfer along with their examples.
6 Prepare 15-20 slides power point presentation on topic of heat transfer
7 Prepare Laboratory set up for conduction, convection, radiation, boiling, condensation and heat transfer equipment.(heat exchanger and evaporator)
8 Prepare a demonstrative model of conduction, convection and radiation.
9 Prepare a demonstrative model of any heat transfer equipment.
10 Prepare Working model of any heat transfer equipment.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Books	Author	Publication with place, year and ISBN
1	Unit Operations of Chemical Engineering	McCabe, Warren L., Julian C. Smith	McGraw Hill Publication, New York 2004(Seventh Edition)
2	Engineering heat transfer	Gupta & Prakash	Nem Chand & Brothers, Roorkee, India,20007 (Eighth Edition)
3	Process heat transfer	D.Q.Kern	Tata McGraw Hill Publication, New Delhi, (Reprint 2008)
4	Unit Operation	K.A. Gavhane	Nirali Prakashan, Pune 2009
5	HEAT TRANSFER	J. P. Holman	McGraw Hill Publication, New York 2010 (Tenth Edition)
6.	HEAT TRANSFER A Practical Approach	YUNUS A. CENGEL	McGraw Hill; 2nd edition

14. SUGGESTED LEARNING WEBSITES

a) https://ndl.iitkgp.ac.in/
b) https://www.vlab.co.in/
c) https://swayam.gov.in/
d) https://onlinecourses.nptel.ac.in

PO-COMPETENCY-CO MAPPING

Semester IV	Process Heat Transfer (4340501)						
	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	Use principles of heat transfer operations for safe, reliable and efficient operation of chemical plant.						
CO1: Classify modes of heat transfer, steady state, unsteady state and types of heat transfer equipment.	2.00	1.00	-	-	-	-	1.0
CO2: Apply laws of heat transfer to various chemical engineering problems without phase change.	3.00	2.00	1.00	3.00	1.00	2.00	2.00
CO3: Apply principles of heat transfer with phase change and dimensionless group.	2.00	1.00	1.00	1.00	1.00	-	1.00
CO4: Estimate the design parameters for heat transfer equipment.	3.00	2.00	2.00	3.00	1.00	2.00	1.00

15. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

Sr. No.	Name and Designation	Institute	Contact No.	Email ID
1	Mr. PATEL NILESHKUMAR SHANKARBHAI (Lecturer in chemical Engineering)	SHRI K. J. POLYTECHNIC, BHARUCH		nileshvgec@gmail.com
2	Mr. CHIRAG RAJESHBHAI PARMAR (Lecturer in chemical Engineering)	GOVERNMENT POLYTECHNIC, RAJKOT		chiragr3128@gmail.com

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Mass Transfer-I
(Course Code: 4340502**)**

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	4th Semester

1. RATIONALE

The operations which involve changes in composition of solutions are known as the mass- transfer operations. Mass transfer operations are required for preliminary purification of raw materials or final separation of products from by-products. Mass transfer operations are major and important activity in most of the chemical plants. Hence the course has been designed to develop the following competency and its associated cognitive, practical and affective domainlearning outcomes.

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:

- Use chemical process plant equipments for mass transfer operation safely

3. COURSE OUTCOMES

The theory should be taught and practical should be carried out in such a manner that students are able to acquire required learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

- Students will be able to

1) Understand basics of Mass Transfer operation.
2) Use concept of diffusion in Fluids & Interphase mass transfer in separation techniques
3) Select mass transfer operations (Drying & extraction) equipment for various applications.
4) Compute material balance for mass transfer operations (Drying & extraction) in different condition.

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	ESE	PA	ESE	PA	200
3	0	4	5	70	30	50	50	

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

5. COURSE DETAILS

Unit	Major Learning Outcomes (Outcomes in cognitive domain)	Topics and Sub-topics
Unit – I **Fundamentals of Mass Transfer**	1a. Describe Importance of mass transfer operation	1.1 Introduction of Mass transfer operations
	1b. Classify mass transfer operations based on phases 1c. Explain Membrane separation operations	1.2 Classification of mass transfer operations 1.3 Introduction , Basic Principle & Various applications of Membrane Separation operation
	1d. Distinguish direct and indirect operations 1e. Describe selection of appropriate separation method	1.4 Direct and indirect operations 1.5 Choice of separation method
	1f. Methods of conducting the mass transfer operations	1.6 Different methods of conducting mass transfer operation 1) Solute recovery and fractionation 2) Unsteady state operation 3) Steady state operation 4) Stage wise operation 5) Continuous contact operation.
Unit – II **Molecular Diffusion in Fluids**	2a. Differentiate Molecular and Eddy diffusion 2b. Explain & Calculate rate of diffusion in Fluids 2c. Distinguish Molar flux, diffusivity and concentration gradient in Fluids 2d Define Fick's law & Derive diffusivity equation	2.1 Molecular andEddy diffusion 2.2 Rate of diffusionin Fluids 2.3 Molar flux, diffusivity and concentration gradient in Fluids 2.5 Fick's law & Derivation of diffusivity equation ($D_{AB}=D_{BA}$)
	2e. Describe the effect of various factors on diffusivity 2f. Explain molecular diffusion in fluids at rest & in laminar flow	2.6 Effect of concentration, Temperature and pressure on diffusivity 2.7 General equation for steady state molecular diffusion in fluids at rest & in laminar flow
	2g. Describe Molecular diffusion in gases 2h. Derive Equation for Steady state diffusion 2i. Evaluate diffusivity of gases using empirical equation	2.9 Molecular diffusion in gases 2.10 Derive Equation for Steady state diffusion of (a) Component A through non diffusing B and simple numerical (b) Equimolar counter current diffusion of A and B with simple numerical 2.11 Empirical equation of diffusivity of Gases
	2j. Describe Molecular diffusion in liquids	2.12 Molecular diffusion in liquids a) Steady state diffusion of A

	2k. Evaluate diffusivity of liquids using empirical equation	through non diffusing B and simple numerical b) Steady state equimolal counter diffusion and simple numerical 2.13 Empirical equation of diffusivity of liquids
Unit – III Interphase Mass Transfer	3a. Explain Equilibrium 3b. Describe Diffusion between phases 3c. Describe various mass transfer coefficients using resistance concept	3.1 Concept of equilibrium 3.2 Diffusion between phases (two resistance concept) 3.3 Local and overall two phases masstransfer co-efficient and their uses
	3e. Define stage, stage efficiency and cascade	3.5 Stage and stage efficiency and types of Cascade
Unit – IV Drying	4a. Discuss drying equilibrium and related concepts 4a.1 Define Moisture content, Equilibrium and free moisture, Bound and unbound moisture 4a.2 Calculate - Moisture content, Equilibrium and free moisture, Bound and unbound moisture from the given data	4.1 Drying equilibrium 4.1.1 Insoluble solids 4.1.2 Hysteresis 4.1.3 Soluble solids 4.1.4 Definitions and calculation of Moisture content, Equilibrium and free moisture, Bound and unbound moisture
	4b. Classify Drying & Drying equipments	4.2 Batch and continuous drying 4.3 Classification of drying equipment
	4c. Describe construction and working of Drying equipments	4.4 Construction and working of following Drying equipments 4.4.1 Tray drier 4.4.2 Vacuum drier 4.4.3 Rotary drier 4.4.4 Spray drier
	4d. Describe drying rate characteristics for batch drying with sketches 4d.1 Derive equation for drying time for constant rate period and falling rate period	4.5 Drying rate curve for batch drying 4.6 Derivation of equation for drying time for constantrate period and falling rate period
	4e. Calculate Drying time	4.7 Calculation of Drying time
Unit – V Liquid liquid Extraction	5a. Apply the liquid extraction	5.1 Industrial application of Liquid Extraction
	5b. Describe the three component system 5c. Explain equilibrium using triangular co-ordinates 5d. Describe the effect of temperature and pressure	5.2 Equilibrium for three component system 5.3 Equilateral triangular co-ordinates system 5.3.1 System of three liquids-one pair partially Soluble 5.3.2 System of three liquids-two pair partially Soluble 5.4 Effect of temperature and

		pressure on solubility
	5e. Select appropriate solvent	5.5 Criteria for choice of solvent
	5f. Distinguish various types of extraction 5g. Describe the materialbalance for various stages 5h. Calculate Material balance in differentconditions	5.6 Single stage extraction and multistage cross current extraction on ternary diagram 5.7 Material balance for single stage, multistage- cross current 5.8 Problems based on material balance
	5i. Define Various equipment use in liquid extraction	5.9 Equipment Single stage extractor, agitated vessel, flow mixer and settler,spray tower, packed tower and centrifugal extractor
Unit – VI **Leaching**	6a. Describe Industrial applications	6.1. Industrial applications of leaching
	6b. Prepare solids Explain the factors affecting leaching	6.2. Preparation of solid 6.3. Temperature of leaching
	6c. Describe different states of operation and equipments	6.4. Methods of operation and equipment for 6.4.1 Unsteady state operation 1. In place operation 2. Heap leaching 3. Percolation tanks 4. Filter press leaching 5. Agitated vessel 6. Leaching by Shanks system
		6.4.2 Steady state operation 1. Leaching during grinding 2. Leaching in door type agitator 3. Leaching in door balanced tray thickener 4. Continues counter current decantation with flow sheet 5. Leaching of vegetable seeds I. Rotacell II. Kennedy extractor III. Continuous horizontal extractor
	6d. Explain Material balance	6.5. Material balance for single stage & Multistage cross current system

6. SUGGESTED SPECIFICATION TABLE WITH HOURS & MARKS (THEORY)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamental of Mass Transfer	06	02	05	00	07

II	Molecular Diffusion in Fluids	08	02	07	06	15
III	Interphase Mass Transfer	03	02	02	02	06
IV	Drying	08	02	06	05	15
V	Liquid liquid Extraction	10	02	08	05	15
VI	Leaching	07	03	07	02	12
Total		**42**	**13**	**37**	**20**	**70**

Legends: R = Remember; U= Understand; A= Apply and above levels (Bloom's revised taxonomy) **Note:** This specification table shall be treated as only as a guideline for students and teachers. The actual distribution of marks in the question paper may vary from above table.

7. SUGGESTED LIST OF EXERCISES/PRACTICAL

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills **(outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

Note*: Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of* ***Course Outcomes*** *related to affective domain. Thus over all development of* ***Programme Outcomes (****as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

Sr. No.	**Unit No.**	**Practical/Exercise** (Outcomes in Psychomotor Domain)	**Approx.Hrs. Required**
1	I	Describe different methods for conducting mass transfer operation (study experiment)	4
2	II	Determine diffusivity of gas-liquid system at room temperature	4
3	II	Determine diffusivity of gas-liquid system showing its dependency on temperature	4
4	II	Determine diffusivity of liquid-liquid system at room temperature	4
5	II	Determine diffusivity of liquid-liquid system showing its dependency on temperature	4
6	IV	Prepare drying curve of moist sand and moist limestone	4
7	IV	Find out equilibrium moisture content and drying time of wet solid	4
8	IV	To determine the drying characteristic for rotary dryer.	4

9	V	Determine the efficiency of single stage extraction	4
10	V	Determine the efficiency of two stage cross current extraction	4
11	V	Determine the distribution coefficient for toluene- acetic acid & chloroform -acetic acid mixture	4
12	V	Prepare ternary diagram for a system of three liquids	4
13	V	Obtain tie-line data for Acetic Acid, Benzene and water	4
14	VI	Measure recovery of salt using sand-salt mixture in single stage leaching	4
15	VI	Measure recovery of salt using sand-salt mixture in two stage leaching	4
16	VI	Describe different methods for steady state leaching operations. (study experiment)	4
Total Hrs			**64**

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	Weightage 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**

8. List of Major Equipment/ Instrument with Broad Specifications

Sr.No.	Equipment & glassware Name with Broad Specifications	Practical No.
1	**Gaseous diffusion system:** Thermostatic bath 2 litre; Temperature controller 0-100 ^{0}C; Vernier 0-100 mm (0.1 mm resolution); Magnetic stirrer with heater 2 MLH; Air blower 0.25HP	**2,3**
2	**Liquid diffusion system:** 1 liter glass beaker, Magnetic stirrer 1 MLH, electrical conductivity sensor &meter to measure conductivity in MHO	**4,5**
3	**Tray dryer:** Temp range 50-100/200, thick MS chamber, digital temp indicator and controller, Air circulation by induction motor, Tray about 80×40×3	**6 to 8**

4	**Extractor:** Glass column ID 75mm, OD 87mm, Height 1000mm; Supply tanks(three)-SS 304, 40 litre; Rota meters(two)-0.3 to 3 lpm-Glass tube, SS316 float; 0.25 HP motor with SS 304/316 shaft and blades	**9 to 13**
5	**Leaching apparatus:** Leaching bag-Polypropylene; Glass column Dia. 40 mm, height 400mm with SS 304 cap at both end; Solvent tank SS304-25 litre with 1 KW immersion heater; Collection tank SS 304, 30 litre; Pump- MOC-Polypropylene, 15 lpmflow rate	**14 & 15**
6	**Glassware** Separating funnels with stand-250ml, 500ml; Burettes-25 ml, 50 ml; Pipettes - 10 ml, 25 ml; conicalflasks- 250 ml, 500 ml; Beakers - 250 ml, 500 ml, measuring cylinder -25ml,50ml,100ml , specific gravity bottle	**2 to 15**

9. 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.

10. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities Other than the classroom and laboratory learning such as:

i. Visit nearby industries and observe the working of mass transfer equipments and collect their specifications
ii. Visit the website of reputed mass transfer equipment manufacturers and prepare a report on these equipments.
iii. Attend NPTEL / MOOCS / SWAYAM platform for self learning.
iv. Refer books available in department or Central library and prepare abstract of it.

11. SPECIAL INSTRUCTIONAL STRATERGY (if any)

i. Show animated videos and drawings of mass transfer equipment

12. SUGGESTED MICRO-PROJECTS

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 contribution in the project work and give a seminar presentation of it before submission.

Suggestive lists of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a) Prepare report: Prepare report of local industries where mass transfer operations are carried out.
b) Prepare model: Demonstrate liquid liquid diffusion, Prepare working model / prototype model of equipments like rotary dryer / spray dryer / extractor etc.
c) Prepare charts: Prepare charts of different mass transfer operations and phases involved in it.
d) Prepare List: Prepare the list of different mass transfer operations and equipments.

13. SUGGESTED LEARNING RESOURCES

A. List of Books:

Sr. No.	Title of Books	Author	Publication
1	Mass Transfer Operations	Robert E. Treybal	Mc Graw- Hill, 3rd Edition, 1981
2	Unit Operation of Chemical Engineering	McCabe, Warren L., Julian C. Smith	McGraw Hill Publication, New York 2004, 7th Edition
3	Separation Process Principles	Ernest J. Henley, J. D. Seader, D. Keith Roper	Wiley India, 2nd Edition, 2005
4	Unit Operations-II	K. A. Gavhane	Nirali Prakashan, Pune, 2009
5	Unit Operations of Chemical Engineering, Volume-1	P. Chattopadhyay	Khanna Publishers, New Delhi, 1995
6	Chemical Engineering, Volume-2	Coulsion and Richardson	Butterworth-Heinemann; 5thEdition, 2002
7	Introduction to Chemical Engineering	L.Badger, Julius T. Banchero	McGraw Hill Publication, New York, 7th Edition, 2004

B. List of Software/Learning Websites

i. www.unitoperation.com
ii. www.nptel.com

14. PO-COMPETENCY-CO MAPPING

Semester IV	MASS TRANSFER OPERATION-I (4340502)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline-specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimen-tation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency	• Use chemical process plant equipments for mass transfer operation safely						
CO1. Understand basics of Mass Transfer operation.	3	1	-	-	-	-	1
CO2. Use concept of diffusion in Fluids & Interphase mass transfer in separation techniques	3	2	2	3	1	-	2
CO3. Select mass transfer operations (Drying & extraction) equipment for various applications.	3	2	2	2	1	-	2
CO4. Compute material balance for mass transfer operations (Drying & extraction) in different condition.	1	2	2	2	1	-	2

15. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Sr. No.	Name and Designation	Institute	Contact No.	Email ID
1	Mr. J. D. Dattani Lecturer in Chemical Engg.	G. P. Rajkot		jddattani@hotmail.com
2	Ms. M. H. Vadera Lecturer in Chemical Engg.	G. P. Gandhinagar	76003 21536	mvadera22@gmail.com

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Chemical Engineering Thermodynamics
(Code: 4340503)

Diploma Programme in which this course is offered	Semesterinwhichoffered
Chemical Engineering Thermodynamics	4th Semester

1. RATIONALE

Diploma Chemical engineer has to deal with the laws of thermodynamics which are applied to flow and non-flow processes in the plant to evaluate heat effects and energy transformation calculation accompanying physical and chemical changes, for calculating temperature change and to determine power generation efficiencies of engines and power plants. Understanding of basic concepts and application of thermodynamics are therefore necessary for chemical engineers. Hence the course has been designed to develop these competencies and its associated cognitive and effective domain learning outcomes.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Solve the problems related to heat and work requirements for physical and chemical changes.
- Identify the various phase behavior of different fluids.
- Explain the working principles of heat engine, heat pump and refrigeration and calculate efficiency

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:

1. Understand the fundamental concepts of thermodynamics
2. Apply the Concept of First Law of Thermodynamics for flow and non-flow processes.
3. Use the equation of state for ideal gas and real gas to predict PVT behavior of fluid.
4. Apply the Concept of second Law of Thermodynamics.
5. Apply the laws of thermodynamics in refrigeration

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	-	-	3	30*	70	-	-	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 tobe 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 NBATerminology)	Unit No.	Approx. Hrs Required
Not Applicable			

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	Weightage in %
1	Question answer or Writing steps exercise (Assignment)	30
2	Executing of exercise	30
3	Result	40
	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 of them by the administrators/management of the institutes. This will ensure the conduction of practice in all institutions across the state in a proper way so that the desired skills are developed in students.

Sr. 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 and PrOs. More could be added to fulfill the development of thiscompetency.

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 (Course Outcomes in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
Unit– I Introduction and Basic Concept	1a. Describe scope of thermodynamics 1b. Explain the System, surrounding, and properties with examples of chemical engineering field	1.1 Scope and limitations of thermodynamics 1.2 System, surrounding, functions, properties and Process 1.2.1 System-Homogeneous and heterogeneous, Closed and Open, Isolated System, State of System
	1c. Differentiate functions, properties and processes	1.3 Properties -Extensive and intensive 1.4 Function -State and Path function 1.5 Process -Reversible and irreversible process, cyclic process

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	1d. Explain type of equilibrium for the given system	1.6 Steady and Equilibrium State 1.7 Thermal, Chemical, Mechanical and thermodynamic equilibrium
	1e. Explain importantphysical quantities	1.8 Force, Pressure, Work, powerand Energy
	1f. Explain Phase Rule	1.9 Gibb's Phase rule, degree of freedom
	1g. Explain Temperature and Zeroth Law of thermodynamics	1.10 Zeroth Law of thermodynamics 1.11 Temperature 1.12 Ideal Gas Temperature Scale
	1h. Solve simple numerical	1.13 Simple examples (numerical)on Force, Pressure, Work and Energy phase rule
Unit– II First Law of Thermody namics	2a. Explain first law and energy - Internal Energy, Enthalpy and Heat capacity concepts with examples of chemical engineering 2b. Apply first law for non-flow & flow process of chemical engineering	2.1 First law of thermodynamics 2.2 Internal Energy, Enthalpy and Heat capacity 2.3 First law for non-flow processes and flow processes of chemical engineering
	2c. Solve simple numerical	2.4 Numerical basedon first law and energy - Internal Energy, Enthalpy and Heat capacity
Unit– III PVT Behavior	3a. Explain PVT behavior of pure fluids	3.1 PVT behavior of pure fluids
	3b. Explain Ideal gas Processes	3.2 Ideal gas and equation of state 3.3 Ideal gas Process: 3.3.1 Constant Volume process 3.3.2 Constant Pressure process 3.3.3 Constant Temperature process 3.3.4 Adiabatic Process 3.3.5 Polytropic Process
	3c. Compare equations of state for real gases	3.4 Equation of state for real gases 3.4.1 Vander Waals Equation 3.4.2 Virial Equation 3.4.3 Compressibility charts
	3d. Solve simple numerical	3.5 Numerical based on Idea gas and real gas equations
Unit–IV Second Law Of Thermo-dynamics	4a. Discuss limitation of first law	4.1 Limitations of first law of thermodynamics
	4b. Describe the concepts of Heat reservoir, Heat engine and Heat pump	4.2 Heat reservoir, Heat engine and Heat pump
	4c. State different statements of Second law	4.3 Clausius Statement 4.4 Kelvin Planck Statement

	4d. Explain Carnot cycle, carnot principle and thermodynamic temperature scale	4.5 Carnot cycle and thermodynamic temperature scale
	4e. Explain Concept of Entropy for the given system	4.6 Concept of Entropy 4.7 Mathematical Expression of entropy
	4f. Calculate entropy change	4.8 Calculation of entropy changes during: 4.8.1 phase change, 4.8.2 ideal gas process 4.8.3 adiabatic mixing process, 4.8.4 isothermal mixing of ideal gases, 4.8.5 chemical reaction
	4g. Solve Numerical	4.9 Numerical based on entropy change and heat engine efficiency
	4h. Explain Third Law of thermodynamics.	4.10 Explain the Statement of Third Law of thermodynamics
Unit– V Refrigeration Cycles and Systems	5a. Refrigeration Cycles and Systems 5b. Describe various refrigeration cycles 5c. Explain various types of Refrigerants and their codes	5.1 Explain refrigeration, COP, Refrigerator capacity 5.2 Vapor-compression cycle and Air-refrigeration cycle (only theory) 5.3 Types of refrigerants and codes 5.4 Choice of refrigerant
	5d. Solve Numerical	5.4 Numerical based on CoP, Refrigerator Capacity

