Vishwakarma Government Engineering College

Chemical Engineering Department

SYLLABUS

[FROM JULY 2024 ONWARDS]

TEACHING SCHEME / DETAIL SYLLABUS

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BE

05 - CHEMICAL ENGINEERING

1

2024-25

Select Elective / Non-Elective

Subject Code

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*L=lectures,T=tutorial,P=Practical,E=TheoryExternal,M=TheoryInternal,I=Practical Internal,V=Practical External,On Job Training(OJT) is equivalent to Practical

							Hours			Credit	Max Marks					
Exp.	Subcode	Branch code	Eff_from	SubjectName	Category	Sem /Year	L.	T.	P.	PBL	Total	E	M	I	V	Total
	BE01000011	005	2024-25	Student Induction Program with essence of Indian Knowledge System	Mandatory Non-Credit Courses – Audit Course	1	0	0	0	NA	0	0	0	0	0	0
	BE01000021	005	2024-25	Physics	Basic Science Courses	1	3	0	2	NA	4	70	30	20	30	150
	BE01000031	005	2024-25	Chemistry	Basic Science Courses	1	3	0	2	NA	4	70	30	20	30	150
	BE01000041	005	2024-25	Mathematics-I	Basic Science Courses	1	3	1	0	NA	4	70	30	0	0	100
	BE01000051	005	2024-25	Basic Electrical Engineering	Engineering Science Courses	1	3	0	2	NA	4	70	30	20	30	150
	BE01000061	005	2024-25	Engineering Graphics & Design	Engineering Science Courses	1	1	0	2	NA	2	70	30	20	30	150
	BE01000071	005	2024-25	Design Thinking	Engineering Science Courses	1	0	0	4	NA	2	0	0	20	80	100
	BE01000081	005	2024-25	Basic Mechanical Engineering	Engineering Science Courses	1	3	0	2	NA	4	70	30	20	30	150
	BE01000101	005	2024-25	Basic Civil Engineering	Engineering Science Courses	1	3	0	2	NA	4	70	30	20	30	150
	BE01000111	005	2024-25	Basic Electronics Engineering	Engineering Science Courses	1	3	0	2	NA	4	70	30	20	30	150
	BE01000121	005	2024-25	Programming for Problem Solving	Engineering Science Courses	1	2	0	4	NA	4	70	30	20	30	150

BE01000131	005	2024-25	Workshop and Manufacturing Practices	Engineering Science Courses	1	0	0	2	NA	1	0	0	20	80	100
BE01000141	005	2024-25	Universal Human Values	Humanities and Social Science, including Management Courses	1	2	0	0	NA	2	70	30	0	0	100
BE01000151	005	2024-25	Contributor Personality Development Program	Humanities and Social Science, including Management Courses	1	2	0	0	NA	2	70	30	0	0	100
BE01000161	005	2024-25	Integrated Personality Development Course	Humanities and Social Science, including Management Courses	1	2	0	0	NA	2	70	30	0	0	100
BE01R00011	005	2025-26	Student Induction Program with essence of Indian Knowledge System	Mandatory Non-Credit Courses – Audit Course	1	0	0	0	0	0	0	0	0	0	0
BE01R00021	005	2025-26	Physics	Basic Science Courses	1	45	0	30	45	4	70	30	50	50	200
BE01R00031	005	2025-26	Chemistry	Basic Science Courses	1	45	0	30	45	4	70	30	50	50	200
BE01R00041	005	2025-26	Mathematics-I	Basic Science Courses	1	30	30	0	60	4	70	30	30	0	130
BE01R00051	005	2025-26	Basic Electrical Engineering	Engineering Science Courses	1	45	0	30	45	4	70	30	50	50	200
BE01R00061	005	2025-26	Engineering Graphics & Design	Engineering Science Courses	1	15	0	30	15	2	70	30	50	50	200
BE01R