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction and Basic Concepts	09	06	04	03	13
II	First Law of Thermodynamics	09	03	04	06	13
III	PVT behavior	09	04	06	06	16
IV	Second Law of Thermodynamics	10	05	07	06	18
V	Refrigeration Cycles and Systems	05	03	04	03	10
	Total	**42**	**21**	**25**	**24**	**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 learningand to teachers to teach and question paper designers/setters to formulate test items/questionsto 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, the 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 the following activities in group and prepare small reports of about 5 pages for each activity. They should also collect/recordphysical evidence such as photographs/videos of the activities for their (student's) portfolio which will be useful for their placement interviews:

a) Prepare the presentation on various topics of thermodynamics
b) Practice various different free available thermodynamic simulation tools.
c) Prepare Chart/Poster on PVT diagram
d) Identify different refrigerants

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 are 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) Tutorial sessions may be organized as given in following table

Sr. No.	Unit No.	Topics/Sub Topics on which Numerical may be given during Tutorial Sessions	Approx. Hrs. Required
1	I	Quiz and Brief questions on Introduction and Concepts of thermodynamics	1
2	I	Numerical based on force, work, energy, pressure	2

3	I	Numerical based on Phase Rule	1
4	II	Numerical based on First Law of thermodynamics, internalenergy, enthalpy, heat capacity etc.	2
5	III	Numerical based on Ideal Gas Processes. Equation of state for real gases (Vander Waal's)	2
6	IV	Numerical based on Entropy change	2
7	V	Numerical based on Carnot engine efficiency, Cop of refrigeration, Tons of refrigeration	4
TOTAL			14

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 moreCOs which are the integration of PrOs, UOs, and ADOs. Each student will have to maintain a dated work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The duration of the microproject should beabout **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 thecompetencyofthecourseandtheCOs.Similarmicro-projectscouldbeaddedbythe concerned course teacher.

a) Prepare a chart on PVT diagram.
b) Prepare model of system showing thermodynamic concepts
c) Prepare chart showing Ideal Gas (Constant Volume) Thermometer
d) Collect the thermodynamic data from any open source (e.g.-V, P-T) and make use of Microsoft Excel® to plot the graph
e) Demonstrate the Joule's Experiment for First Law in simple way.
f) Note down the change in temperature by applying heat to ice.
g) Mention simple example of potential energy and kinetic energy from day-to-day life.
h) Perform simple experiment explaining First and Second Law of thermodynamics (Balloon and water, Balloon and candle)
i) Prepare a chart on flow process
j) Prepare report on Steady state and equilibrium state with appropriate example
k) Prepare chart showing different codes of refrigerants

13. SUGGESTEDLEARNINGRESOURCES

Sr. No.	Title of Books	Author	Publication with place, year and ISBN
1	A Textbook of Chemical Engineering Thermodynamics	Narayan,K.V.	PHI Learning PVT Ltd. New Delhi,2013, ISBN :9788120347472
2	Introduction to Chemical Engineering Thermodynamic	Smith J.M., Van Ness H.C., Abott M.M	McGraw-Hill, New York,1996 ISBN :978-9353168490
3	Chemical Engineering Thermodynamics	Rao Y.V.C	Sangam Books, Hyderabad,1997, ISBN : 9780863116889.
4	Engineering Thermodynamics	P.K.Nag	Tata Mc-Graw-Hill Publishing Company Ltd,New Delhi ISBN:0070591148
5	Chemical Engineering Thermodynamics–I	Gavhane, K.A.	Nirali Prakashan, Pune 2009
6	A Textbook of Engineering Thermodynamics	R. K. Rajput	Publisher: Laxmi Publications, third edition 2007 ISBN 10: 813180058X ISBN 13: 978-8131800584

14. SUGGESTED LEARNING WEBSITES

a) https://nptel.ac.in/
b) www.msubbu.in
c) Resources | Thermodynamics & Kinetics | Chemistry | MIT OpenCourseWare
d) Basic Thermodynamics online course video lectures by IIT Kharagpur (freevideolectures.com)
e) ** TEST, The Expert System for Thermodynamics: A thermodynamics Web Portal ** (thermofluids.net)
f) moran.pdf (krodriguez.net)

15. PO-COMPETENCY-CO MAPPING

SemesterVI	Chemical Engineering Thermodynamics(4340503)						
	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	• Solve the problems related to heat and work requirements for physical and chemical changes. • Identify the various phase behavior of different fluids. • Explain the working principles of heat engine, heat pump and refrigerationand calculate efficiency						

CO1. Understand the fundamental concepts of thermodynamics	3	-	1	-	-	-	-
CO2. Apply the Concept of First Law of Thermodynamics for flow and non-flow processes.	**3**	**2**	**1**	**-**	**-**	**-**	**-**
CO3. Use the equation of state for ideal gas and real gas to predict PVT behavior of fluid.	2	1	2	-	-	-	1
CO4. Apply the Concept of second Law of Thermodynamics.	1	1	2	-	1	-	1
CO5. Apply the laws of thermodynamics in refrigeration	1	-	1	-	1	-	1

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

Sr. No.	Name and Designation	Institute	Contact No.	Email ID
1	Ms. SINGH UPASANA TEJNARAYAN. Lecturer in Chemical Engg.	SKJP, BHARUCH		upasanat_singh@yahoo.com
2	Ms. PATEL PARUL KANUBHAI. Lecturer in Chemical Engg.	G P Gandhinagar		parul.chem@gmail.com

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Safety and Pollution Control in Chemical Industry
(Code: 4340504)

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	4th Semester

1. RATIONALE:

In the race of becoming an economic powerhouse without compromising safety and environmental degradation is utmost priority for all stakeholders. Better Industrial safety and pollution control in chemical industries leads to improve in reputation, work culture and safe and smooth run of plant without breakdown which leads to economic growth. Chemical engineer plays an important role in industrial safety and pollution control. This course deals with basic concepts and methods for industrial safety and pollution control.

2. COMPETENCY:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Use principles of safety & pollution control to operate plant safely, and control pollution within permissible limits in chemical industries.**

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:

1. Understand basic concepts of Environment, Health & Safety.
2. Apply hazard control method in chemical industries.
3. Discuss hazard identification method & Risk assessment method.
4. Apply pollution control methods in chemical 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	0	2	4	30*	70	25	25	150

(*):Out of 30marks 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	Prepare a report of "Learning From Incident" for a given Incident	I	2
2	Demonstrate handover of equipment(any one of heat exchanger/Pump/Vessel etc.) for maintenance by applying lock out tag out (LOTO)	II	2
3	Prepare Work permit for maintenance of any equipment (heat exchanger/Pump/Vessel etc.)	II	2
4	Demonstrate working of different fire extinguishers according to classes of fire	II	2
5	Apply HAZOP method for a given chemical plant or any job/task	III	2
6	Remove suspended Impurities from air using cyclone system	IV	2
7	Determine pH value of given sample of water.	V	2
8	Determine the chloride content in given sample.	V	2
9	Determine Total solid in given sample.	V	2
10	Determine dissolved oxygen of given sample.	V	2
11	Determine biological oxygen demand of given sample.	V	4
12	Determine chemical oxygen demand of given sample.	V	2
13	Measure dosage of alum for waste water treatment.	V	2
14	prepare chart of solid waste management method suitable for solid waste	VI	2
Total			**30**

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.	Performance Indicators for the PrOs	Weightage 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**

Sr. No.	Performance Indicators for the (Study)PrOs	Weightage in %
1	Understand importance of Practical	20
2	Prepare report of practical in prescribed format	30
3	Solve assignment questions.	30
4	Viva-voce	20
	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 of them by the administrators/management to the institutes. This will ensure the conduction of practice in all institutions across the state in a proper way so that the desired skills are developed in students.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	**pH meter:** pH range-2.00 to +16.00, Resolution: 0.01, Accuracy: ±0.02, mV range: ±1999 mV, Temperature range: -10 to +105°C	7
3	**Incubator (BOD set up):** Chamber volume:285.0 litre, range :+50C to 600C, controller accuracy:+/-0.50C set value of temp., PID Control: microprocessor based PID controller	11
4	**Cyclone separator:** 20" diameter cyclone dust collector,3" carbon steel straight wall and a 38" carbon steel cone tapering to an 8" x 8" discharge, 3" inlet and 3" exhaust. Splits in the middle for easy clean out	6
5	**Weighing machine:** Digital min. measurement 1 microgram	6, 8,9, 10, 11, 12, 13
6	**Oven:** Size: 24” x 24” x 24”, Shelves: 2 Adjustable Wire mash type Heating Element: Ni-chrome wire, 1.5 kw, Temp. Controller: PID type, Front membrane keys LED Display, 250 °C, Max. Temp., Auto Tune facility, Power supply : Single phase, AC 230 volts from mains	9
7	**Muffle furnace:** Structure: Rectangular horizontal, Outer body: M.S powder coated, Complete with control gear bulb, Max. temperature Range: 900°C to1200°C, Digital display control indicator Muffle size: 9"*4"*4"	9

8	**Fire Extinguisher:** (1). DCP stored pressure type 6 kg, (2) Carbon dioxide Extinguisher 4.5 kg.	4

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 Introduction to Industrial Safety and pollution control	1a. Describe importance of safety in Industry	1.1 Importance of Industrial Safety and pollution control
	1b. Discuss Significant Industrial Disasters	1.2 Significant Industrial Disaster: Bhopal gas tragedy
	1c. Define Safety	1.3 terminologies: a. Safety b. Pollution c. Exposure d. Severity e. Probability f. Hazard g. Risk h. Accident i. Unsafe Act and Unsafe Condition j. Nearmiss k. Aspect and Impact

	1d. List out various Indian and International Safety, health and Environmental laws, and standards	1.4 Overview of Indian and International Safety, health and Environmental Standards and Laws Air and Water quality specifications by GPCB or CPCB)
Unit – II Hazards and Their Control	2a. Describe chemical Industrial hazards	2.1 Describe Chemical industrial Hazards a. Chemical hazard b. Electrical hazard c. Mechanical hazard d. Biological hazard e. Radiation hazard
	2b. Classify Chemical Hazard	2.2 Classification of Chemical hazard
	2c. List out various Occupational diseases and their causes	2.3 Occupational diseases and their causes
	2d. Explain Hazard control methods	2.4 Hazard control hierarchy
		a. Elimination b. Substitution c. Engineering Controls Ventilation and lighting, Enclosure, Isolation d. Administrative Controls Work permit system, Lock Out Tag Out(LOTO) Management, Drills and table top exercises, Good Housekeeping- 5S, Color codes and symbols for safety in chemical plants e. Personal Protective Equipments (PPEs)
	2e. Explain Fire Hazard and its control methods	2.5 Fire hazards & their causes 2.6 Fire Triangle and Fire Extinguishment method 2.7 Classes of fire and respective suitable firefighting equipment 2.8 Fire extinguisher operation: PASS
	2f. Discuss MSDS	2.9 MSDS
Unit – III Hazard Identification and Risk Assessment	3a. Explain Hazard Identification Methods	3.1 List out various Hazard Identification methods : 3.2 Explain Hazard Identification Method: Hazard Operability Study (HAZOP)
	3b. Explain Risk Assessment Methods	3.3 List out various Risk Assessment Methods 3.4 Explain Risk Assessment method: ETA and FTA

Unit – IV Air Pollution Control	4a. Define Air Pollution, Pollutants and its sources	4.1 Air Pollution Pollutants, and its sources
	4b. Describe Particulate control equipments	4.2 Particulate control equipments Gravity Settling Chamber, Cyclone separator, Fabric Filter, Wet Scrubber and Electrostatic Precipitator
	4c. Describe Thermal incineration	4.3 Thermal incineration, stack
	4d. Apply control methods for gaseous air pollution due to Sulfur dioxide emission	4.4 Methods for control of Sulfur dioxide emission a. Extraction of sulfur from fuels: Hydrodesulphurization of coal b. Desulphurization of flue gases by Wet processes (wet scrubbing methods)
	4e. Apply control methods for gaseous air pollution from Nitrogen Oxides.	4.5 Methods for control of Nitrogen Oxides a. Modification of operating condition b. Modification of design condition
Unit – V Water Pollution Control	5a. Define Water Pollution. 5b. List out different Water Pollutants and its sources	5.1 Water Pollution Pollutants, and its sources
	5c. Explain characteristics of water	5.2 characteristics of water DO, BOD,COD, VM, Suspended Matter (turbidity), TDS, pH
	5d. Describe removal of pollutants by applying Waste water treatment methods	5.3 Waste water treatment method a. Primary treatment i. Pretreatment ii. Sedimentation iii. Floatation b. Secondary treatment i. Aerobic process ii. Anaerobic process: Activated sludge process iii. trickling filter
	5e. Describe removal of pollutants by applying various treatment methods on suspended solids	5.4 Suspended solids treatment methods a. Micro straining b. Coagulation c. Filtration
	5f. List treatment methods for dissolved solids	5.5 Dissolved solids and treatment methods a. Ion exchange b. Reverse Osmosis

	5g. Explain oxidation and disinfection	5.6 Chemical oxidation/Disinfection
	5h. Explain Sludge processing	5.7 Thickening, Digestion, Conditioning, Dewatering, Oxidation and ultimate sludge removal
	5i. Describe Effluent treatment plant drawing schematic block diagram	5.8 Effluent treatment plant- ETP
Unit – IV Solid Waste Management	4a. Define solid waste 4b. Classify solid waste	4.1 solid waste classification
	4c. Explain methods of solid Waste Disposal	4.2 Methods of solid waste disposal a. Open Dumping b. Sanitary Land filling c. Incineration d. Compositing e. Reuse, recovery and recycling 4.3 Public Health aspects

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	**Introduction to Industrial Safety and pollution control**	4	2	5	0	7
II	**hazards and Their Control**	12	2	8	10	20
III	**Hazard Identification and Risk Assessment**	4	2	2	3	7
IV	**Air Pollution Control**	6	2	2	5	9
V	**Water Pollution Control**	12	2	8	10	20
VI	**Solid Waste Management**	4	2	2	3	7
	Total	**42**	**12**	**27**	**31**	**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, the following are the suggested student-

related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Student should perform the following activities in group and prepare small reports of about 5 pages for each activity. They should also collect/record physical evidence such as photographs/videos of the activities for their (student's) portfolio which will be useful for their placement interviews:

a) Make a survey on Accident/incidents happened in your city with the help of newspaper/TV or any social media.
b) Visit any public place and nearby industry, prepare a report on safety features incorporated at both place.
c) Make a survey on awareness of people regarding firefighting and emergency response at your society/village. Conduct an awareness drive and again survey the same.
d) Make a survey of air quality of your city with the help of internet.
e) Visit nearby fire station and make a report of same.
f) Make a report on Sewage water treatment plant located in your city.
g) Make a survey of solid waste management in your city/village.
h) Make a report on Environment Impact assessment of any project, Available on internet
i) Prepare a report on Nature based solutions for climate change in India, Gujarat and your district/city/village. Efforts needed for their improvements. At last engage yourself for NBS and acknowledge same in the report with the help of photos.

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, V-lab, and O-labs 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 adapted 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 student sought 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.

a) Prepare a Chart or Presentation of International and Indian safety health and environmental laws.
b) Prepare a chart or presentation of various hazard symbols involved in chemical industries.
c) Prepare a chart or presentation of color coding for piping and cylinders.
d) Prepare a presentation of different Personal Protective Equipments.
e) Prepare a chart of your institute layout having a safety features like escape route, firefighting equipment, and first aid kit etc. location mark.
f) Develop a demonstration or working model of firefighting equipment.
g) Prepare a Presentation of various Hazard identification and Risk Assessment methods.
h) Prepare a presentation or demonstration or working model of any Particulate matter control equipments or gaseous pollution control methods.
i) Prepare a case study report on any air pollution incident.
j) Prepare a presentation or demonstration or working model of any water pollution control methods or solid waste management.
k) Prepare a case study report on any water pollution incident.

13. SUGGESTED LEARNING RESOURCES:

Sr. No.	TitleofBooks	Author	Publication with place, year and ISBN
1	Manual of Chemical Technology, Chem tech-I	D.Venkateswarlu, K.R.Upadrashta, K.D. Chandrasekaran	Chemical Engineering Education Development Centre, IIT, Madras, 1975
2	Fundamentals of Industrial Safety & Health	Dr. K. U. Mistry	Siddharth Prakashan, Ahmadabad
3	Chemical Process Safety: Fundamentals with application	Daniel A. Crowl Joseph F. Lowar	3rd Edition, 2011, Prentice Hall, USA
4	Industrial Hygiene and chemical safety	M. H. Fulekar	I.K. International
5	Industrial Safety Management	N. K. Tarafdar, K. J. Tarafdar	Dhanpatrai and Co.Ltd., New-Delhi, 1st Edition, 2012

6	Industrial safety management	L. M. Deshmukh	Tata McGraw Hill, New Delhi, 2006
7	Industrial Safety, Health & Environment management	Sunil S. Rao, R.K. Jain	Khanna Publishers, New Delhi, 2006
8	Environmental Pollution control	C. S. Rao	New age international Pvt. Limited, 2nd edition
9	Pollution Control in Process Industries	S. P. Mahajan	Tata Mc GrawHill,
10	Text Book of Environmental Pollution and Control	Dr. Bhatia H. S.	Galgotia Publication,1st edition, New Delhi
11	Environmental Engineering	G. N. Pandey, Carney G. C.	Tata Mc GrawHill, New Delhi
12	Industrial Safety and Environment	Anupama Prashar Pratibha Bansal	S.K.Kataria & Sons

14. SUGGESTEDLEARNINGWEBSITES

a) https://ndl.iitkgp.ac.in/
b) https://www.vlab.co.in/
c) https://nptel.ac.in/
d) https://www.osha.gov/
e) https://labour.gov.in/industrial-safety-health
f) https://www.iso.org/popular-standards.html
g) https://ndma.gov.in/
h) https://www.csb.gov/videos/
i) https://www.oisd.gov.in
j) https://cpcb.nic.in/
k) https://gpcb.gujarat.gov.in/
l) https://www.accuweather.com/
m) https://unfccc.int/

15. PO-COMPETENCY-CO MAPPING

Semester IV	Safety and Pollution Control in Chemical Industry (4340504)						
	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	• **Use principles of safety & pollution control to operate plant safely, and control pollution within permissible limits in chemical industries.**						
CO1: Understand basic concepts of Environment, Health & Safety.	2	-	-	1	2	1	-
CO2: Apply hazard control method in chemical industries.	2	2	2	2	2	1	2
CO3: Discuss hazard identification method & Risk assessment method.	2	1	1	2	2	1	2
CO4: Apply pollution control methods in chemical industries.	2	2	2	2	3	1	2

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

Sr. No.	Name and Designation	Institute	Contact No.	Email ID
1	Ms. Khushbu N Chaudhary Lecturer in Chemical Engg.	G. P. Gandhinagar		khushbu.ch306@gmail.com
2	Mr. Savan S Prajapati Lecturer in Chemical Engg.	G. P. Rajkot		svnprajapati@gmail.com

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Entrepreneurship & Start-ups
(Course Code: 4300021)

Diploma programmer in which this course is offered	Semester in which offered
All Branches of Diploma Engineering	5th Semester

1. RATIONALE

Entrepreneurs have significant impact on our country's current developing economy. The social expectations towards engineering professionals are certainly emerging as job creators especially with the thrust given to "Make in India" and "Vocal for Local" campaigns. Startup India is a well-known flagship initiative of the Government of India, intended to catalyze startup culture and build a strong and inclusive ecosystem for innovation and entrepreneurship. The last 6 years have witnessed tremendous growth of start-ups i.e. from 733 in 2016-17 to 14000 in 2021-22. This course focuses on the basic roles, skills and functions of entrepreneurship with special attention to startup. The course is directed to help students to enhance capabilities in the field of managing the given task as well as to understand peripheral influencing aspects for starting a new business. It will certainly help students to think in a direction to establish a small industry /start-up and develop /validate it using fundamental know how.

2. COMPETENCY

The purpose of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Establish a small enterprise /start-up validate it and make it scalable.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

Upon completion of the course, the student will be able to demonstrate knowledge of the following topics:

1) Understanding the dynamic role of entrepreneurship and Startups by Acquiring Entrepreneurial spirit and resourcefulness, quality, competency, and motivation
2) Identify a Business Idea and implement it
3) Select suitable Management practices like leadership and Ownership, resource institutes
4) Overview of Support Agencies and Incubators
5) Building Project Proposal & knowing CSR , Ethics, Ex-Im, & Exit strategies

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)	Total Credits (L+T+P/2)	Examination Scheme		
		Theory Marks	Practical	Total Marks

						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 integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the 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 Soft PRACTICAL EXERCISES (During Theory)

The entrepreneurial or start-up journey begins by readying for your future dream from college projects and pursuing the same beyond college hours also. It is encouraged to go through COs and identify traits and search for various state and national agencies for your entrepreneurship / start-up journey and convert the same into successful product in market.

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

Note

i. *Though the course does not contain any Practical work, a few **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The below 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	Weightage in %
1	Entrepreneur Traits and Behavior Modelling	30
2	Various State and Central Entrepreneurship Promotional Schemes and Start-up Policies	30
3	Business Model for a Startup and study of Unicorns*	40
Total		**100**

6. 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 course competency.

a. Work as a leader/a team member (while doing a micro-project).
b. Model behavioral practices of an entrepreneur while planning for an enterprise
c. Practice ethics and consider methods/ processes that reduce waste and/or possibly conserve environment in designing a new business till it's commercialization.

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-Planning
ii. 'Organization Level' in 2nd year-Model Development
iii. 'Characterization Level' in 3rd year-Make it Scalable

7. 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 UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Major LearningOutcomes (in cognitive domain)	Topics and Sub-topics
1) Introduction to Entrepreneurship and Start – Ups	1a) Define Entrepreneurship 1b) Discuss characteristics and functions of entrepreneurship. 1c) Identify different types of Entrepreneurships 1d) Compare the concepts entrepreneurand intrapreneur and find out the motivation behind it 1e) Distinguish between entrepreneur and managers 1f) Identify 7-M Resources 1g) Know MSME & Startup India, standup India, SSIP and its registration process for both.	1. Definition, Traits of an entrepreneur, 2. Functions of Entrepreneurship - Job Creation, Innovation, Inspiration, Economic Development 3. Types of Entrepreneurship 4. Motivation for Intrapreneurship 5. Types of Business Structures, 6. Similarities and differences between entrepreneurs and managers. 7. 7-M Resources 8. Micro, Small, Medium Enterprise/ MSME - Industry Registration Process 9. Startup India, Standup India and SSIP Gujarat & Startup registration process

2) Business Ideas and their implement ation (Idea to Start-up)	2a) Finding Ideas and making an activity map 2b) Develop the plans forcreating and starting the business 2c) To identify business using the ideation canvas and the business model canvas 2d) To know market research related terms 2e) To know market mix related terms 2f) Learn Product related terminologies 2g) Emphasize on Innovation 2h) Explain concept of Risk and SWOT	1. Discovering ideas and visualizing the business with Activity map 1.1 Idea Generation 1.2 Product Identification 2. Business Plan- The Marketing Plan and Financial Plan/ Sources of Capital 3. Business opportunity identification and evaluation 4. Market research 4.1.1. Questionnaire design 4.1.2. Sampling 4.1.3. Market survey 4.1.4. Data analysis & interpretation 5. Marketing Mix (4Ps- product,price, promotion place) 5.1.1. Identifying the target market 5.1.2. Competition evaluation and Strategy adoption 5.1.3. Market Segmentation 5.1.4. Marketing, Advertising and Branding 5.1.5. Digital Marketing 5.1.6. B2B, E-commerce and GeM 6. Product Terms- PLC, Mortality Curve and New product Development Steps, Inventory, Supply Chain Management 7. Importance and concept of Innovation, Sources and Process 8. Risk analysis and mitigation by SWOT Analysis
3) Management Practices	3a) Explain the concept and differences between industry, commerce and business. 3b) Describe various types of ownerships in the organization. 3c) Explain different types of leadership models. 3d) Analyze the nature and importance of various functions of management 3e) Discuss Financial organization Management 3f) Distinguish management and administration	1. Industry, Commerce and Business 2. Types of ownership in the organization -Definition, Characteristics, Merits &Demerits 3. Different Leadership Models 4. Functions of Management- Merits & Demerits 4.1 Planning 4.2 Company's Organization Structure 4.3 Directing 4.4 Controlling 4.5 Staffing- Recruitment and management of talent. 5. Financial organization and management 6. Differences between Management and Administration

4) Support Agencies and Incubators	4a) Identify support agencies and current promotional schemes for enterprise and startups 4b) Advocacy to investor 4c) To Explain various Legal Issues	1. State & National Level Support agencies and Current Promotional Schemes for new Enterprise 2. Start-up Incubation and modalities 3. Communication of Ideas to potential investors – Investor Pitch 4. Legal Issues 4.1. Contracts 4.2. Copyrights 4.3. Insurance 4.4. IPR 4.5. Licensing 4.6. Patents 4.7. Trade Secrets 4.8. Trademarks
5) Project Proposal & Exit strategies	5a) To work on the development of a project proposal 5b) Describe social responsibility and relate with economic Performance. 5c) Explain managerialethics 5d) To know Ex-Im Policies 5e) Identify suitable strategies of succession and harvesting	1. Project Planning i. Project planning and report ii. Feasibility study iii. Project cost estimation iv. Breakeven point, v. Return on investment and Return on sales 2. Corporate Social Responsibilities and Economic performance 3. Business Ethics 4. Ex-Im policies 5. Succession and harvesting strategy 6. Bankruptcy and avoidance

8. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to Entrepreneurship and Start – Ups	08	4	6	2	12
II	Business Ideas and their implementation (Idea to Startup)	08	6	4	4	14
III	Management Practices	12	6	8	8	22
IV	Support Agencies and	08	4	4	4	12

	Incubators					
V	Project Proposal & Exit strategies	06	2	4	4	10
Total		**42**	**22**	**26**	**22**	**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.*

9. SUGGESTED STUDENT ACTIVITIES

Other than the classroom 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 make a portfolio i.e. perform at least FIVE from following list of activities individually or in group (not more than 2). They should prepare reports of about 2-5 pages for each activity and collect/ record physical evidence for their portfolio which may be useful for their placement interviews:

i. Develop two products from household waste (attach photographs).
ii. Download product development and innovative films from internet.
iii. Prepare a collage for "Traits of successful entrepreneurs."/ "Motivation & Charms of Entrepreneurship"
iv. Invite entrepreneurs, industry officials, bankers for interaction. Interview at least four entrepreneurs or businessman and identify
v. Identify your hobbies and interests and convert them into business idea.
vi. Mock Business Model- Choose a product and design a unique selling preposition, brand name, logo, advertisement (print, radio, and television), jingle, packaging, and labeling for it.
vii. Develop your own website. Share your strengths and weakness on it. Declare your time bound goals and monitor them on the website.
viii. Choose any product/ advertisement and analyze its good and bad points/ cost sheet/ supply chain etc. (individuals should select different ads)
ix. Compare schemes for entrepreneurship promotion of any bank.
x. Visit industrial exhibitions, trade fairs and observe nitty-gritty of business. Get news of Vibrant Gujarat Events. (Upcoming in Jan 2024)
xi. Open a savings account and build your own capital.
xii. Arrange a visit to a Mall, observe products, supply chain management and prepare report.
xiii. Organize industrial visit and suggest modifications for process improvement. Conduct a market survey for a product /project before visit. In the visit collect data on machinery specifications, price, output/hour, power consumption, manpower requirement, wages, raw material requirement, specification, price, competitor's product price, features, dealer commissions, marketing mix etc. Make a detailed report at the end of the visit.
xiv. Select a social cause, set objectives, plan and work for its accomplishment. Find details about some famous NGOs
xv. Present Own Dream Start-up story as Seminar OR Analyze 2 products from Shark Tank program.

10. 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.
c) ***'L' in section No. 4 means*** different types of teaching methods that is to be employed by teachers to develop the outcomes.
d) Show animation/ video related to course content.
e) Various Apps related to subject topics/ sub-topics
f) Other Common instructions as under
    1) Instructors should emphasize more on exemplary and deductive learning.
    2) Students should learn to recognize, create, shape opportunities, and lead teams forproviding economic-social value to society.
    3) Business simulations should be used to enhance behavioral traits of successfulintrapreneurs and entrepreneurs amongst students.
    4) Emphasis should be on creating entrepreneurial society rather than only setting upof enterprise.
    5) They must be encouraged to surf on net and collect as much information aspossible.
    6) Each student should complete minimum ten activities from the suggested list.Minimum possible guidance should be given for the suggested activities.
    7) Students should be promoted to use creative ideas, pool their own resources, finishtheir presentation, communication and team skills.
    8) Alumni should be frequently invited for experience sharing, guiding andrewarding students.
    9) Display must be arranged for models, collages, business plans and othercontributions so that they motivate others.
    10) You may show video/animation film / presentation slides to demonstrate variousmanagement functions, traits of entrepreneur etc.
    11) Arrange a visit to nearby venture capital firm.
    12) Give 1 Mini project and 1project report for future business to all the students.
    13) The following pedagogical tools will be used to teach this course:
        a) Lectures and Discussions
        b) Role Playing
        c) Assignments and Presentations
        d) Case Analysis
        e) Quiz on Management and Entrepreneurship
        g) Mimic/ narrate examples from world's leading businessmen among the students.
        h) Guide students on how to address issues on environment and sustainability

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-projects are 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 a dated work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The duration of the guidance for micro project should be about **6-8** ***(six to eight) student engagement hours*** during the theory/ 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/ practical exercise is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:
(It can be a Seminar with bound /hand written notes/ ppts of individual students OR a product/ service portfolio)

1) Entrepreneur Traits and Behavior Modelling
2) Various State and Central Entrepreneurship Promotional Schemes and Start-up Policies
3) Business Model for a Startup and study of Unicorns
4) Make your own Product / Service portfolio/ Proposal with USP, logo, advertisement (print, radio, and television), jingle,packaging, labeling and branding for it.

13. SUGGESTED LEARNING RESOURCES

Sr. No	Title of Book	Author	Publication with place, year and ISBN
1	Entrepreneurship in Action	Coulter	PHI 2nd Edition
2	Entrepreneurship Development	E. Gordon & K. Natarajan	Himalaya
3	Entrepreneurship	Robert D. Hisrich & Mathew J. Manimala	McGraw Hill Education; ISBN 978-1259001635
4	Entrepreneurial Development	S S Khanka	S Chand & Company; ISBN: 978-8121918015
5	Entrepreneurship Development and Management	A. K. Singh	Jain Book Agency (JBA) publishes, New Delhi
6	Entrepreneurship Development& Management	R.K. Singal	S K Kataria and Sons; ISBN: 978-8189757007
7	Small Scale Industries and Entrepreneurship	Vasant Desai	Himalaya 2008
8	Entrepreneurship	Roy Rajeev	Oxford University Press; ISBN: 978-0198072638
9	Industrial Engineering and Management	O.P.Khanna	Dhanpat Rai and Sons, Delhi
10	Industrial Organization and Management	Tara Chand	NemChand and Brothers; Roorkee
11	Industrial Management and Entrepreneurship	V. K. Sharma.	Scientific Publishers, New Delhi
12	Entrepreneurship Developmentand Small Business Enterprise	Poornima M Charantimath	Pearson Education; ISBN: 978-8131759196
13	Entrepreneurship Development	S Anil kumar	NEW AGE Intern. Pvt Ltd; ISBN: 978-8122414349

14	The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company	Steve Blank and Bob Dorf	K & S Ranch ISBN – 978-0984999392
15	The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses	Eric Ries	Penguin UK ISBN – 978-0670921607
16	Demand: Creating What People Love Before They Know They Want It	Adrian J. Slywotzky with Karl Weber	Headline Book Publishing ISBN – 978-0755388974
17	The Innovator's Dilemma: The Revolutionary Book That Will Change the Way You Do Business	Clayton M. Christensen	Harvardbusiness ISBN: 978-142219602
18	How to write a business plan,	Brian Finch	2nd edition, 2007, Kogan Page India Pvt. Ltd.
	Advance Reading		
19	HBR - Creating business plan	-	20-minute manager series, 2014.
20	HBR – Creating business plan	-	Expert solution to everyday challenges, 2007.

14. SOFTWARE/LEARNING WEBSITES

[A] List of Software/Learning Websites:

Sr. No.	Topic Key Word	Link
1	MoCI	https://www.india.gov.in/website-ministry-commerce-and-industry
2	MSME	1)https://msme.gov.in/ 2) https://www.msmex.in/learn/government-schemes-for-startups-and-msmes-in-india/
3	Start-up, Stand-up India & SSIP Gujarat	1) https://www.startupindia.gov.in/ 2) https://www.standupmitra.in 3) https://udyamimitra.in/page/standup-india-loans 4) https://www.ssipgujarat.in/
4	Make in India	https://www.makeinindia.com/
5	Atmanirbhar Bharat Abhiyan Vocal for Local	https://indiancc.mygov.in › uploads › 2021/08
6	Skill India	https://skillindia.gov.in
7	MSDE	https://www.msde.gov.in/
8	Vibrant Gujarat	https://www.vibrantgujarat.com/
9	NABARD	www.nabard.com
10	PAN	https://www.onlineservices.nsdl.com/paam/endUserRegisterContact.html
11	I-hub	https://ihubgujarat.in
12	GSTIN	https://reg.gst.gov.in/registration

13	IEC Code	https://www.dgft.gov.in/CP
14	Mudra	https://www.mudra.org.in/
15	Export-Import	http://niryatbandhu.iift.ac.in/exim/
16	NSIC	https://www.nsic.co.in/
17	DIC	https://ic.gujarat.gov.in/dic -contact.aspx -District Industries Centre
18	EDI	https://www.ediindia.org/
19	CED	https://ced.gujarat.gov.in/home
20	NIESBUD	https://www.niesbud.nic.in/
21	Start-up Talky	https://startuptalky.com/list-of-government-initiatives-for-startups/
22	Invest India	https://www.investindia.gov.in/startup-india-hub
23	SAAC	https://www.saccindia.org/india/startups.html?utm_source=google&utm_medium=cpc&gclid=EAIaIQobChMIutLQ4dfW_wIVeppmAh1cOAAIEAMYASAAEgIJO_D_BwE
24	Action for India	https://actionforindia.org/afi-activity-accelerator-programs.html?gclid=EAIaIQobChMIutLQ4dfW_wIVeppmAh1cOAAIEAMYAiAAEgLVGvD_BwE
25	Indian Chamber of Commerce	https://www.indianchamber.org/
26	FICCI	https://www.ficci.in/api/home
27	GCCI	https://www.gujaratchamber.org/

[B] Some Films (To be seen on Sundays/holidays by students on their own, not to be shown in polytechnics in any case**)**

i. Any Body Can Dance (2013)
ii. Corporate (2006)
iii. Do Duni Char (2010)
iv. Guru (2007)
v. Oh My God (2013)
vi. Pirates of Silicon Valley (1999)
vii. The Pursuit of Happiness (2006)
viii. Rocket Singh (2010)
ix. Start-up.com (2001)
x. The Social Network (2010)
xi. Wall Street (1987)
xii. Band Baja Barat (2010)
xiii. You've Got Mail (1998)
xiv. Steve Jobs (2015)
xv. Chef (2014)
xvi. "Office Space (1999)
xvii. Erin Brockovich (2000)
xviii. The Founder (2016)

15. PO-COMPETENCY-CO MAPPING:

Semester V	Entrepreneurship & Startups

	(Course Code: **4300021**)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design / development of solution	PO4 Engineering Tools, Experimentation & Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency	Use concepts of management optimally to establish a small enterprise or start-up, validate it and make it scalable.						
CO1-Understanding the dynamic role of entrepreneurship and Startups by Acquiring Entrepreneurial spirit and resourcefulness, quality, competency, and motivation	3	1	2	-	-	2	2
CO2- Identify a Business Idea and implement it	3	2	2	1	1	3	3
CO3-Select suitable Management practices like leadership and Ownership, resource institutes	3	-	1	1	2	2	3
CO4- Overview of Support Agencies and Incubators	2	3	2	2	1	2	2
CO5- Building Project Proposal & knowing CSR , Ethics, Ex-Im, & Exit strategies	3	2	2W	1	1	3	3

*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.	Mr. Ujjval V Buch (MBA)	G.P.Ahmedabad	9825346922	uvbuch@gmail.com
2.	Dr. Satya Acharya	EDI, Bhat.	7600050606	satya@ediindia.org

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**

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Waste to Energy Conversion Technology
(Course Code: 4350502)

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

1. RATIONALE

The objective of the course is to provide insights into waste management options by reducing the waste destined for disposal and encouraging the use of waste as a resource for alternate energy production. This course is designed to provide an understanding of the various aspects of Waste to Energy. The various sources of waste generation are analyzed with a focus on its potential for energy production. The need for characterization of wastes will be discussed along with the existing norms for waste utilization for alternate energy source. Various Technological options available for the production of energy form waste.

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:

- **To Supervise operation and to Optimize energy and Other Inventories**

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:

a) Identify different wastes as a energy source
b) Apply concept of Thermo-chemical process for energy conversion
c) Apply concept of Biochemical process for energy conversion
d) Utilize algal biomass as source of energy production

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	-	-	3	30*	70	-	-	**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: ***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
Not Applicable			

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	Question answer or Writing steps exercise (Assignment)	30
2	Executing of exercise	30
3	Result	40
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.

Sr. 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 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(Course Outcomes in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
Unit:1 Characterization of waste	1a. Classification of waste as energy	1.1 Definition of wastes and their classification 1.2 Important quality parameters of different types of wastes 1.3 Wastes suitable for energy production
	1c. Characterization of wastes	1.4 Characterization of solid wastes and waste water
	1d. Explain Technologies for Waste to Energy Conversion	1.5 Energy from wastes, some scenario 1.6 Routes for energy production from wastes 1.7 Define Biochemical Conversion and Thermo-chemical Conversion
	1b. Explain Status of wastes	1.8 Status of waste to Energy conversion in India.
	1d. Solve simple numerical	1.9 Numerical based on Characterization of wastes
Unit:2 Thermo-chemical Conversion	2a. Explain Mechanism of combustion	2.1 Definition and scope of combustion/incineration 2.2 Environmental and health impacts of incineration 2.3 Advantages and Disadvantages of combustion 2.4 Air requirement for combustion
	2b. Classification of combustors	2.5 Type of combustor 2.6 Energy production from wastes through incineration
	2c. Explain Basic chemistry of gasification	2.7 Concept and Advantages of gasification
	2d. Classification of Gasifier	2.8 Types of Gasifier 2.9 Energy production through gasification of wastes
	2e. Comparison Combustion and gasification	2.10 Comparison between incineration and gasification

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	2f. Classification of pyrolysis	2.11 Definition and mechanism of pyrolysis 2.12 Types of pyrolysis 2.13 Operating conditions and end product distribution
	2g Explain Properties of Pyrolysis products	2.14 Use of pyrolysis products 2.15 Properties of bio oil and need of its upgradation 2.16 Utilization of pyro char and gases
	2h. Solve simple numerical	2.17 Numerical based on combustion, gasification and Pyrolysis
Unit:3 Biochemical Conversion	3a. Outline Properties of biogas	3.1 Properties of biogas (Calorific value and composition) 3.2 Factors affecting biogas yield
	3b. Explain and Classify Anaerobic digestion	3.3 Feedstock's and primary products of Anaerobic digestion 3.3 Mechanism of anaerobic digestion 3.5 Flow sheet for anaerobic digestion of wastes 3.6 Types of anaerobic digesters and their operation
	3c. Energy production from wastes through fermentation	3.7 Different energy sources from biomass / wastes through fermentation 3.8 Production of ethanol from starchy crops (corn), lingo cellulosic biomass (LCB) and through gasification route 3.9 Butanol production from LCB
	3d. Energy production from wastes through transesterification	3.10 Transesterification process and Organic wastes for transesterification 3.11 Production of bio oil from oil seeds and its major composition 3.12 Up gradation of bio oil to bio diesel
	3e. Solve simple numerical	3.13 Numerical based on biochemical conversion process
Unit:4 Cultivation of algal Biomass	4a. Explain algal cultivation	4.1 Why algal cultivation? 4.2 Algal metabolism and synthesis of fat and protein
	4b. Classify algae	4.3 Classification of microalgae phyla 4.4 Lipid content in algal cell
	4c Show growth of microalgae	4.5 Reactor systems for cultivation/ growth of microalgae
	4b. Energy production from algal Biomass	4.6 Important energy production routes for algal biomass 4.7 Conversion of algal oil to biodiesel 4.8 Types of conversion process, mechanisms and comparison 4.9 Factors affecting biodiesel yield

		4.10 Upgradation of algal oil to bio diesel using homogenous and heterogeneous catalysts

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Characterization of waste	6	2	4	2	8
II	Thermo-chemical Conversion	14	5	10	10	25
III	Biochemical Conversion	14	5	10	10	25
IV	Cultivation of algal	8	6	6	0	12
	Total	**42**	**18**	**30**	**22**	**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 Classification of waste along with their Mechanism and applications
2	Prepare chart of Status of waste to Energy conversion in India
3	Prepare chart/model types of Combustor
4	Draw suitable chart for various Combustor equipment
5	Prepare 15-20 slides power point presentation showing Classification of waste along with their examples
6	Prepare 15-20 slides power point presentation Characterization of wastes
7	Prepare 15-20 slides power point presentation on Waste to energy technology
8	Prepare a demonstrative model of any Gasifier reactor
9	Prepare a demonstrative model of any waste to energy conversion technology equipment
10	Prepare Working model of any waste to energy conversion technology equipment
11	Prepare 15-20 slides power point presentation on energy crisis in India and its solution
12	Prepare a model on pyrolysis system that can convert plastic into gas or oil.
13	Prepare chart/model of Incineration.
14	Prepare 15-20 slides power point presentation on comparison of seven different countries best practices for waste energy recovery with India.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Books	Author	Publication with place, year and ISBN
1	Waste-to-Energy: Technologies and Project Implementation	Marc J Rogoff Dr and Francois Screve	William Andrew; 2nd edition (15 June 2011)

2	Biogas Technology	Khandelwal K. C. and Mahdi S. S	Vol. I & II Tata McGraw Hill Publishing Co. Ltd., 1983
3	Solid Waste Engineering	Vesilind P.A. and Worrell W. A	2nd Ed. Cengage India (2016)
4	Thermo-chemical Processing of Biomass: Conversion into Fuels, Chemicals and Power	Robert C. Brown,	John Wiley and Sons, USA (2019)
5	Municipal Solid Waste to Energy Conversion processes	Young G.C	John Wiley and Sons

14. SUGGESTED LEARNING WEBSITES

a) https://onlinecourses.nptel.ac.in/noc23_ch05/
b) https://www.teriin.org/projects/green/pdf/National-Waste.pdf
c) https://www.eai.in/ref/ae/wte/typ/clas/india_industrial_wastes.html
d) Ministry of New & Renewable Energy - Government of India (mnre.gov.in)
e) http://www.ottusa.com/synthetic_fuel/synthetic_fuel
f) OSHA Technical Manual (OTM) | Occupational Safety and Health Administration
g) https://youtu.be/jYry2xe-HqY
h) https://youtu.be/MuYdfxanAk8
i) https://youtu.be/uXU2Pcxokb4

15. PO-COMPETENCY-CO MAPPING

Semester V	Waste to energy conversion technology (4350502)						
	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	To Supervise operation and to Optimize energy and Other Inventories						
CO1: Identify different wastes as a energy source	2.00	3.00	1.00	-	1.00	1.00	3.00
CO2: Apply concept of Thermo-chemical Conversion for biogas production	1.00	3.00	3.00	1.00	2.00	1.00	2.00
CO3: Apply concept of Bio-chemical Conversion for biogas production	1.00	3.00	3.00	1.00	2.00	1.00	2.00
CO4: Utilize algal biomass as source of energy production	1.00	2.00	2.00	-	2.00	1.00	2.00

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

Sr. No.	Name and Designation	Institute	Contact No.	Email ID
1	Mr. SHAH PARTH SATISHBHAI (Lecturer in chemical Engineering)	GOVERNMENT POLYTECHNIC, GANDHINAGAR	----------	parthgcet@gmail.com
2	Mr. SOSA VIDURKUMAR PUNJABHAI (Lecturer in chemical Engineering)	GOVERNMENT POLYTECHNIC, RAJKOT	----------	vidur.sosa@gmail.com

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2023(COGC-2021)
Semester-V

Course Title: Chemical Engineering Project -I
(Course Code: 4350503)

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

1. RATIONALE

Project work serves as a means for students to utilize their coursework knowledge and skills to solve particular problems or execute projects, ultimately fostering innovative skills. In addition, Developing a plant for a chemical product is a complex task that requires a comprehensive report encompassing various aspects such as the chemical process and unit operations, properties of raw materials and products, economic factors, safety and pollution issues, and material and energy consumption. Chemical engineering students need to prepare such reports to become successful entrepreneurs while keeping in mind sustainability factors. A wide range of sustainable chemical products can be chosen from different sectors, including petrochemicals, fertilizers, pharmaceuticals, pesticides, natural products, polymers, and dyes. Careful consideration must be given to major equipment specifications, plant layout, and location to ensure the sustainability and success of the project.The syllabus provided is a guide, and instructors have the option to motivate students to develop prototypes, conduct experiments, or generate novel ideas that spark innovation.

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:

- **Identifying a chemical product, evaluating its essential features and characteristics, understanding the manufacturing processes involved, and selecting appropriate Process, equipment and instruments for the production.**

3. COURSEOUTCOMES(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:

a) Select a chemical product based on market demand, raw material availability, and potential profitability.
b) Analyze the market and historical trends of a chemical product and explain its essential features and characteristics.
c) Evaluate the properties and applications of chemical products in different contexts.
d) Identify critical steps involved in production process.
e) Select major equipments and instruments for chemical manufacturing processes.

4. TEACHINGANDEXAMINATIONSCHEME

Teaching Scheme(InHours)			Total Credits(L+T+P)	ExaminationScheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
0	0	4	2	0	0	50	50	100

***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	selecting one chemical product based on specific criteria such as demand, availability of raw materials, and potential profitability	1	8
2	Evaluate the historical development of the selected chemical product, including major breakthroughs, challenges	2	4
3	Compare the chemical and physical properties of the selected chemical product with other similar products in the market	3	4
4	Identify the various applications of the selected chemical product in different industrial and commercial contexts	3	8
5	Analyze the advantages and disadvantages of each manufacturing process for the selected chemical product to determine the most suitable sustainable process.	4	12
6	Create a flow diagram of the manufacturing process for the selected chemical product, including inputs and outputs at each step.	4	8
7	select and use appropriate equipment and instruments for the selected chemical process	5	12
		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 (The instructor is permitted to make slight modifications as deemed necessary).	Weightage in %

1	Clarity and organization of the report	20
2	Demonstration of technical knowledge	25
3	Significance of problem/solution/conceptual feasibility analysis	15
4	Rigor and appropriateness of the methodology	15
5	Accuracy and relevance of the results	15
6	Analysis and interpretation of the results	05
7	Overall contribution to the field	05
	Total	**100**

6. MAJOREQUIPMENT/INSTRUMENTSANDSOFTWAREREQUIRED: N/A

7. AFFECTIVE DOMAIN OUTCOMES

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

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. COURSE DETAILS

Unit	Major Learning Outcomes(Course Outcomes in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
Unit-I **Chemical Product Selection and Market Analysis**	1.1 Identify a chemical product by conducting a market survey	1. Choose a chemical product from a range of chemical sectors, including but not limited to petrochemicals, fertilizers, pharmaceuticals, pesticides, natural products, polymers, acids and alkalis, specialty chemicals, dyes, and pigments.
	1.2 selecting one based on specific criteria such as demand, availability of raw materials, and potential profitability.	

Unit-II **Product survey and Industry Analysis**	2.1 Explain the essential features and characteristics of the selected chemical product.	2.1 Introduction of the selected chemical product, including its essential features and applications
	2.2 Examine the current trends in the market and industrial landscape of the selected chemical product.	2.2 Historical development of the selected chemical product, including major milestones and breakthroughs.
	2.3 Evaluate the historical development of the selected chemical product, including major breakthroughs, challenges.	2.3 The current state of the selected chemical product, including market trends and major industries involved in its production.
Unit-III **Characteristics and Application of chemicals involved in process**	3.1 Discuss the chemical and physical properties of the raw materials used in the production of the selected chemical product, and their impact on the final product.	3.1 The properties of raw materials used in the production of the chemical product.
		3.2 chemical and physical properties of the final product
	3.2 Compare the chemical and physical properties of the selected chemical product with other similar products in the market (if any).	3.3 Application of final product in different industrial and commercial contexts (Instructors are requested to stimulate students to think creatively and unconventionally).
	3.3 Identify the various applications of the selected chemical product in different industrial and commercial contexts.	
Unit-IV **Process Analysis for Sustainable Manufacturing**	4.1 Understand the different manufacturing processes involved in producing a chemical product and their respective steps, inputs, and outputs.	4.1 Different manufacturing processes with flow diagram involved in producing the chemical product and their respective steps, inputs, and outputs.
	4.2 Analyze the advantages and disadvantages of each manufacturing process for the selected chemical product to determine the most suitable sustainable process.	4.2 Merits, demerits, and engineering challengesof each manufacturing process for the selected product.
		4.3 Various critical steps in the production process.
	4.3 identify the critical steps in the production process.	4.4 waste generation/environmental impact of each process.
	4.4 Create a flow diagram of the manufacturing process for the selected chemical product, including inputs and outputs at each step.	

Unit-V **Selection of Major Process Equipments and Instrumentation**	5.1 Identification of the necessary equipment and instruments for the selected chemical process	5.1 Description of the necessary equipment and instruments for the selected chemical process.
	5.2 Understanding the functions and roles of each equipment and instrument in the manufacturing process	5.2 Advantages and disadvantages of selected instruments.
		5.3 The functions and roles of each equipment and instrument in the manufacturing process.
	5.3 select and use appropriate equipment and instruments for the selected chemical process	5.4 Selection criteria for instrument

9. SUGGESTEDSPECIFICATIONTABLEFORQUESTIONPAPERDESIGN:N/A

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 learningand to teachers to teach and question paper designers/setters to formulate test items/questionsto assess the attainment of the UOs. The actual distribution of marks at different taxonomylevels(of R, Uand A) in thequestion paper mayslightlyvaryfromabovetable.*

10. SUGGESTEDSTUDENTACTIVITIES

Following are the suggested student-related activities which can be undertaken to accelerate the attainment of the various outcomes in this course:

1. Industrial visit
2. Laboratories experiment
3. Literature Study
4. Attend Workshops
5. Internships
6. Take Part in Competitions
7. Course/topic based presentation

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) Faculty can act as mentors to their students, providing guidance and support as they work on their final year projects.
b) Faculty can facilitate group work, encourage peer feedback and provide

opportunities for students to work together on projects.

c) Faculty can provide opportunities for students to work with laboratory equipment and conduct experiments, for example.
d) Guide students to address issues on environment and sustainability with reference to using the knowledge of this course.
e) Provide regular feedback and assessment on student work.
f) Faculty can provide resources and support for students to pursue their own interests and areas of study.
g) Faculty can provide opportunities for students to share their work with their peers and receive feedback.
h) Faculty can incorporate active learning strategies, such as group discussions and problem-solving activities, into their final year project instruction.

12. SUGGESTEDMICRO-PROJECTS: N/A

13. SUGGESTEDLEARNINGRESOURCES

Sr. No.	TitleofBooks	Author	Publication with place, year and ISBN
1	Encyclopedia of Chemical Processing and Design	Jhon J. McKetta, William A. Cunninghalm	Marcel Dekker Inc., New York and Basel
2	Encyclopedia of Chemical Technology	Kirk and Othmer	John Wiley and Sons, Wiley Interscience
3	Ullman's Encyclopedia of Industrial Chemistry	Ullman	VCH Publishers, Germany
4	Chemical Process Technology Encyclopedia	Coincidine	McGraw-Hill
5	Perry's Chemical Engineers' Handbook	Robbert H. Perry, Down W. Green	McGraw-Hill
6	Plant Design and Economics for Chemical Engineers	Max Peters, Klaus Timmerhaus	McGraw Hill
7	Chemical Engineering Plant Design	Frank C. Vilbrandt, Charles E. Dryden	McGraw Hill
8	Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design	Gavin Towler, R. K. Sinnott	Butterworth-Heinemann
9	Process Engineering	James R. Couper	Marcel & Dekker Economics
10	Stoichiometry	B. I. Bhatt, S.M. Vora	Tata McGraw Hill
11	Safety and Accident Prevention in Chemical Operation	Faweett, Wood	Interscience Publishers
12	A course in Industrial Safety	K.U. Mistry	N.K.M. Publication

13	Pollution Control in Process Industries	S.P. Mahajan	Tata-McGrawHill
14	Safe Handling of Hazardous Chemicals	A.K. Rohatgi	J.K. Enterprise

14. SUGGESTEDLEARNINGWEBSITES

a) https://archive.nptel.ac.in/course.html
b) https://chemicalengineeringworld.com
c)https://www.chemengonline.com/
d)https://chemicalengineeringsite.in/

15. PO-COMPETENCY-CO MAPPING

Semester V	Chemical Engineering project –I (4350503)						
	POs						
Competency &CourseOutcomes	PO1 Basic&Discipline-specificknowledge	PO2 ProblemAnalysis	PO3 Design/developmentofsolutions	PO4 EngineeringTools, Experimentation &Testing	PO5 Engineeringpractices forsociety,sustainability& environment	PO6 ProjectManagement	PO7 Life-longlearning
Competency	Supervise operation and maintenance of various heat transfer equipments						
CO1: Select a chemical product based on market demand, raw material availability, and potential profitability.	3	1	-	1	1	-	1
CO2: Analyze the market and historical trends of a chemical product and explain its essential features and characteristics	1	2	1	2	-	-	3
CO3: Evaluate the properties and applications of chemical products in different contexts	2	-	-	-	2	-	2
CO4: Identify critical steps involved in production process	3	2	1	-	-	1	2
CO5:Select major equipment and instruments for chemical manufacturing processes.	2	-	2	1	1	1	1

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

Sr. No.	Name and Designation	Institute	Contact No.	Email ID

1	Mr. TARAKKUMAR CHANDRAKANTBHAI PADHIYAR (Lecturer in chemical Engineering)	SHRI K. J. POLYTECHNIC, BHARUCH	9879294415	tcp.gpv@gmail.com
2	Mr. JENISH DAMJIBHAI RUPAPARA (Lecturer in chemical Engineering)	GOVERNMENT POLYTECHNIC, GANDHINAGAR	7600694681	jenish.rupapara@gmail.com

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Semester-V

Course Title: Summer Internship-II

(Course Code: 4350504)

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

1. RATIONALE

Chemical Process Industries covert raw materials in to useful products using various processes and operations. The role of chemical engineer is to operate and handle various processes, operations and equipment effectively and ensuring safe work conditions and compliance health and safety regulation. Internship is educational and career development opportunities, providing practical experience in a field of chemical engineering. It will expose Technical students to the industrial environment, which cannot be simulated in the classroom and hence creating competent professionals for the industry. It may help students to acquaint themselves with the field they are interested in. Summer Internship-II offer students the chance to put what they are learning into action, in a real-world environment. It may help student to strengthen existing soft skills that are beneficial to career, in addition to scientific and technical skills like accountability, interpersonal skills, organization skills, problem-solving skills, teamwork, creative thinking and time management skills etc. Summer Internship-II is a great way to gain hands-on experience real-life engineering workplace and supplement their engineering education. This allows students to apply academic coursework, and to gain insight into the professional life of an engineer. It will help to optimize manufacturing process thereby achieving production target with an economical cost.

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:

- Operate various unit operations and processes by using standard operating procedure in the chemical process industry.
- Get hands-on training, technical experience and opportunities to learn, understand and sharpen the technical / managerial skills in a real-world environment.

3. COURSE OUTCOMES(COs)

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

1. Apply basic chemical engineering knowledge to understand working of various unit operations and processes in the chemical process industry.
2. Make use of standard operating procedures for various unit operations and processes in the chemical process industry.

3. Identify engineering problems and troubleshooting in the chemical process industry.
4. Identify the various safety measures and pollution control techniques used in the chemical process industry.
5. Develop lifelong learning in team management, communication skills and supplement technical knowledge.

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	
0	0	0	3	00	00	50	50	100

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

5. MODE OF INTERNSHIP

- **Internship in the industry**

Internship in the industries/organization is to be arranged for the students of 5th semester based on internship guideline.

- **Project based internship**

Suitable topic related to Chemical Engineering like project based on industrial problem, working model of the equipment, Lab experiment and data analysis, and Design and analysis of the system/equipment, etc can be given as a mini project to the students of 5th semester.

6. INTERNSHIP GUIDELINES:

The summer internship-II for students in industries/organization is to be arranged in the beginning of 5th semester/ as per schedule given by GTU.

- Time Duration: 6 Weeks
- Training area: Large/Medium/Small Scale Chemical Process/ Allied industries

The general suggestive procedure for arranging internship is given below:

Step 1: Request Letter/ Email from the office of Institute should send to industry to allot slots of 6 weeks during the schedule given by GTU as internship periods for the students. Students request letter/profile/ interest areas may be submitted to industries for their willingness for providing the internship.

Step 2: Industry will confirm the internship slots and the number of students allocated for internships via Confirmation Letter/ Email. In case the students arrange the training themselves, the confirmation letter will be submitted by the students in the department office of the institute.

Step 3: Students on joining internship at the concerned Industry / Organization submit the Joining confirmation Letters / Email to department office.

Step 4: Students will undergo summer internship-II at the concerned Industry / Organization. Faculty mentor(s) evaluate(s) the performance of students and Evaluation Report should be maintained in department office.

Step 5: Students will prepare and submit summer internship-II report after completion of internship.
Step 6: Summer Internship-II Certificate to be obtained from industry and submit it to department office.

7. ROLE AND RESPONSIBILITY OF STUDENT

Summer Internship-II is a student centric activity. Therefore, the major role is to be played by the student.

- The student should interact with mentor to suggest choice for training and suitable Industry/Organization. If students have any contact in the industry/Organization, then same may be utilizes for getting permission for summer Internship for themselves and their peers.
- The students have to fill the consent form duly signed by their parents and submitted to department office of the institute.
- The student should follow all rules/regulation and safety procedures of the Industry/Organization during internship period.
- It is the responsibility of student to collect information from industry about manufacturing process, working of equipment/Equipment specification, raw material, maintenance procedure, organization structure etc.
- In case they face any major problem in the industry such as an accident or any disciplinary issue, they should immediately report the same to the institute.
- The student should prepare a Summer Internship-II report along with Student's Diary/ Weekly Logbook and submit to department at the time of submission.

8. EXPECTED LEARNING AREA FOR THE STUDENT DURING SUMMER INTERNSHIP-II

The following areas are expected to learn by students during summer internship program.

- Organization hierarchy
- Manufacturing process of industry
- Reaction involved in the process.
- Flow diagram of the manufacturing process
- Major equipment involved in the process
- Major utilities used in the plant
- Instrumentation and Control system in the industry
- Raw materials and products handling/ MSDS
- Raw materials and products laboratory testing
- Standard operating procedure of the process/equipment
- Permit System followed in the industry
- Hazards associated in the Industry
- Safety measures followed in the industry
- Awareness about various PPEs used in the industry
- Pollution control and effluent treatment techniques followed in the industry

9. STUDENT'S DIARY/ WEEKLY LOGBOOK

- The main purpose of writing diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students thought process and

reasoning abilities.

- The students should record observations, impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students.
- Student's Diary/ WEEKLY LOGBOOK should be submitted by the students along with internship report at the time of submission.
- For sample format of Student's Diary/ Weekly Logbook refer Annexure-3.

10. SUMMER INTERNSHIP REPORT

After completion of Internship, the student should prepare a comprehensive report to indicate what he has observed and learnt in the internship period. Student diary will also help to a great extent in writing the internship report.
The following is the suggestive format for the internship report.

- Cover Page
- Institute Certificate
- Industry completion Certificate
- Student Declaration
- Acknowledgement
- Content page
- Chapters
- Appendix (optional)
- References (optional)

Chapter-1: Introduction to industry/organization (Types of products and services, history, turnover, location and number of employee, Organization structure of industry/organization and general plant layout etc)
Chapter-2: Manufacturing process, reaction along with its process flow diagram
Chapter-3: Major equipments/instruments used in process industries with their standard operating procedure and troubleshooting
Chapter-4: Raw materials and products handling/MSDS
Chapter-5: Safety measures and Work permit system
Chapter-6: Plant Utilities, Instrumentation and Process control system
Chapter-7: Pollution control and effluent treatment techniques

Note: The chapters and content may be change based on Type of Industry/Organization and Area of Internship.

11. EVALUATION

It will be evaluated on the basis of the following criteria:

- Attendance and regularity in maintenance of the student's diary
- Adequacy, quality of information and purposeful write-up/presentation
- Organization of the information, format, drawings, sketches, other information recorded
- Variety and relevance of learning experience/ Depth of knowledge and skills
- Practical applications, relationships with basic theory and concepts taught in the course

12. 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 competency.

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

13. SUGGESTIVEFORMAT

The following are suggestive format for Summer Internship-II course.
Annexure-1: Student Registration From
Annexure-2: Request Letter from Institute to Industry/Organization
Annexure-3 Student's Diary/ Weekly Logbook
Annexure-4: Summer Internship-II Completion Certificate
Annexure-5: Student Declaration
Annexure-6: Summer Internship-II Report Format
Annexture-7: Suggested Evaluation Rubrics

14. PO-COMPETENCY-CO MAPPING

Semester V	Summer Internship-II (4350504)						
	PO5						
Competency &Course Outcomes	PO1 Basic&Discipline-specificknowledge	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
CO1: Apply basic chemical engineering knowledge to understand working of various unit operations and processes in the chemical process industry	3.00	2.00	1.00	2.00	2.00	1.00	2.00
CO2: Make use of standard operating procedures for various unit operations and processes in the chemical process industry.	3.00	1.00	-	2.00	2.00	2.00	1.00

CO3: Identify engineering problems and troubleshooting in the chemical process industry.	3.00	3.00	2.00	2.00	2.00	2.00	2.00
CO4: Identify the various safety measures and pollution control techniques used in the chemical process industry.	3.00	2.00	1.00	2.00	3.00	1.00	2.00
CO-5: Develop lifelong learning in team management, communication skills and supplement technical knowledge.	2.00	1.00	1.00	1.00	-	3.00	3.00

15. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

Sr. No.	Name and Designation	Institute	Contact No.	Email ID
1	Mr. Jagdish Dattatrya Raut (Lecturer in Chemical Engineering)	Government Polytechnic, Valsad	---------	jagdish.raut@gmail.com
2	Mr. Parth Dhruvkumar Prajapati (Lecturer in Chemical Engineering)	Government Polytechnic, Valsad	---------	pdprajapati266@gmail.com

Annexure-1: STUDENT REGISTRATION FROM

[Name of the Institute]

[Name of the Department]

STUDENT REGISTRATION FROM

Title of Internship	
Type of Industry/Organization	
Enrollment Number	
Student Name	
Student Details	Contact No.:
	Communication Address:
	Parents Contact No.:
Name of Institute	
Mentor Details (Institute)	Name:
	Designation:
	Mobile No:
	Email Address:
Industry /Organization Details	Name:
	Address:
	Email:
	Contact No.
	Website:
Mentor Details (Industry)	Name:
	Designation:
	Mobile No:
	Email:

Student Signature Institute Mentor Signature

Annexure-2: REQUEST LETTER FROM INSTITUTE TO INDUSTRY/ ORGANIZATION

[Institute Letter Head]

Date: DD/MM/YYYY

To
The General Manager (HR)
_____
_____

Subject: Request for 6 Weeks Summer Internship-II for student(s) of Diploma-Chemical Engineering

Dear Sir,

In Diploma-Chemical Engineering program, Gujarat Technological University has introduced Summer Internship-II for the students in the beginning of 5th semester.

In view of the above, I request your good self to allow our following _____student(s) for internship training in your esteemed organization. Kindly accord your permission and give one week time for student(s) to join training after confirmation.

Sr No.	Name of student	Enrollment No.

A line of confirmation will be highly appreciated. You are requested to provide Summer Internship completion certificate to above student(s) after completion of internship period.

With Warm regards,

Authorized Signatory
Designation
(Name of the Institute)

INSTITUT E SEAL

Annexure-3 STUDENT'S DIARY/ WEEKLY LOGBOOK

Week:	1 / 2 / 3 / 4 / 5 / 6	Date: to
Name of Organization		
Department/Division		
Name of Plant Head/ Supervisor/In-charge		
Main Topic: Process/Observation/Information/Drawing/Learning points		
Sign of Plant Head/Supervisor/In-charge:		

Annexure-4: SUMMER INTERNSHIP-II COMPLETION CERTIFICATE

[Industry Letter Head]

Date: DD/MM/YYYY

TO WHOM IT MAY CONCERN

This is to certify that _____, Enrollment No._____, a student of chemical Engineering Department, <Institute Name>has successfully completed his/her summer internship-II in the field of <Internship Area/Department>from <Start Date>to<End Date> (Total number of Weeks: ___) under the guidance of <Industry Mentor/Plant Head>.

During the period of her/ his internship program with us, he / she had been exposed to different processes and was found sincere, enthusiastic and dedicated toward work assigned.

We wish him/her every success in his/her life and career.

For <Industry/Organization Name>
Authorized Signature
Designation

ORGANIZATIO N SEAL

Annexure-5: STUDENT DECLARATION

[Name of the Institute]

[Name of the Department]

DECLARATION

I/We hereby declare that the Summer Internship-II report submitted along with the Internship entitled **<Internship Title>**submitted in partial fulfillment for the degree of Diploma in Chemical Engineering , Gujarat Technological University, Ahmedabad, is a bonafide record of work carried out by me/us at<Industry/Organization Name> under the supervision of <Industry / Institute Mentor Name> and that no part of this report has been directly copied from any students' reports or taken from any other source, without providing due reference.

Name of Student Signature

Annexure-6: SUMMER INTERNSHIP-II REPORT FORMAT

CoverPage<Removethis>

[SUMMER INTERNSHIP-II]

<FontSize18><1.5line spacing>

A REPORT ON
<INTERNSHIP AREA/DEPARTMENT>
<NAME OF INDUSTRY/ORGANIZATION>

<FontSize14>

Submitted by

<FontSize14><Italic>

[NAME OF THE CANDIDATE]

<FontSize16>

[GTU Enrolment Number]

<FontSize14>

In partial fulfillment for the award of the degree of

<FontSize14><1.5linespacing><Italic>

DIPLOMA IN CHEMICAL ENINEERING

<FontSize16>

in

[Name of the Department]

[Name of the Institute with City]
<FontSize14>

Institute Logo

GTU Logo

Gujarat Technological University, Ahmedabad

<FontSize16><1.5line spacing>

[Month,Year]

Following are the guidelines for the preparation Summer Internship-II Report.

PAPER: Use A4 (210mm X 297mm) Paper.

MARGINS: Margins for pages including the regular text should be as below:

Left : 1.25 Inches

Right : 1.0 Inch

Top : 1.0 Inch

Bottom: 1.0 Inch

PREPARATION OF CHAPTERS

Color:

All the text including Tables should be Black prints. However, Graphs and Figures can have color prints.

Font:

Chapter Headings : Times New Roman 16pts, bold print all capitals

Section Headings : Times New Roman 14pts, bold print all capitals

Subsection Headings: Times New Roman 12pts, bold print leading capitals (only first letter in each word should be capital

Regular Text : TimesNewRoman12pts, normal prints

Special Text : Times New Roman Italics 12 pts (for foot notes, symbols, quotes, Mathematical notations….)

Annexture-7: SUGGESTED EVALUATION RUBRICS

Suggested Evaluation Rubrics
(Institute/Industry Mentor)

Enrollment No: _____

Name of Student: _____

Date of Evaluation: _____

Sr. No.	Parameter	Excellent	Good	Average	Poor	Very Poor	Obtained Marks
	Mark	5	4	3	2	1	
1	Student regularity, Proactiveness/ responsiveness towards the given tasks during the Internship period						
2	Regularity in maintenance of the diary/Log book						
3	Quality and organization of information						
4	Purposeful writeup, content, drawing and sketches in the internship report						
5	Depth of technical knowledge and skills						
6	Variety and relevance of learning experience						
7	Quality of presentation						
8	Development of soft skills like communication, presentation, team work/leadership and management skills						
9	Application of basic theory and concepts of chemical engineering						
10	Quality of work/ Practical applications in forms of Outcome achieved.						
	Total Marks Obtained Out of 50 (Minimum Passing Marks: 20)						

Name of Mentor/Examiner:

Signature of Mentor/Examiner:

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Fertilizer Technology
(Course Code: 4350505)

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

1. RATIONALE

Indian economy is dominated by agriculture sector. Synthetic fertilizers are must for producing good crops. Hence it is needed to provide comprehensive and balanced understanding of essential link between chemistry and the synthetic fertilizer industry. It is therefore vital for chemical engineers to understand for each fertilizer product, its flow diagram for Industry production. For this purpose chemical engineers should have skills for arranging treatment, reaction and separation steps in a flow diagram for variety of fertilizers including Nitrogenous fertilizers, Phosphatic fertilizer, Potash Fertilizer, Complex fertilizer and Bio fertilizers is essential. Hence this course is designed to achieve this objective.

2. COMPETENCY

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

- Supervise the different stages in fertilizer production

3. COURSEOUTCOMES(COs)

The theory should be taught and practical's should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain:

i. Apply the concept of unit process and unit operations for manufacturing of various fertilizers
ii. Characterize fertilizers on the basis of different properties.
iii. Identify engineering problems in various fertilizers manufacturing.
iv. Outline applications of various fertilizer.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme(InHours)			Total Credits(L+T+P)	ExaminationScheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	-	2	5	30*	70	25	25	150

(*):Out of 30marks under the theory CA,10marks 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	Prepare chart for fertilizer classification with chemical formula and nutrient content	I	02
2	Estimate nutrient content (% N, %P2O, % K2O) in different fertilizers from their chemical formula	I	02
3	Estimate percentage of Nitrogen in Ammonium chloride by substitution method	II	02
4	Estimate percentage of Nitrogen in Ammonium sulfate by substitution method	II	02
5	Estimate percentage of Nitrogen in Ammonium chloride by back titration	II	02
6	Estimate percentage of Nitrogen in Ammonium sulphate by back titration	II	02
7	Analysis of Urea by Formaldehyde method	II	02
8	Estimate percentage of Nitrogen in Ammonium Chloride/Sulphate by Kjeldhal's method	II	02
9	Estimate biuret content in Urea sample by colour comparison	II	02
10	Estimate ratio from Ammonia to Phosphoric acid in DAP	III	02
11	Prepare potassium sulphate	IV	02
12	Prepare potassium chloride	IV	02
13	Prepare potassium nitrate	IV	02
14	Estimate percentage of Nitrogen in DAP by Formaldehyde method	V	02
15	Estimate percentage of Nitrogen in DAP by Kjeldhal's method	V	02
16	Preparation of Organic fertilizer	VI	02
		Total	**28**

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 of them by the administrators/management of the institutes. This will ensure the conduction of practice in all institutions across the state in a proper ways the desired skills are developed in students.

Sr.No.	Equipment Name with Broad Specifications	PrO. No.
1	Hot Air Oven: Temperature is controlled by digital temperature indicator cum controller from ambient to 250°C with ± 0.1°C Accuracy. Power supply: 220/230V, 50Hz single phase, Capacity (Approx.): 50 – 100 liter, Type of Shelves: 03, Material of Inner Chambers: SS304, Material of Outer Chamber: MS with powder coated paint, Material of Shelves:SS wire mesh	All
2	Laboratory Weighing Balance: Type of Laboratory Balance: Analytical, Sensitivity (mg): 1 mg, Maximum Capacity of weighing (grams): 200 g, Shape of PAN:Circular, PowerSupply: Single Phase, Display: LED.	All
3	Hot Plate With Magnetic Stirrer: Number of stirring Positions:1,Calibration:Automatic Calibration, Magnetic stirrer with a hot plate, Speed Control Accuracy of sets peed (+/-) (RPM): 5, Maximum stirring capacity per position:3000ml,Top plate Material: Stainless steel	All
4	Lab cooling bath: 220V/50HZ, 1.5KW, 370*340*480mm	All
5	Kjeldahl apparatus: Flasks:30ml,50ml,100ml, Heating Element : Kanthal A-1, Heater Watt :200 watt ,Max. Temperature : 350°C	8,16
6	Glassware : Burette, Pipette, Round bottom flask, Conical flask, Beaker, Condensor, Measuring cylinder, Separating funnel.	ALL
7	Accessories: Burner, Stand	All
8	Chemicals: Ammonium chloride, Ammonium sulphate, Urea, DAP,KCL, KOH, NaCl, Indicators	All

7. AFFECTIVE DOMAIN OUTCOMES

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

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. UNDER PINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom'staxonomy* 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(Course Outcomes in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
Unit – I Overview of fertilizer	1a. Justify the need for synthetic fertilizer	1.1 Synthetic fertilizers
	1b. Categorize fertilizers	1.2 Classification of fertilizers
	1c. Explain role of essential elements for plant growth	1.3 Role of essential Elements in plant Growth 1.3.1 Macro elements 1.3.2 Micro elements
	1d. Select the relevant fertilizers for the different types of crops	1.4 Application of fertilizers considering nutrient balance and types of crop
Unit – II Nitrogenous Fertilizers	2a. Describe different properties of ammonia, nitric acid and urea 2b. Prepare synthesis path for manufacturing synthesis gas, ammonia, nitric acid and urea 2c. Describe ammonia synthesis converter 2d. Explain storage and transportation of ammonia 2e Estimate concentration of Nitric acid 2f. Describe the engineering problems of ammonia, nitric acid and urea manufacturing	2.1 Physical, chemical properties and applications of ammonia, nitric acid and urea 2.2 Manufacturing of ammonia synthesis gas 2.3 Explain sketch of ammonia synthesis converters 2.4 Manufacturing of ammonia 2.5 Storage and Transportation of Ammonia 2.6 Manufacturing of Nitric Acid 2.7 Concentration of Nitric acid by Mg(NO3) 2.8 Manufacturing of Urea 2.9 Major engineering problems of ammonia, nitric acid and urea manufacturing
	2g. Describe the manufacturing process	2.10 Manufacturing of 2.10.1 Ammonium nitrate 2.10.2 Ammonium sulphate 2.10.3 Ammonium chloride
Unit – III Phosphatic Fertilizer	3a. Describe various physical, chemical properties and uses of Phosphoric acid 3b. Describe the manufacturing process of Phosphoric acid by Wet process and Electric furnace method 3c. Describe the engineering problems of phosphoric acid 3d. Describe the manufacturing Superphosphate and Triple superphosphate	3.1 Physical, chemical properties and applications of phosphoric acid 3.2 Manufacturing phosphoric acid by Wet Process 3.2.1 Strong sulphuric Acid Leaching 3.2.2 Hydrochloric Acid Leaching 3.2.3 Electric Furnace Process 3.3. Major engineering problems of phosphoric acid 3.4. Manufacturing of Superphosphate

		3.5 Manufacturing of Triple superphosphate
Unit – IV Potassic Fertilizers	4a. Describe physical, chemical properties ,manufacturing and uses of potassium chloride, potassium nitrate and potassium sulphate	4.1 Physical, chemical properties, manufacturing and uses of 4.1.1Potassium Chloride 4.1.2 Potassium nitrate 4.1.3 Potassium sulphate
Unit – V Complex Fertilizer	5a. Explain the manufacturing of NPK,ASP,CAN and DAP fertilizers with sketches	5.1 Manufacturing of 5.1.1 NPK fertilizer 5.1.2 Ammonium Sulphate Phosphate (ASP), 5.1.3 Calcium Ammonium Nitrate(CAN) 5.1.4 Di-ammonium phosphate
Unit – VI Bio Fertilizer	6a. Justify the need for biofertilizers and its benefits 6b. Describe the Nitrogen fixing and Phosphate solubilising biofertilizers 6c. Explain preparation a biofertilizers 6d.Explain organic fertilizers	6.1 Types of Biofertilizers 6.2 Biofertilizers: 6.2.1 Nitrogen-fixing biofertilizers 6.2.2 Phosphate solubilizing biofertilizers 6.3 Preparation of a biofertilizers 6.4 List out organic fertilizers 6.5 Outline advantages of organic fertilizers over conventional fertilizer

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R	U	A	Total
			Level	Level	Level	Marks
I	Overview of fertilizer	4	02	02	02	06
II	Nitrogenous Fertilizers	14	06	10	06	22
III	Phosphatic Fertilizer	8	04	06	04	14
IV	Potassic Fertilizers	5	03	04	03	10
V	Complex Fertilizer	6	02	06	02	10
VI	Bio Fertilizer	5	02	04	02	8
	Total	**42**	**19**	**32**	**19**	**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, Uand 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 are relatively simpler or descriptive are 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 a dated work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The duration of the microproject should be about **14-16** ***(fourteen to sixteen) student engagement hours*** during the course. The student sought 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 a chart of the properties of given product
2) Prepare a chart to demonstrate manufacturing process.
3) Prepare a report on major engineering problem of given manufacturing process
4) Prepare a chart of application of given products
5) Prepare a power point presentation on a topic “List of Fertilizer manufacturing industries in India”
6) Prepare a PowerPoint presentation or animation showing different types of Fertilizer manufacturing Process
7) Library survey regarding fertilizers in different industries
8) Prepare a model of different fertilizers product flow diagram

13. SUGGESTEDLEARNINGRESOURCES

Sr. No.	TitleofBooks	Author	Publication with place, year and ISBN
1	Outlines of Chemical Technology, 3rd edition	M. Gopala Rao, Marshall Sitting	Affiliated East West Press (Pvt) Ltd-New Delhi
2	Shreve's Chemical Process Industries, 5th edition	Austin G.T.	McGraw Hill publication – New Delhi
3	Chemical Technology – Vol. I , 2nd edition	G.N. Pandey and Shukla	Vani Books Company -Hyderabad
4	BioFertilizers and Organic Farming	Vayas S C and Modi H A	Akta prakashan, Nadiad

14. SUGGESTEDLEARNINGWEBSITES

i. http://nptel.ac.in/courses/103107086/4

ii. http://ijset.com/ijset/publication/v1s6/285-291%20IJSET_PK%20JAGA.pdf

iii.www.gses.com/images/pressreleases/Manufacturing-Process-Fertilizer.pdf

iv. http://nzic.org.nz/ChemProcesses/production/1A.pdf

v. http://tnau.ac.in/eagri/eagri50/SSAC222/lec12.pdf

vi. www.fnca.mext.go.jp/bf/bfm/pdf/Biofertilizer_Manual.pd

15. PO-COMPETENCY-CO MAPPING

SemesterIV	Fertilizer Technology (4350505)						
	POs						
Competency &Course Outcomes	PO1 Basic& Discipline-specific knowledge	PO2 Problem Analysis	PO3 Design/development of solutions	PO4 Engineering Tools, Experiment &Testing	PO5 Engineering practices for society, sustainability & environment	PO6 Project Management	PO7 Life-long learning
Competency	Supervise operation and maintenance of various equipments						
CO1: Apply the concept of unit process and unit operations for manufacturing of various fertilizers	2.00	-	-	-	2.00	-	1.00
CO2: Characterize fertilizers on the basis of different properties.	3.00	2.00	-	3.00	-	2.00	2.00
CO3:. Identify engineering problems in various fertilizers manufacturing	2.00	1.00	-	1.00	1.00	-	-
CO4: Outline applications of various fertilizer.	3.00	2.00	-	3.00	-	2.00	1.00

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

Sr. No.	Name and Designation	Institute	Contact No.	Email ID
1	Mr. R.P. Hadiya (Lecturer in chemical Engineering)	**G P Rajkot**	----------	rphadiya@yahoo.co.in
2	Mr. J D Rathod (Lecturer in chemical Engineering)	**G P Valsad**	----------	Jdrathod94@gmail.com

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)
Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester-6th
Course Title: Chemical Reaction Engineering
(Course Code: 4360501)

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

1. RATIONALE

To design Chemical reactor, engineer must have knowledge about many areas of chemical engineering like thermodynamics, chemical kinetics, fluid mechanics, heat transfer, mass transfer, and economics. Chemical reaction engineering integrates the aspects which are required for the appropriate design of chemical reactor. For design and operation of the commercial reactors performing different kind of chemical reactions, essential concepts of chemical reaction engineering are required. This course make diploma engineer to perform task of selecting, sizing and determining the optimal operating conditions for the reactor.

2. COMPETENCY

With the aim to develop the required skills in the students so that they are able to acquire the following competency, the course content should be taught, and the curriculum should be implemented.

- To operate & maintain different kind of chemical reactor to produce chemicals with good quality and minimum cost.

3. COURSE OUTCOMES (COs)

The teaching of theory and the implementation of practical exercises should be designed in a way that enables students to attain the necessary learning outcomes across cognitive, psychomotor, and affective domains, ultimately demonstrating the specified results.

1) Describe fundamental aspects of various chemical reactions.
2) Determine rate, rate constant, activation energy and order of reaction.
3) Analyze kinetic data to find out rate equation for batch reactor.
4) Control different reactors efficiently using fundamental knowledge of their functioning.
5) Estimate volume, space time and space velocity for Ideal reactors.

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	2	4	70	30*	25	25	150

(*) *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 average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.*

Legends: L - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** - Practical; **C** - Credit; **ESE** - End Semester Examination; **CA** – Continuous Assessment

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'.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1.	To determine the activation energy of the reaction between Sodium thio sulphate and HCl using Arrhenius Equation.	II	02
2.	To determine order of the reaction between Sodium thio sulphate and HCl.	II	02
3.	To determine the kinetics of a reaction between Ethyl Acetate and Sodium Hydroxide under condition of excess Ethyl Acetate at room temperature.	III	02
4	To determine the kinetics of a reaction between Ethyl Acetate and Sodium Hydroxide by integral method of analysis at room temperature.	III	02
5	To determine the activation energy of the reaction between Ethyl Acetate and Sodium Hydroxide.	II	02
6	To determine the kinetics of a reaction between Ethyl Acetate and Sodium Hydroxide under by differential method of analysis at room temperature.	III	02
7.	To determine the kinetics of a reaction between n- Butyl Acetate and Sodium Hydroxide by differential method of Analysis at room temperature.	III	02
8.	To determine the kinetics of a reaction between n- Butyl Acetate and Sodium Hydroxide by integral method of Analysis at room temperature.	III	02
9.	To determine the activation energy of the reaction between n- Butyl Acetate and Sodium Hydroxide using Arrhenius Equation.	III	02

10.	Kinetic Study of Batch Reactor.		
11.	Kinetic Study of Continuous Stirred Tank Reactor.	II,IV, V	02
12.	Kinetic Study of Plug Flow Reactor.	II,IV, V	02
13.	Kinetic Study of Semi Batch Reactor.	II,IV, V	02
14.	Kinetic Study of Solid – Liquid Non Catalytic Reactor.	II,IV, V	02
			28 Hrs.

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

S. No.	Sample Performance Indicators for the PrOs	Weightage 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 EQUIPMENTS/ INSTRUMENTS REQUIRED

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

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Continuous Stirred Tank Reactor Assembly, MOC: SS 304, Cap.: 2-3 Ltrs , With Stirrer MOC :SS 304 (With Suitable motor)	10
2	Reactor with Glass Tube (Standard Company), (12 mm Dia * 1 M Length), with Rota Meter and Tank, With Air Compressor	11
3	Semi Batch Reactor, 2-3 Ltrs Cap, MOC SS 304, With Stirrer , MOC SS 304	12

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

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit – I Basics of Chemical Reactions	1a. Differentiate between various types of reactions such as chemical reactions Catalytic vs. Non-catalytic and the like 1b. Describe Biochemical Reaction 1c. Describe the factors affecting rate of reaction	1.1 Scope and importance of chemical reaction engineering 1.2 Classification of chemical reactions, a. Homogeneous vs. Heterogeneous, b. Catalytic vs. Non-catalytic c. Reversible vs. Irreversible d. By Molecularity e. Exothermic vs. Endothermic f. By order of reaction 1.3 Introduction to Biochemical reaction 1.4 Reaction rate on various basis and variables affecting the rate of reaction
Unit– II Kinetics of	2a. Derive the rate law 2b. Calculate rate constant	2.1 Rate equation/ Rate law 2.2 Concentration dependent term of rate Equation, Rate constant, Elementary and

Homogeneous Reactions	2c. Estimate Molecularity and order of reaction 2d. Explain temperature dependency from Arrhenius law 2e. Describe the significance of activation energy 2f.Calculate activation energy	non-elementary reactions 2.3 Molecularity and order of reaction 2.4 Temperature dependent term of rate Equation, Temperature dependency from Arrhenius law 2.5 Activation energy
Unit– III **Interpretation of batch reactor data**	3a. Describe the methods for analysis of kinetic data 3b. Explain the relationships for constant volume batch reaction system 3c. Derive integrated rate equation	3.1 Methods for analysis of kinetic data Differential vs. Integral method Half-life method 3.2 Relationship for constant volume batch reaction system 3.3 Total pressure of the system and the partial pressure of reacting material Concentration and Conversion 3.4 Integrated rate equation for different order of irreversible reactions: Uni-molecular first order, Bi-molecular, Second order, Tri-molecular third order, nth order, Zero order
Unit– IV **Ideal reactors**	4a. Describe ideal reactors 4b. Describe the construction, benefits, limitations and applications of different types of reactors such as batch reactors and others. 4c. Describe the construction, benefits, limitations and applications of different types of multiphase reactors such as slurry reactor and others	4.1 Features of ideal reactors 4.2 Different types of reactors: Batch reactor, Semi batch reactor, Flow reactors, MFR/CSTR, PFR (Tubular), Fixed bed reactors, Fluidized bed reactors 4.3 Multi phase reactors: G-L-S reactor, Slurry reactor, Bubble column reactor, Spray reactor, Trickle bed reactor
Unit– V **Design of single Ideal reactor**	5a. Explain the performance equation of different types of reactors such as Ideal batch reactor and other 5b. Explain space time and space velocity 5c. Differentiate holding time and Space time 5d. Calculate time/volume of reactor.	5.1 Performance equation of : Single Ideal reactor for Single reaction Constant density system, Ideal batch reactor, Steady state mixed flow reactor, Steady state plug flow reactor 5.2 Flow reactors: Space time, Space velocity, Holding time Vs. Space time

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	Basics of Chemical Reactions	6	3	4	3	10
II	Kinetics of Homogeneous Reactions	8	4	6	4	14
III	Interpretation of batch reactor data	8	4	6	4	14
IV	Ideal reactors	10	6	6	4	16
V	Design of single Ideal reactor	10	4	5	7	16
Total		**42**	**21**	**27**	**22**	**70**

Legends: R = Remember, **U** = Understand, **A**= Apply and above Level (Bloom's revised 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.

Sr. No.	Micro Project
1.	Power Point Presentation on All the Topics of the syllabus.
2.	Prepare a chart on Classification of the Reactions.
3.	Prepare a chart on Arrhenius Law.
4.	Prepare a chart on comparison of Differential & Integral Method.
5.	Prepare a chart or model of Batch Reactor.
6.	Prepare a chart or model of Semi Batch Reactor.
7.	Prepare a chart or model of Continuous Stirred Tank Reactor.
8.	Prepare a chart or model of Plug Flow Reactor.
9.	Prepare a chart or model of Fixed Bed Reactor.
10.	Prepare a chart or model of Fluidized Bed Reactor.
11.	Prepare a chart or model of different multi-phase reactor.
12.	Prepare chart on Performance Equation of different types of Ideal Reactor.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Chemical Reaction Engineering	Octave Levenspiel	Third Edition, John Wiley and Sons
2	Essentials of Chemical Reaction	H. Scott Fogler	Fourth Edition, Prentice Hall

	Engineering		International
3	The Engineering of Chemical Reactions	Lanny D. Schmidt	Second Edition, Oxford University Press

14. SOFTWARE/LEARNING WEBSITES

1. http://nptel.ac.in/courses/103108097/
2. http://www.umich.edu/~elements/toc/frames.html
3. http://ocw.mit.edu/courses/chemical-engineering/10-37-chemical-and-biologicalreaction-engineering-spring-2007/lecture-notes/
4. https://www.youtube.com/watch?v=DpLAsVcofao&list=PLwdnzlV3ogoUC9IWVOPTGqV5eEVNRAfGa
5. https://www.youtube.com/watch?v=uNC9acjbK2c&list=PLwdnzlV3ogoUC9IWVOPTGqV5eEVNRAfGa&index=3
6. https://www.youtube.com/watch?v=w3DcsesIYyo&list=PLidJKPid3sndR_OdT8OU5oC2I6-Qa4pAO&index=2
7. https://www.youtube.com/watch?v=kHmOntjDT1I&list=PLidJKPid3sndR_OdT8OU5oC2I6-Qa4pAO&index=3

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	To operate & maintain different kind of chemical reactor to produce chemicals with good quality and minimum cost.						
CO 1) Describe fundamental aspects of various chemical reactions.	3.0	--	--	2.0	1.0	1.0	2.0
CO 2) Determine rate, rate constant, activation energy and order of reaction.	3.0	1.0	3.0	2.0	1.0	1.0	1.0
CO 3) Analyze kinetic data to find out rate equation for batch reactor.	3.0	2.0	3.0	2.0	1.0	1.0	--
CO 4) Control different reactors efficiently using fundamental knowledge of their functioning.	3.0	1.0	1.0	2.0	2.0	1.0	2.0
CO 5) Estimate volume, space time and space velocity for Ideal reactors.	3.0	2.0	2.0	2.0	--	1.0	--

*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	Mr. ACHARYA MAULIK RAMESHBHAI	GOVERNMENT POLYTECHNIC, GANDHINNAGAR	9924222100	acharya.maulik@gmail.com
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GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)
Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester- 5
Course Title: Petroleum Refining and Petrochemical Technology
(Course Code: 4360502)

Diploma programme in which this course is offered	Semester in which offered
Chemical Engineering	5th Semester

1. RATIONALE

Petroleum refining plays a critical role in the global economy. Petroleum refining and petrochemical industries are major industries which essentially produce fuels and other wide varieties of products which are used every day. A diploma chemical engineer has to apply relevant concepts to ensure safe and efficient industrial operation in refineries and petrochemical industries. As environmental regulations are being stringent day by day there is a need to make proper quality checks and testing of petroleum products. This course is designed to develop such competency and skills.

2. COMPETENCY

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

- Supervise petroleum refinery and petro-chemical plant

3. COURSE OUTCOMES (COs)

The theory should be taught and practical should be carried out in such a manner that students are able to acquire required learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

- Analyze properties of crude petroleum and petroleum products
- Explain fractionation of crude petroleum and treatment techniques
- Apply refinery processes to maximize desired petro products
- Explain manufacturing processes of petrochemicals

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	2	4	30	70	25	25	150

5. SUGGESTED PRACTICAL EXERCISES

The practical/exercises should be properly designed and implemented with an attempt to develop different types of practical skills (Course Outcomes in psychomotor and affective domain) so that students are able to acquire the competencies (Programme Outcomes). Following is the list of practical exercises for guidance. Note: Here only Course Outcomes in the psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of Programme Outcomes/Course Outcomes in affective domain as given in a common list at the beginning of curriculum document for this programme. Faculty should refer to that common list and should ensure that students also acquire those Programme Outcomes/Course Outcomes related to affective domain.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1.	Prepare a detail chart of modern refinery	I	02
2.	Prepare a detail chart of petrochemical products	V	02
3.	Determine flash point of petroleum product by Penskey Martin method.	I	02
4.	Determine fire point of petroleum product by Penskey Martin method.	II	02
5.	Measure softening point of petroleum product.	II	02
6.	Measure Aniline point of petroleum product.	II	02
7.	Determine penetration number of Grease.	II	02
8.	Determine Carbon residue by Ram's bottom method.	II	02
9.	Determine Carbon residue by conradson method	II	02
10.	Measure smoke point of kerosene.	II	02
11.	Measure cloud point of given petroleum product.	II	02
12.	Measures pour point of given petroleum product.	II	02
13.	Measure initial & final boiling point of petroleum product.	II	02
14.	Measure Viscosity of lube oil by Redwood /Saybolt/Engler viscometer	II	02
			28 Hrs.

S.No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Handling of apparatus for precise measurements	10
2	Record observations correctly	10
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 EQUIPMENTS/ INSTRUMENTS 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 way other than the desired skills is developing in students.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Penskey Martin Apparatus: Electrical heating with gas test jet and electric heater with energy regulator. Assembly is resting in an air bath which is covered with a dome shaped metal top. The cup is fitted with an insulated handle and locking arrangement. The round shaped heater with a different temperature regulation system suitable for operation on 220 Volts AC mains.	3,4
2	Softening point Apparatus: Ring and Ball Apparatus with electric motorized stirrer and electric heater, concealed hot plate with temperature regulator.	5
3	Penetrometer: A rack, pinion and pointer assembly, dial is graduated from 0-400 in on tenth millimeter sub division. Two sample containers made of Aluminium, round dial fitted on Aluminium painted stand having	7

	adjustable penetration needle, holder sample container and transfer dish.	
4	Ram's bottom Apparatus: It consists of a solid metal bath having walls to accommodate cocking bulbs with heating elements around the bath, the temperature may be controlled by a Pyrometer depending upon the type supplied, and cocking bulbs are supplied with apparatus.	8
5	Conradson Apparatus: The Apparatus consists of a Spun Sheet Iron Crucible, porcelain crucible, and sheet iron hood and sheet iron block on a stand with triangular wire bridge.	9
6	Smoke point apparatus: The complete assembly consists of a brass lamp body with chimney, 0-50mm black glass scale with white markings, brass plated door with curved glass window, a candle socket, plated brass candle with wick tube & air vent, a mirror can be attached to the chimney to aid smoke detection and mounted on a cast iron base with aluminum support rod.	10
7	Cloud and pour point Apparatus: It consists of a main cooling bath made of stainless steel sheet and stand unit with drain plug and cover with provision for fitting thermometer and a filling aperture for adding freezing mixture. A glass jar for containing oils, jacket, disc and gasket.	11, 12
8	Distillation Apparatus: The instrument consists of metal shield fitted with asbestos board to support distillation flask with height adjustable device. It has a slide for the vapor tube and lining with a glass window for clear view of inside objects. The condenser bath is provided with a Mild Steel black painted stand. Electrically operated on 220 volts AC mains.	13
9	Redwood Viscometer: Redwood Viscometer No.1 comprises Stainless steel bath with electrical heating arrangement suitable to operate at 220 Volts AC Mains with tap, oil cup with precision stainless steel jet, cup cover, ball valve, and thermometer-clip. Stirrer and stand.	14
10	Saybolt apparatus: Stainless Steel bath with oil cup which is centrally placed in a water bath. The bath has a lid which contains a Water Cooling Tube, Two handles with Two Stirrer Blades, Thermometer socket, Straight heater; Stirring is done by turntable arrangement.	14
11	Engler Viscometer: It consists of a stainless steel water bath having an oil cup with a double walled lid. The water bath with a stirring device mounted on a stand. A thermometer clip to the water bath and the oil cup	14

	lid has a thermometer socket. The bath is fitted with a 500 watts heater. It is supplied with a wooden or ebonite valve to fit the jet. It can operate on 220 Volts AC mains.	
12	Glassware: Beaker, Thermometer, Measuring cylinder, funnel, Round bottom flask	All
13	Accessories: Burner, Stand	All
14	Materials: Petrol, Diesel, Kerosene, Lube oil, Grease, Aniline	All

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 housekeeping
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	**Unit Outcomes (UOs)** (in cognitive domain)	**Topics and Sub-topics**
Unit – I Basics of Petroleum and Refinery	1 a. State basic occurrence of petroleum 1 b. Explain composition of petroleum 1 c. Classify Petroleum 1d. Explain various types of refineries 1 e. Explain types of refinery Process 1 f. List Various refinery Products	1.1 Occurrence of petroleum 1.2 Composition of Petroleum 1.3 Classification of Petroleum 1.4 Types of Refineries 1.5 Refinery processes 1.5.1 Physical Changes 1.5.2 Chemical Changes 1.6 Refinery Products

Unit– II Fractionation of Petroleum	2 a. Explain primary treatment of crude oil	2.1 Primary treatment of crude 2.1.1 Dehydration and Desalting of crude oil 2.1.2 Pipe still heaters
	2 b. Explain distillation of crude oil and crude residue	2.2 Atmospheric distillation of crude 2.3 Vacuum distillation of crude residue
	2 c. List important physical properties of various petroleum products 2 d. Define physical properties of petroleum products with their importance 2 e. Explain test methods of important physical properties 2 f. Measure physical properties of petroleum products	2.4 Physical properties of petroleum products and its measurements : 2.5.1 Petrol 2.5.2 Diesel 2.5.3 Kerosene 2.5.4 Lubricant oil 2.5.5 CNG and LPG 2.5.6 Grease
Unit– III Refinery Processes	3a. Compare Cracking methods 3a.1 Explain Purpose of cracking 3a.2 Explain effect of temperature and pressure on Cracking 3a.3 Explain cracking methods	3.1 Cracking 3.1.1 Purpose of cracking 3.1.2 Effect of temperature and pressure on Cracking Cracking methods 3.1.3 Thermal cracking 3.1.3.a Visbreaking 3.1.3.b delayed coking and Fluid coking 3.1.4 Catalytic cracking 3.1.5. Fluidized bed catalytic cracking
	3b. Define reforming 3b.1 Explain need of Reforming 3b.2 Explain Pt catalyst-Reforming	3.2 Reforming 3.2.1 Purpose of Reforming 3.2.2 Plat forming(Pt catalyst-Reforming)
	3c. Define green refineries 3c.1 List raw materials and products of green refineries 3c.2 Advantages of green refineries 3c. 3 Explain manufacturing of Hydrogenated vegetable oil or green diesel	3.3 Green refineries 3.3.1 Raw materials and products of green refineries 3.3.2 Conversion of conventional refinery to green refinery 3.3.3 Manufacturing of Hydrogenated vegetable oil or green diesel

Unit– IV Treatment Techniques	4a. Explain the purposes of sulfur removal 4a.1 Explain methods of sulfur removal - Doctor's sweetening, Catalytic desulfurization, MEROX treatment 4b. Explain Treatment of Kerosene by liquid SO_2 extraction 4c. Distinguish solvent extraction processes – Furfural, Phenol 4d. Explain the Purpose of dewaxing 4e. Explain Ketone dewaxing	4.1 Purposes and methods of sulfur removal 4.2 Doctor's sweetening 4.3 Catalytic desulfurization 4.4 MEROX treatment 4.5 Treatment of Kerosene by liquid SO_2 extraction 4.6 Solvent extraction processes 4.6.1 Furfural extraction method 4.6.2 Phenol extraction method 4.7 Purpose of dewaxing Dewaxing Techniques 4.8 Dewaxing with solvent 4.9. Ketone dewaxing
Unit– V Petrochemicals	5a. Define petrochemicals 5a.1 Classify petrochemicals 5b. Explain manufacturing of - C1 compounds- Methanol and Formaldehyde -C2 compounds - Vinyl chloride and Ethylene Oxide - C3 compounds- Propylene oxide -Chemicals from aromatics- Linear Alkyl Benzene	5.1 Petrochemicals 5.2 Manufacturing of important C1 compounds 5.2.1 Methanol 5.2.2 Formaldehyde 5.3 Manufacturing of important C2 compounds 5.3.1 Vinyl chloride 5.3.2 Ethylene Oxide 5.4 Manufacturing of important C3 compounds 5.4.1 Propylene oxide 5.5 Chemicals from aromatics 5.5.1 Manufacture of Linear Alkyl Benzene

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	Basics of Petroleum and Refinery	4	4	2	2	8
II	Fractionation of Petroleum	8	4	4	3	11
III	Refinery Processes	9	5	6	3	14
IV	Treatment Techniques	10	6	6	5	17
V	Petrochemicals	11	8	6	6	20
Total		**42**	**27**	**24**	**19**	**70**

10. SUGGESTED STUDENT ACTIVITIES

Following is the list of proposed student activities. These could be individual and group based.

i. Course/topic based presentation

ii. Market survey of various petrochemical products of different manufacturers and their comparison based on their specification, composition and cost

iii. MCQ/Quiz

iv. Undertake micro-Project in team/individually

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

i. Lecture and demonstration of animated videos of refinery and petrochemical plant

ii. Arrange an industrial visit to nearby petrochemical industry

iii. 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.

iv. Massive open online courses (MOOCs) may be used to teach various topics/subtopics.

v. Guide students to address issues on environment and sustainability with reference to 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. 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 a 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 student sought 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 a chart of the properties of a given product petroleum product
2) Prepare a chart to demonstrate the refinery process.
3) Prepare a chart on classification of petroleum and petrochemicals
4) Prepare a chart on Test methods of given petroleum products
5) Prepare a power point presentation on fractionation of petroleum
6) Prepare a PowerPoint presentation or animation showing different types of refinery operations and processes
7) Prepare a report on recent trends in petroleum industries
8) Prepare a model of different petrochemical product flow diagram
9) Prepare a working/demo model of any petroleum testing equipment

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Modern Petroleum refining Processes	B. K. Bhaskar Rao	Oxford and IBH, 2007
2	Outlines of chemical Technology	M. Gopala Rao, Marshall Sitting	3rd Edition East-West Press Pvt. Ltd, Delhi
3	Shreve's Chemical Process Industries	Austin G.T.	McGraw Hill publication – New Delhi, 5th edition
4	A Text on Petrochemicals	B. K. Bhaskar Rao	2nd Edition, Khanna Publishers, Delhi, 1998
5	Petroleum Refinery Engineering	W. L. Nelson	McGraw Hill, New York, 1958

14. SOFTWARE/LEARNING WEBSITES

1. **https://onlinecourses.nptel.ac.in/noc23_ch64**
2. **https://www.e-education.psu.edu/fsc432/content/overview-refinery-products-and-processes**
3. http://www.setlab.com/resources/refining/solvent-extraction-dewaxing/#1498503459530-b4e0a336-25dd
4. https://thepetrosolutions.com/solvent-extraction-process-in-petroleum-oil-refinery/
5. https://www.e-education.psu.edu/fsc432/content/dewaxing
6. https://thepetrosolutions.com/thermal-cracking-process-in-oil-refinery/
7. https://www.linkedin.com/pulse/sustainable-fuel-production-green-refineries-answer-bpcl?trk=public_post
8. https://decarbonisationtechnology.com/article/132/conversion-to-a-green-refinery
9. https://renewable-carbon.eu/news/green-refinery/

15. PO-COMPETENCY-CO MAPPING

Semester	Petroleum Refining and Petrochemical Technology (4360502)						
	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	Supervise petroleum refinery and petro-chemical plant						
CO1: Analyze properties of crude petroleum and petroleum products	3.00	1.00	1.00	3.00	-	2.00	2.00
CO 2 : Explain fractionation of crude petroleum and treatment techniques	2.00	1.00	2.00	-	3.00	-	-
CO 3: Apply refinery processes to maximize desired petro products	3.00	1.00	1.00	-	2.00	-	1.00
CO 4: Explain manufacturing processes of petrochemicals	2.00	-	-	-	2.00	-	1.00

*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	Ms. S. M. Chauhan, Lecturer in Chemical Engineering	Government Polytechnic, Valsad	—----------	sejalmchauhan@gmail.com
2	Mr. R. V. Nayak, Lecturer in Chemical Engineering	Shri K. J. Polytechnic, Bharuch	—----------	rnayak_79@rediffmaill.com

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)
Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester- 6
Course Title: Project engineering
(Course Code: 4360503)

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

1.RATIONALE:

A project moves to completion through a series of stages starting from preliminary evaluation of economics and market to commercial production. Project engineering of a new chemical plant and the expansion or revision of existing one require the use of engineering principles and theories combined with consideration of practical limits imposed by industrial conditions. In this course special emphasis is given on the applied economics and engineering principles involved in the design of chemical plants. Use of these principles is highly required for any successful chemical engineer to work in the area of production, administration, sales, marketing, research, and development of a new chemical project.

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:

- **Gain knowledge of organization and implementation of project in terms of financial analysis when it comes to start up a new industry after undergoing all major subjects of chemical engineering.**
-

3. COURSE OUTCOMES (COs):

The theory, 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:

1. **Gain basic knowledge of chemical engineering plant and process design in industries.**
2. **Understand how a project to be started and concept of plant and process design.**
3. **Select process equipment or instruments of the same function based on both technical and commercial point of view.**
4. **Choose appropriate plant location and plant layout for project.**
5. **Apply knowledge of economic for project to run an industry in a profitable.**

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: 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'.*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
	Not Applicable		

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	Weightage 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 EQUIPMENTS/ INSTRUMENTS REQUIRED

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

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	**Not Applicable**	

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(Course Outcomes in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
Unit – I **Introduction**	1a. Describe role of Chemical Engineer. 1b. Justify the need of plant design. 1c. Explain chemical Engineering Design. 1d. Describe criteria for good designs. 1e. Explain Process design.	1.1 Role of Chemical Engineer. 1.2 Chemical Engineering Design. 1.3 Need of plant design. 1.4 Process Design 1.5 Design and selection of chemical engineering equipment 1.6 Criteria for good design
Unit– II Development of project for plant and process design	2a. List of chemical engineering plant project objective 2b. Describe process evolution stages. 2c. Explain pilot plant 2d. Explain components of chemical Engineering plant Design factor 2e. Explain source of information. 2f. Explain Process design and its components	2.1 chemical engineering plant project objective. 2.2 Process evolution stages and their Importance. 2.3 Plant design factors 2.3.1 Technical factors 2.3.2 Economic factors 2.3.3 Legal factors 2.3.4 Safety and sanitation. 2.4 Source of Information. 2.5 Continuous v/s Batch processing, 2.6 Shift and Operating schedules 2.7 Types of flow diagrams.

Unit– III **Selection of chemical engineering equipments**	3a. Explain Plan for selection of equipment 3b. Differentiate Standard and special equipment 3c. Prepare specification sheet for equipments 3d. Select appropriate equipments 3e. Explain piping and insulation 3f. Classify different insulation.	3.1 selection of material 3.2 Plan for selection of equipment 3.3 Selection of process equipments and specification sheet for equipment 3.4 Standard v/s Special equipment. 3.5 Selection of equipments (a) Size reduction equipment, (b) Heat transfer equipment, (c) Material handling equipment (d) Mass transfer equipment (e) Pumps 3.6 Piping, Pipe strength and wall thickness 3.7 Piping design problems, 3.8 Types of insulation, Factors governing selection of insulation.
Unit– IV **Plant Layout and Location**	4a. Describe principles of plant layout 4b. Explain factors affecting plant location	4.1 Factors of plant layout 4.2 Principles of plant layout 4.3 Factors for selection of plant location: Primary factors and specific factors
Unit– V **Economic evaluation of the project**	5a. Evaluate total capital investment 5b. Estimate equipment cost solve the numerical based on cost indices 5c. Explain types of depreciation 5d. Calculate depreciation using different methods 5e. Identify components of total product cost 5f. Estimate profitability 5g. Calculate break-even capacity	5.1 Capital investment. 5.2 Fixed capital investment, 5.3 Working capital investment. 5.4 Cost Indices, Cost-Size relation, and cost-Time relation. 5.5 Numerical based on Cost Indices 5.6 Depreciation and it's types 5.7 Methods for determining depreciations Arbitrary methods, Methods with interest on investment 5.8 Numeric based on depreciation. 5.9 Total product cost (TPC) 5.10 Net and gross earnings 5.11 Percent return on investment, Turnover ratio. 5.12 Break-even analysis (Analytical method) 5.13 Break-even chart (Graphical method) 5.14 Numerical of Break-even analysis

9.SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN:

Unit	Unit Title	Teaching	Distribution of Theory Marks

No.		Hours	R Level	U Level	A Level	Total Marks
I	**Introduction**	06	02	06	02	10
II	**Development of project for plant and process design**	08	02	10	04	16
III	**Selection of chemical engineering equipments**	10	02	10	04	16
IV	**Plant Layout and Location**	04	02	06	00	08
V	**Economic evaluation of the project**	14	04	08	08	20
Total		**42**	**12**	**40**	**18**	**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 are relatively simpler or descriptive are 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 a 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 student sought 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 economic evolution or cost estimation of given project.
2 Prepare chart of process design.
3 Prepare chart/model types flow diagram.
4 Prepare specification sheet of equipment of given project.
5 Draw suitable chart for plant design.
6 Prepare 15-20 slides power point presentation on any topic of project engineering.
7 Prepare material balance diagram of given project.
8 Prepare detailed IPD (instrumentation and process diagram) of given project.
9 Prepare plant layout of given project.
10 Prepare block flow diagram of given project.

13. SUGGESTED LEARNING RESOURCES:

(A) Books

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Chemical Engineering Plant Design.	Vilbrandt, Frank Carl and Dryden,Charles E.	McGraw Hill, New Delhi, 4th edition
2	Plant Design and Economics for Chemical Engineers,	Peters, Max and Klaus Timmerhaus	McGraw Hill, New Delhi, 4th edition
3	Chemical engineering Design *Principles, Practice and Economics of Plant and Process Design*	Gavin towler Ray sinnott	Butterworth-Heinemann Elsevier (2008)
4	Process Engineering Economics	Couper, James R.	Marcel and Dekker

14. SOFTWARE/LEARNING WEBSITES:

- https://nptel.ac.in
- www.cheresources.com
- http://people.clarkson.edu/~wwilcox/Design/refcosts.html
- http://app.knovel.com/web/toc.v/cid:kpCEDPPEP4
- https://www.lib.utexas.edu/chem/info/chemengecon.html
- http://www.mhhe.com/engcs/chemical/peters/data/ce.html

15. PO-COMPETENCY-CO MAPPING:

Semester	Project engineering (4360503)						
	POs						
Competency & Course Outco mes	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	**Gain knowledge of organization and implementation of project in terms of financial analysis when it comes to start up a new industry after undergoing all major subjects of chemical engineering.**						
Gain basic knowledge of chemical engineering plant and process design in industries.	**3**	**1**	**2**	**-**	**2**	**1**	**1**
Understand how a project to be started and concept of plant and process design.	**3**	**2**	**2**	**-**	**1**	**1**	**1**
Select process equipment or instruments of the same function based on both technical and commercial point of view.	**3**	**2**	**2**	**-**	**2**	**1**	**1**
Choose appropriate plant location and plant layout for project.	**2**	**1**	**2**	**-**	**1**	**1**	**1**
Apply knowledge of economic for project to run an industry in a profitable.	**2**	**3**	**2**	**-**	**1**	**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:

Sr. no	Name and Designation	Institute	Contact No.	Email
1	Mr. SHUKLA HARSH BHARATKUMAR	SHRI K. J. POLYTECHNIC, BHARUCH		hb_ch20@yahoo.com
2	Mr. CHIRAG RAJESHBHAI PARMAR	GOVERNMENT POLYTECHNIC, RAJKOT		chiragr3128@gmail.com

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)
Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester- VI
Course Title: Instrumentation and Process Control
(Course Code: 4360504)

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

1. RATIONALE

The course aims to provide students with a comprehensive understanding of process control and instrumentation. It covers the foundational principles of process control, including application of Laplace transform approach for single loop systems, analysis of dynamic responses in open and closed loop systems, Furthermore, the course delves into the practical application of various controllers, such as P, PI, PD and PID. In addition to control theory, the course emphasizes instrumentation for process control and offers hands-on experience. It covers the operational principles of different measuring devices for variables like temperature, level, pressure, and flow. The course also introduces students to the concept of PLC and DCS.

2. COMPETENCY

The course should be taught, and curriculum should be implemented with the aim to develop require skills so that students are able to acquire following competency: **Student will be able to apply the concept of process control and measure various process parameters in chemical industry.**

3. COURSE OUTCOMES (COs)

1) Apply the basic concept of process control in the chemical industry.
2) Apply basic concepts of various controllers in process control.
3) Select appropriate instruments to measure various process parameters in chemical plants.
4) Measure various process parameters in the chemical industry using relevant devices.

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	
2	0	2	3	30*	70	25	25	150

(*): 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 subcomponents of the Cos.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Dynamics Of First Order System (Step and Impulse Response Of thermometer)	1	02
2	Dynamics Of First Order System (Step Response of Single Tank Liquid Level System)	1	02
3	Dynamics Of Two First Order Systems Connected in Series (Step Response Non-Interacting System)	1	02
4	Dynamics Of Two First Order Systems Connected in Series (Impulse Response Non- Interacting System)	1	02
5	Dynamics Of Two First Order Systems Connected in Series (Step Response of Interacting System)	1	02
6	Dynamics Of Second Order System (Step Response Of U-Tube Manometer)	1	02
7	Measure level using direct method	4	02
8	Measure temperature of fluid using bimetallic thermometer	4	02
9	Measure temperature of fluid using thermocouple	4	02
10	Prepare a chart of components of DCS system	2	02
11	Measure specific gravity by Hydrometer	4	02
12	Level controller trainer	2	02
13	Flow controller trainer	2	02
	Total		**26Hrs.**

NOTE: 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.

The following are some sample (suggested) '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	Weightage 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 a practical report in prescribed format.	10
6	Solve assignment questions.	20
7	Viva-voce	10
	Total	100

6.MAJOR EQUIPMENTS/ INSTRUMENTS REQUIRED

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Interactive & Non-Interacting System Apparatus: Process Tank: Material Stainless Steel, Circular, with level scale (3 Nos.) Capacity: 2.5 to 3.5 liters. Supply Tank: Material Stainless steel, Capacity 20 liters. Overhead tank: Material Stainless steel, Capacity 5 liters. Water Circulation: FHP Pump, Tullu/Standard make. Piping: SS/PVC, size Flow Measurement: Rotameter. Instruction Manual: An ENGLISH instruction manual will be provided along with the Apparatus. The whole unit is assembled rigidly on a base plate. Most of the parts are powder coated and the rest are painted with auto paints. SERVICES REQUIRED Water supply Drain Electrical supply: 1 Phase, 220V AC, 0.5 kW. Table for set-up support. Processes when connected in interacting and non-interacting mode. It is a combined unit to study 1) Single capacity process. 2) Non interacting process different mode can be compared with mathematically predicted response. Setup consists of supply tank, pump for water circulation, Rota meter for flow measurement, process tanks with scales, which can be connected to interacting and non-interacting mode. The components are assembled on frame to form tabletop set-up. line-height:	3, 4, 5

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	Unit Outcomes (UOs)	Topics and Sub-topics
Unit – I Introduction of Process Control & Control Systems	1.Explain Need for control and automation in process control. 2.Explain Steady state and dynamic system. 3.Explain servo and regulatory system. 4.Development of Block diagram of process controller. 5.Apply basics of Laplace transform. 6.Explain Negative and positive feedback. 7. Explain First order system and second order system with examples of different systems.	1.1 Introduction of Process Control: Need for control and automation. 1.2 Steady state and dynamic system 1.3 Servo and regulatory control, Open and close loop block diagrams 1.4 The Control Systems: Block diagram, Standard block diagram symbols, Negative and positive feedback, Development of block diagrams, Process measuring element, Controller, Final control element. 1.5 Basic concept of Laplace transform. 1.6 First order system: Mercury thermometer, interacting and non-interacting liquid level system. 1.7 Second order system: U-Tube manometer.
Unit– II Controllers and Final Control Elements	1. Justify need for controllers. 2. Explain Pneumatic controller. mechanism of PI, PD, PID control. 3. Explain response of various modes of control. 4. Explain schematic of control loops. 5. Explain PLC, DCS system.	2.1 Controllers and Final Control Elements 2.1.1 Pneumatic controller mechanism of Proportional control, Proportional integral (PI) control, Proportional derivative (PD) control, Proportional integral derivative (PID) control. 2.1.2 Response of a typical control system showing the effects of various modes of control (no control, P, PI, PID) 2.1.3 Control loops: Temperature control, Pressure control, Flow control, Level control

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
		2.1.4 PLC, DCS
Unit– III Introduction to Process Measurement	1. Justify need for instrumentation in chemical plant. 2. Classify instruments in chemical plant. 3. Describe Basic elements of instruments. 4. Compare Static and Dynamic Characteristics of instruments. 5. Select appropriate instrument for measurement based on instrument range.	3.1 Introduction of Process Measurement: Importance of instrumentation in chemical plant 3.2 Classification of instruments 3.3 Basic elements of instruments 3.4 Static and dynamic characteristics 3.5 Selection criteria for various measuring devices in chemical industry for: Temperature, Pressure, Level and Flow
Unit– IV Measuring Devices	1. Compare different types of temperature measurement devices. 2. Explain Principle, Construction & Working of: Bi-metallic, Resistance thermometers, Industrial thermocouple, Radiation and optical Pyrometers. 3. Describe principal construction, and working of Bourdon tube gauge, Dead weight Gauge. 4. Describe principle, construction, and working of Target meter. 5. Classify and explain level measuring devices.	4.1 Temperature Measurement: 4.1.1 Principle, Construction & Working of: 4.1.1.1 Bi-metallic thermometer 4.1.1.2 Resistance thermometer 4.1.1.3 Industrial thermocouple: their principle, construction, working range, lead wires. 4.1.1.4 Radiation and optical Pyrometers 4.2 Pressure Measurement: 4.2.1 Pressure gauges: Principle, construction and working: 4.2.2.1 Bourdon tube gauge 4.2.2.2 Dead weight gauge 4.3 Flow Measurement: Principle, construction and working of Target meter 4.4 Measurement of head & level: Principle, construction and working: 4.4.1 Direct level measuring devices 4.4.1.1 Probe and tape 4.4.1.2 Sight glass 4.4.2 Indirect level measuring devices: 4.4.2.1 Air trap box method 4.4.2.2 Diaphragm box method

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 of Process Control & Control Systems	11	7	7	3	17
II	Controllers and Final Control Elements	07	8	8	3	19
III	Introduction of Process Measurement	03	4	3	1	8
IV	Measuring Devices	07	10	10	6	26
Total		**28**	**29**	**28**	**13**	**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 the 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 evidence 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 are relatively simpler or descriptive are 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 and Vlab 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 a dated work diary consisting of individual contributions to the project work and give a seminar presentation of it before submission. The duration of the microproject should be about 14-16 (fourteen to sixteen) student engagement hours during the course. The student sought to submit micro-project by the end of the semester (so that they develop industry-oriented COs).
A suggested 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 on working of PLC and DCS system.
2) Predict accuracy and precision of a standard measurement equipment
3) Prepare charts on First order dynamics for mixing process, temperature measurement, liquid level measurement etc.
4) Prepare a chart on liquid level equipment.
5) Prepare a PowerPoint presentation on a topic “P, PI, PD, PID controllers.”
6) Interpret PID diagram of a chemical industrial process.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year, and ISBN
1	Process Systems Analysis and Control	Donald Coughanowr, Steven E. LeBlanc	3rd edition, McGraw-Hill (2009)
2	Fundamentals of Industrial Instrumentation and Process Control	William C. Dunn	Mc-Graw-Hill (2005)
3	Industrial Instrumentation and Control	S.K. Singh	3rd edition, McGraw-Hill (2008)

Sr. No.	Title of Book	Author	Publication with place, year, and ISBN
4	Process Control and Instrumentation	R. P. Vyas	Denett & Co. (2015)
5	Industrial Instrumentation	Donald P. Eckman	John Wiley & Sons Inc, New York (2019)
6	Practical Process Control for Engineers and Technicians	Wolfgang Altmann	Elsevier Science (2005)
7	Chemical Process Control: An Introduction to Theory and Practice	George Stephanopoulos	Pearson Education India (2015)
8	Instrument Engineers' Handbook, Volume 1: Process Measurement and Analysis	Bela G. Liptak (Editor)	5th edition, CRC Press (2016)

14.SOFTWARE/LEARNING WEBSITES

Students can refer to video lectures available on websites including NPTEL.

- https://nptel.ac.in/courses/103103037
- https://www.tec-science.com/thermodynamics/temperature/how-does-a-bimetallic-strip-thermometer-work/ (Bimetallic thermometer animation)
- http://users.telenet.be/instrumentatie/temperature/temperature-scales.html (Temperature scales)
- https://en.wikipedia.org/wiki/Thermometer (Thermometer)
- https://instrumentationtools.com/bimetallic-thermometer/ (Bimetallic thermometer)

15.PO-COMPETENCY-CO MAPPING

Semester-VI	Instrumentation and Process Control (4360504)						
	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	**Student will be able to apply the concept of process control and measure various process parameters in chemical industry.**						
4360504.1	3	2	-	3	2	1	2
4360504.2	2	3	2	1	2	2	2
4360504.3	2	3	2	2	2	2	2
4360504.4	3	2	2	3	2	2	3

*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

Sr. No.	Name and Designation	Institute	Contact No.	Email
1	Mr. M.P Deshpande (Lecturer in chemical Engineering)	G.P Valsad	-	mehuldeshpande@gpvalsad.ac.in
2	Mr. J.D Rathod (Lecturer in chemical Engineering)	G.P Valsad	-	Jdrathod94@gmail.com

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2023(COGC-2021)
Semester-VI

Course Title: Chemical Engineering project -II
(Course Code: 4360505)

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	6thSemester

1. RATIONALE

Project work serves as a means for students to utilize their coursework knowledge and skills to solve particular problems or execute projects, ultimately fostering innovative skills. In addition, Developing a plant for a chemical product is a complex task that requires a comprehensive report encompassing various aspects such as the chemical process and unit operations, properties of raw materials and products, economic factors, safety and pollution issues, and material and energy consumption. Chemical engineering students need to prepare such reports to become successful entrepreneurs while keeping in mind sustainability factors. A wide range of sustainable chemical products can be chosen from different sectors, including petrochemicals, fertilizers, pharmaceuticals, pesticides, natural products, polymers, and dyes. Careful consideration must be given to Material balance, Energy balance, Economic evaluations, Safety, major equipment specifications, plant layout, and location to ensure the sustainability and success of the project. The syllabus provided is a guide, and instructors have the option to motivate students to develop prototypes, conduct experiments, or generate novel ideas that spark innovation.

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:

- **Experimentation/Research/ Understanding the manufacturing processes involved, Carry out material balance, Economic evaluations, Pollutions control, Safety and Waste Treatment etc.**

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:

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a) Apply the principles of material balance to calculate the mass flow in and out of a chemical process.
b) Select appropriate utilities for chemical production process.
c) Prepare plant layout for chemical production process.
d) Examine economic feasibility of the chemical plant.
e) Develop a strategy for ensuring safety and environmental protection.

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	
0	0	4	2	0	0	50	50	100

***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	Apply the principles of material balance to quantitatively calculate the mass flow in and out of a chemical process, ensuring the conservation of mass.	1	12
2	Select utilities for chemical manufacturing process.	2	4
3	Describe various utilities for chemical manufacturing process.	2	4
4	Evaluating a range of potential locations for a chemical plant.	3	8
5	Prepare plant layout	3	4
6	Explain Site selection parameters	3	4
7	Identify and categorize the various costs associated with plant establishment, operation, and maintenance.	4	4
8	Prepare Economic evaluation of plant.	4	8
9	Prepare MSDS for raw materials and Product.	5	4
10	Discuss appropriate waste treatment method.	5	4
		Total	**56**

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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 (The instructor is permitted to make slight modifications as deemed necessary).	Weight age in %
1	Clarity and organization of the report	20
2	Demonstration of technical knowledge	25
3	Significance of problem/solution/ conceptual feasibility analysis	15
4	Rigor and appropriateness of the methodology	15
5	Accuracy and relevance of the results	15
6	Analysis and interpretation of the results	05
7	Overall contribution to the field	05
	Total	**100**

6. MAJOR EQUIPMENT/INSTRUMENTS AND SOFTWARE REQUIRED: N/A

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.

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8. SUGGESTED COURSE DETAILS:

Unit	Major Learning Outcomes(Course Outcomes in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
Unit-I **Material Balance Calculations for Chemical Processes**	Apply the principles of material balance to quantitatively calculate the mass flow in and out of a chemical process, ensuring the conservation of mass.	1. Balancing Reactors: Mass in and out of chemical reactors, stoichiometry, extent of reaction, and conversion. 2. Distillation and Separation Processes: Mass in and out of distillation columns, separation efficiency, and component recovery. 3. Filtration and Separation: Mass flow in filtration, separation factors, and solid-liquid separation. 4. Sequential Processes: Mass balance through a series of unit operations, cumulative material balance. 5. Recycle and Bypass Streams: Handling recycle streams, calculating fresh feed requirements, and bypass streams.
Unit-II **Utilities in Chemical Manufacturing Processes**	Select utilities for chemical manufacturing process. Describe various utilities for chemical manufacturing process.	Utilities such as: Electricity, Water, Steam, Gases etc. in Chemical Processes.
Unit-III **Site selection and plant layout**	Evaluating a range of potential locations for a chemical plant. Prepare plant layout	1) Site Selection Parameters: Geographic Location, Infrastructure Availability, Environmental Impact and sustainability.

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	Explain Site selection parameters	2) Plant Location: Market Accessibility, Infrastructure Assessment, Cost Analysis, Site Evaluation. 3) Plant Layout: Space utilization and optimization, Material Handling, Safety Design, Environmental Considerations
Unit-IV **Economic assessment**	Identify and categorize the various costs associated with plant establishment, operation, and maintenance. Prepare Economic evaluation of plant.	Various costs associated with the design, construction, and operation of the plant such as: ROI, Revenue and Profitability, Payback Period, Total capital investment, Fixed Capital Investment, Working Capital Investment, Depreciation, Break even analysis etc.
Unit-V **Material Safety Information and Effective Waste Handling**	Identifying, evaluating, and communicating the hazards, safety measures with these substances, ensuring the safety and well-being of individuals and the environment.	1)For Raw Materials: Identification and Classification, Physical and Chemical Properties, Hazards Identification, First Aid Measures, Fire-Fighting Measures, Accidental Release Measures, Handling and Storage. 2) For Products: Transport Information, Disposal Considerations, Physical and Chemical Properties, Stability and Reactivity and remaining same as raw material.

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	Discuss appropriate waste treatment method for environmental safety and sustainability.	1) Waste Minimization and Source Reduction, Physical, chemical and biological Treatment. Recycling and Reuse, Emerging green Technologies and Innovations.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN:N/A

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

Following are the suggested student-related activities which can be undertaken to accelerate the attainment of the various outcomes in this course:

1. Industrial visit
2. Laboratories experiment
3. Literature Study
4. Attend Workshops
5. Internships
6. Take Part in Competitions
7. Course/topic based presentation

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) Faculty can act as mentors to their students, providing guidance and support as they work on their final year projects.
b) Faculty can facilitate group work, encourage peer feedback and provide opportunities for students to work together on projects.
c) Faculty can provide opportunities for students to work with laboratory equipment and conduct experiments, for example.
d) Guide students to address issues on environment and sustainability with

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reference to using the knowledge of this course.

e) Provide regular feedback and assessment on student work.
f) Faculty can provide resources and support for students to pursue their own interests and areas of study.
g) Faculty can provide opportunities for students to share their work with their peers and receive feedback.
h) Faculty can incorporate active learning strategies, such as group discussions and problem-solving activities, into their final year project instruction.

12. SUGGESTED MICRO-PROJECTS: N/A

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Books	Author	Publication with place, year and ISBN
1	Encyclopedia of Chemical Processing and Design	Jhon J. McKetta, William A. Cunninghalm	Marcel Dekker Inc., New York and Basel
2	Encyclopedia of Chemical Technology	Kirk and Othmer	John Wiley and Sons, Wiley Interscience
3	Ullman's Encyclopedia of Industrial Chemistry	Ullman	VCH Publishers, Germany
4	Chemical Process Technology Encyclopedia	Coincidine	McGraw-Hill
5	Perry's Chemical Engineers' Handbook	Robbert H. Perry, Down W. Green	McGraw-Hill
6	Plant Design and Economics for Chemical Engineers	Max Peters, Klaus Timmerhaus	McGraw Hill
7	Chemical Engineering Plant Design	Frank C. Vilbrandt, Charles E. Dryden	McGraw Hill
8	Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design	Gavin Towler, R. K. Sinnott	Butterworth-Heinemann
9	Process Engineering	James R. Couper	Marcel & Dekker Economics
10	Stoichiometry	B. I. Bhatt, S.M. Vora	Tata McGraw Hill
11	Safety and Accident Prevention in Chemical Operation	Faweett, Wood	Interscience Publishers
12	A course in Industrial Safety	K.U. Mistry	N.K.M. Publication

` GTU - COGC-2021 Curriculum

13	Pollution Control in Process Industries	S.P. Mahajan	Tata-McGrawHill
14	Safe Handling of Hazardous Chemicals	A.K. Rohatgi	J.K. Enterprise

14. SUGGESTED LEARNING WEBSITES

a) https://archive.nptel.ac.in/course.html
b) https://chemicalengineeringworld.com
c) https://www.chemengonline.com/
d) https://chemicalengineeringsite.in/

15. PO-COMPETENCY-CO MAPPING

Semester V	Chemical Engineering project –II(4360505)						
	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	Understanding the manufacturing processes involved, Carry out material balance, Energy balance, Economic evaluations, Pollutions control, Safety and Waste Treatment						
CO-1 Apply the principles of material balance to calculate the mass flow in and out of a chemical process.	2	1	1	1	-	1	-
CO-2 Select appropriate utilities for chemical production process.	1	-	2	-	2	1	1
CO-3 Prepare plant layout for chemical production process.	1	1	1	-	2	2	1
CO-4 Examine economic feasibility of the chemical plant.	2	1	1	-	1	2	2
CO-5 Develop a strategy for ensuring safety and environmental protection.	1	-	1	1	3	1	2

16. SUGGESTIVE PROJECT REPORT FORMAT

Diploma Engineering

Project Report

(Chemical Engineering project –I /II)

(4350508/4360505)

[CHEMICAL SEM-5/6]

Enrolment No	
Name	
Branch	
Academic Term	
Institute	

Directorate Of Technical Education

Gandhinagar - Gujarat

DTE's Vision:

- To provide globally competitive technical education;
- Remove geographical imbalances and inconsistencies;
- Develop student friendly resources with a special focus on girls' education and support to weaker sections.
- Develop programs relevant to industry and create a vibrant pool of technical professionals.

Institute's Vision:

Institute's Mission:

Department's Vision:

Department's Mission:

Certificate

This is to certify that Mr./Ms ……. Enrollment No. ……. of …… Semester of *Diploma in*……..of…… ……. (GTU Code) has satisfactorily completed the Project work in course **Chemical Engineering project –I/II (4350508/4360505)** for the academic year: …… Term: Odd/Even prescribed in the GTU curriculum.

Place:……..

Date: ……..

Signature of Project Guide **Head of the Department**

Instructions:

- Report should start with cover page consisting of GTU logo, institute logo and department logo, along with project details such as name and enrolment number of students, guide name, project title, and year of submission, semester etc.
- The report should consist of above three pages after the cover page.
- Report should include Acknowledgement, Abstract, Index, conclusion and references along with content.
- Report should be in Times new roman fonts only, with Main title size 16-bold, heading size 14 –bold, Sub heading 12-bold and main content size 12.
- Report should contain proper header and footer. The header should contain project title, subject code and year of project. Whereas footer should contain page number and department name. Size should be 10 in both header and footer.
- Please ensure that the project report adheres to the correct format, using your discretion.

- **Suggestive index for reference-Chemical engineering project-I**

Sr No.	Title	Page no.
1	Chemical Product Selection and Market Analysis	
	1.1 Introduction	
	1.2 Market analysis-Market size ,List of manufacturer, Availability of raw material etc.	
2	Product survey and Industry Analysis	
	2.1 Essential features and applications	
	2.2 Historical development	
	2.3 Current market trends	
3	Characteristics and Application	
	3.1 Chemical and physical properties of Raw materials	
	3.2 Chemical and physical properties of Final product	
	3.3 Application of final product	
4	Process Analysis	
	4.1 Different manufacturing processes	
	4.2 Merits, demerits of manufacturing processes	
	4.3 Engineering challenges of manufacturing processes	
	4.4 Various critical steps of production processes	
	4.4 Determine the most suitable sustainable process	
	4.5 Flow diagram of selected process with description	
	4.6 waste generation and environmental impact	
5	Major Process equipments and Instrumentation	
	5.1 Necessary equipments and instruments	
	5.2 Advantages and disadvantages of instruments and equipments	
	5.3 Selection criteria	
	5.4 Functions and roles of equipments and instruments	
6	Conclusion	
7	References	

- **Suggestive index for reference-Chemical engineering project-II**

Sr No.	Title	Page no.
1	Material Balance	
2	Utilities in Chemical Manufacturing Processes	
	2.1 List of utilities	
	2.2 Justification for selected utilities	
3	Site selection and plant layout	
	3.1 Site Selection Parameters	
	3.2 Plant Location Analysis	
	3.3 Plant layout	
4	Economic assessment	
	4.1 Costs associated with the design, construction, and operation	
5.	Material Safety Information	
	5.1 Raw Materials	
	5.2 Product	
	5.3 Specific safety concern	
6	Effective Waste Handling	
	6.1 List of waste generated	
	6.2 Waste treatment method	
	6.3 Emerging Sustainable- Green Technologies and Innovations	
7	Conclusion	
8	References	

17. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

Sr. No.	Name and Designation	Institute	Contact No.	Email ID
1	Mr. TARAKKUMAR CHANDRAKANTBHAI PADHIYAR (Lecturer in chemical Engineering)	SHRI K. J. POLYTECHNIC, BHARUCH	9879294415	tcp.gpv@gmail.com
2	Mr. JENISH DAMJIBHAI RUPAPARA (Lecturer in chemical Engineering)	GOVERNMENT POLYTECHNIC, GANDHINAGAR	7600694681	jenish.rupapara@gmail.com

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
2	Mr. Shivam N. Pandya	Shri. K.J.Polytechnic ,Bharuch		Pshivam.1992@gmail.com

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)
Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester - 6
Course Title: Process Equipment Design
(Course Code: 4360507)

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

1. RATIONALE

Equipment design encompasses the process of defining various aspects of dimensions of equipments, such as diameter and length, along with the specification of thickness and the overall weight distribution across its components. Standard simulation software tools are readily available for the purpose of equipment design. Nevertheless, to effectively utilize these software applications and ensure their accurate implementation, a fundamental understanding of this field is crucial. Considering the rapid pace at which knowledge continues to evolve, it is imperative that students are well-informed about the most recent advancements in equipment design. This knowledge is especially vital for individuals aspiring to pursue careers as Design Engineers, Process Engineers, or Process Development Engineers. Furthermore, it proves beneficial for Production Engineers engaged in process plants, aiding them in effectively troubleshooting issues related to equipment operation.

2. COMPETENCY

To design various parts of process equipments and select the suitable equipment for the desired operation.

3. COURSE OUTCOMES (COs)

After applying the knowledge of chemical engineering in the field of the process design of the will achieve the following outcomes:

1. Understand the need of the process design in chemical engineering.
2. Apply the flow devices equipment design concept
3. Design of Heat Transfer Equipments
4. Design of Mass Transfer Equipments
5. Design of Chemical Process Reactors

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: 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

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to user in uniformity of practical's in all institutions across the state.

S. No.	Equipment Name with Broad Specifications	PrO. No.
Not Applicable		

7. AFFECTIVE DOMAIN OUTCOMES

The following sampleAffective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs andPrOs.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 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 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 Process Engineering Design	1a. Describe the scope of Process Engineering 1b. Convert units 1c. Calculate the numericals of Dimensionless Number 1d. Draw block diagram, PFD and P&ID for given manufacturing process.	1.1Introduction to Process Engineering 1.2 Calculations related to Unit conversions 1.3 Define and Calculate various dimensionless numbers used in Process Design 1.4 Introduction to Block Diagram, PFD and P&ID
Unit– II Design of Piping, Fluid Moving Devices and Flow Meters	2a. Discuss methods of Piping design 2b. Write down design steps of Fluid Moving devices. 2c. Calculations related Schedule Number 2d. Discuss on trouble-shooting of Fluid Flow Systems 2e. Discuss Rules of Thumb for process design of fluid flow systems	2.1 Introduction to Process Design of Piping and Fluid Moving Devices 2.2 Numericals on Schedule Number Equation 2.3 Power Required in Fan, Blower and in Adiabatic Compressor 2.4 Troubleshooting of Fluid Flow Systems 2.5 Rules of Thumb for process design of fluid flow systems
Unit– III Design of Heat Transfer Equipments	3a. Classify Heat Exchangers 3b. Discuss types of S&T HE 3c. Describe the various parts of S&T HE 3d. Compare different S&T HE 3e. Explain different types of TEMA designations 3f. List steps for general design method of S&T HE 3g. Explain criteria of selection between Horizontal and Vertical Condenser 3i. Recall rule of thumb for Process Design of Heat Exchanger	3.1 Various types of Heat Exchangers 3.2 Types of Shell and Tube Heat exchangers and its parts 3.3 Advantages and Disadvantages of Different Types of Shell and Tube Heat Exchangers Over Each Other 3.4 Different Types of TEMA Designations 3.5 Steps to Design Shell and Tube Heat Exchangers 3.6 Criteria of Selection between Horizontal Condenser and Vertical Condenser 3.7 Rules of Thumb for Process Design of Heat Exchanger

Unit– IV Design of Mass Transfer Equipments	4a. Classify Mass Transfer Equipments 4b. Recall the general steps for design of distillation column. 4c. Discuss the advantages and disadvantages of Vacuum distillation 4d. Discuss the ways of Identifying VLE of system 4e. Calculate No. of theoretical steps for binary distillation using McCabe-Thiele Method 4f. Discuss the criteria for selection of an absorber 4g. Describe various internals for packed tower. 4h. Describe various internals for tray tower. 4i. Explain Phase Equilibrium Diagram for LLE 4j. Discuss the selection criteria of solvent for LLE 4k. Write the general design steps for counter-current LLE. 4l. Recall the industrial applications for Mass Transfer Operations 4m. Recall rules of thumb for Process Design of Distillation Column, Absorber and LLE.	4.1 Introduction to Mass Transfer Equipment 4.2 General steps for design of distillation column. 4.3 Advantages and Disadvantages of Vacuum distillation 4.4 Determination of VLE data 4.5 No of theoretical stages using McCabe Thiele Method 4.6 Criteria for selection of absorber 4.7 Internals for packed and tray columns 4.8 Phase Equilibrium Diagram for LLE 4.9 Choice of Solvent for LLE 4.10 General design steps for counter-current LLE 4.11 Industrial applications of various mass transfer operations 4.12 Rules of Thumb for Process Design of Distillation Column, Absorber and LLE.
Unit– V Design of Reactors	5a. Classify reactors 5b. Discuss different types of mixing devices used in Reaction systems 5d. Types of Heating Jackets and Coils 5e. Classify multi-phase reactors 5f. Recall Rules of Thumb for process and mechanical design of reactors	5.1 Introduction to Process Design of Reactors 5.2 Different types of Reactors 5.3 Different Types of Agitators 5.4Heat Transfer in Batch Reactors 5.5 Introduction to different types of multi-phase reactors 5.6 Rules of Thumb for process and mechanical design of reactors

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 Process Engineering Design**	5	3	3	3	9

II	**Design of Piping, Fluid Moving Devices and Flow Meters**	8	3	4	7	14
III	**Design of Heat Transfer Equipments**	9	3	4	7	14
IV	**Design of Mass Transfer Equipments**	14	6	7	10	23
V	**Design of Reactors**	6	3	4	3	10
Total		**42**	**18**	**22**	**30**	**70**

Examiners' and Paper Setters must follow the marks scheme while design of Question Papers, however a difference (∓5%) is acceptable.

10. SUGGESTED STUDENT ACTIVITIES

- Open source software like DWSIM, Thermosolver, ChemSep can be used for property prediction and design.
- Students can refer to video lectures available on the websites including NPTEL lecture series.
- Students can develop their own programs/spreadsheets for the solution of problems.
- Students' must go through handbooks to learn how to find and estimate literature data.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

- Case Studies of Process Design Engineering Problems
- Suggest students how advancement in design can solve major engineering problems in manufacturing

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

1. Create drawing sheets on design of various parts of chemical engineering equipments.
2. Create drawing sheets for PFD and P&ID of various manufacturing process
3. Simulate chemical engineering processes in open sources process simulators
4. Use of spreadsheets for solving process calculations case study
5. Create small modular programs in open source softwares for iterative calculations

Faculties can give one or more of the above suggested micro-projects. This should relate highly to the competency of the course and the COs. Similar micro-projects could be added by the concerned course teacher.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Introduction To Process Engineering And Design	Shuchen B Thakore Bharat I Bhatt	Publisher: McGraw Hill Education; 2nd edition (2017), New Delhi ISBN-10: 935134178X ISBN-13: 978-9351341789
2	Chemical Engineering Design: Principles, Practice And Economics Of Plant And Process Design	Gavin Towler Ray Sinnott	Publisher: Butterworth-Heinemann Inc; 3rd edition (2021) ISBN-10 : 0128211792 ISBN-13: 978-0128211793
3	Ludwig's Applied Process Design for Chemical and Petrochemical Plants	A. Kayode Coker	Publisher: Gulf Professional Publishing; 4th edition (2010), ISBN-10: 075068366X ISBN-13: 978-0750683661
4	Perry's Chemical Engineers' Handbook	Don W. Green, Marylee Z. Southard	Publisher: McGraw Hill; 9th edition (2018), ISBN-10: 0071834087 ISBN-13: 978-0071834087
5	Chemical Process Equipment: Selection and Design	James R. Couper, W Roy Penney, James R. Fair	Publisher: Butterworth-Heinemann; 3rd edition (2012), ISBN-10 : 012396959X ISBN-13 : 978-0123969590
6	Rules Of Thumb For Chemical Engineers: A Manual Of Quick, Accurate Solutions To Everyday Process Engineering Problems	Carl Branan	Publisher: Elsevier (2008) ISBN-10: 813121737X ISBN-13: 978-8131217375
7	Process Engineering and Plant Design: The Complete Industrial Picture	Siddhartha Mukherjee	Publisher: CRC Press; 1st edition (2021), ISBN-10 : 0367248417 ISBN-13 : 978-0367248413
8	Chemical Process Equipment: Design And Drawing	Maidargi Suresh C.	Publisher: PHI Learning Pvt Ltd (2015), ISBN-10 : 9788120351509 ISBN-13 : 978-8120351509

14. SOFTWARE/LEARNING WEBSITES

1. https://sist.sathyabama.ac.in/sist_coursematerial/uploads/SCH1307.pdf
2. https://msubbu.in/ln/design/index.html
3. https://archive.nptel.ac.in/courses/103/107/103107207/

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							
CO1: Understand the need of the process design in chemical engineering.	3	-	-	2	1	-	1
CO 2: Apply the flow devices equipment design concept	2	3	2	1	-	-	2
CO 3: Design of Heat Transfer Equipments	3	3	3	1	1	-	2
CO 4: Design of Mass Transfer Equipments	3	3	3	1	1	-	2
CO 5: Design of Reactors	3	3	3	1	1	-	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

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GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)
Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester-VI
Course Title: Clean and Renewable Energy Production Technology
(Course Code: 4360508)

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

1. RATIONALE

The energy has become an important and one of the basic infrastructures for the economic development of the country. Diploma students undertaking this course are expected to understand the fundamentals of production of energy from different fossil fuels through cleaner routes as well as from renewable resources. It is intended to help the student to keep their knowledge upgraded with the current thoughts and newer technology options along with their advances in the field of the utilization of different types of energy resources for cleaner energy production.

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:

- **To Supervise operation and use Renewable Energy as an indicator global development**
- **Understanding technology of Renewable Energy Production**

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:

a) Identify types of energy as an indicator of global development
b) Analyze various energy sources from coal, petroleum crude and gaseous fuels
c) Apply concept of solar technology for energy production
d) Apply concept of wind technology for energy production
e) Apply concept of hydro and geothermal technology for energy production

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	70	30	0	0	100

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'*.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
Not Applicable			

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.

S.No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Question answer or Writing steps exercise (Assignment)	30
2	Executing of exercise	30
3	Result	40
Total		**100**

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 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	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit – I Introduction of energy	1a. Explain energy as an indicator of development	1.1 Define energy and importance of energy 1.2 Define clean energy and renewable energy 1.3 Explain Need of the clean and renewable energy
	1b. Explain World and Indian energy scenario	1.4 Explain World and Indian energy scenario
	1c. Comparison Routes for clean energy from fossil fuels and renewable energy	1.5 Comparison Routes for clean energy from fossil fuels and renewable energy
Unit– II Energy source from coal, petroleum and gaseous fuels	2a. Explain coal as a Source of Energy	2.1 Coal and its composition 2.2 Describe origin of coal 2.3 Types and properties of coal 2.4 Describe Coal pricing 2.5 Characterization of coal 2.5.1 Proximate analysis 2.5.2 Ultimate analysis
	2c. Explain petroleum as a source of energy	2.6 Define petroleum and its composition 2.7 Describe origin of petroleum 2.8 Types of petroleum 2.9 Properties of petroleum products 2.10 Pricing of petroleum 2.11 Characterization of petroleum 2.11.1 Density and API 2.11.2 Cetane and Octane number, 2.11.3 Aniline point and Diesel index 2.11.4 Reid vapor pressure
	2c. Gaseous Fuels: Properties and Routes for Energy Production	2.12 Types of gaseous fuels 2.13 Properties of gaseous fuels 2.14 Naturally available gaseous fuels 2.15 Applications of gaseous fuels
	2d. Numerical problem based on Energy source from coal, petroleum crude	2.16 Numerical problem based on Energy source from coal, petroleum crude

Unit– III Solar energy production	3a. Explain solar energy 3b. Explain total energy received from the sun 3c. Explain Solar Insolation 3d. List out application of solar energy 3e. Explain Techniques for solar energy production	3.1 Sun as a source of energy 3.2 Solar radiation and spectrum 3.3. Explain: 3.3.1 Angle of incidence 3.3.2 Tilt angle 3.3.3 Hour angle 3.3.4 Angle of declination 3.3.5 Latitude 3.4 Application of solar energy 3.5 Advantage and disadvantage of solar energy 3.6 Techniques for solar energy production or conversion to usable form 3.6.1 Solar thermal 3.6.2 Solar photovoltaic.
	3f. Numerical based on Solar energy production	3.7 Numerical based on Solar energy production
Unit– IV Wind energy production	4a. Explain Wind as a source of energy 4b. Types of wind machines 4c. Explain energy production from wind 4d. Explain Wind mills 4e. Explain wind energy in India	4.1 Wind as a source of energy 4.2 Wind energy system 4.3 Types of wind machines 4.4 Energy production from wind 4.5 Wind energy computation and the nature of wind 4.6 Describe Horizontal axis windmill and vertical axis windmill 4.7 Advantage and disadvantage of windmill 4.8 Wind energy in India and future of wind energy
	4f. Numerical based on wind energy production	4.9 Numerical based on wind energy production
Unit– V Production of hydro and geothermal energy	5a. Explain energy production from hydro 5b. Classify hydro power 5c. Mechanism of hydro energy production 5d. Explain Hydropower in India and world	5.1 Hydrologic cycle as a renewable energy source 5.2 Mechanism of hydro energy production 5.3 Components of hydro power plants and their role 5.4 Classification of hydro power 5.5 Advantages and disadvantages of hydropower 5.6 Hydropower in India and world

	5e. Explain energy production from geothermal 5f. Mechanism of conversion of geothermal energy to electricity	5.7 Geothermal energy as a source of renewable energy 5.8 Application routes of geothermal energy 5.9 Mechanism of conversion of geothermal energy to electricity 5.10 Different types of electricity production plant or scheme 5.11 Advantages and disadvantages geothermal energy 5.12 World scenario and Indian scenario geothermal energy
	5g.Numerical problem based on hydro and geothermal energy production	5.13 Numerical problem based on hydro and geothermal energy production

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 of energy	4	3	4	0	7
II	Energy source from coal, petroleum and gaseous fuels	12	7	8	5	20
III	Solar energy production	8	4	6	4	14
IV	Wind energy production	8	4	6	4	14
V	Production of hydro and geothermal energy	10	6	5	4	15
Total		**42**	**24**	**29**	**17**	**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

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 renewable energy
2	Prepare chart of Characterization of coal
3	Prepare chart/model types of Horizontal axis windmill
4	Draw suitable chart for techniques for solar energy production
5	Prepare 15-20 slides power point presentation showing geothermal energy as a

	source of renewable energy
6	Prepare 15-20 slides power point presentation on hydro energy production
7	Prepare 15-20 slides power point presentation on types of wind machines
8	Prepare a demonstrative model of Horizontal axis windmill, vertical axis windmill
9	Prepare a demonstrative model of wind energy
10	Prepare Working model of wind energy/Solar energy

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Energy Sources	G. D. Rai	2nd Ed. by Khanna Publications, New Delhi
2	Energy Technology	Rao & Parulaker	Khanna Publications
3	Renewable Energy Resources	Twidel, J. and Tony W.	Second Edition, Taylor & Francis 2006
4	Energy Management and Conservation	Kreith F., Goswami D.Y.	CRC Press 2008
5	Solar Energy: Principles of thermal Collection and Storage	Sukhatme S., J Nayak J.	3 rd Ed., Tata McGrow-Hill Pulishing Company Ltd. 2008
5	Sustainable utilization of natural resources	Mondal P and Dalai A	CRC Press 2017
6	Renewable Energy Engineering	J.P. Hadiya and H.G. Katariya	Books India Publications Second edition 2018

14. SOFTWARE/LEARNING WEBSITES

https://archive.nptel.ac.in/courses/103/107/103107157/
www.vlab.co.in
https://ndl.iitkgp.ac.in
https://youtu.be/wsz-LEFuLdc
https://www.un.org/en/climatechange/what-is-renewable-energy
https://www.nationalgrid.com/stories/energy-explained/what-is-green-energy

15. PO-COMPETENCY-CO MAPPING

Semester VI	Clean and Renewable Energy Production Technology (4360508)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific	PO 2 Problem Analysi	PO 3 Design/ development of	PO 4 Engineering Tools, Experimenta	PO 5 Engineering practices for society,	PO 6 Project Management	PO 7 Life- long learning

	knowledge	s	solutions	tion & Testing	sustainability & environment		
Competency	**To Supervise operation and Identify types of energy as an indicator global development**						
Identify types of energy as an indicator of global development	2	1	1	-	2	1	2
Analyze various energy sources from coal, petroleum crude and gaseous fuels	2	3	3	1	2	1	2
Apply concept of solar technology for energy production	1	3	3	-	2	1	2
Apply concept of wind technology for energy production	1	3	3	-	2	1	2
Apply concept of hydro and geothermal technology for energy production	1	3	3	-	2	1	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

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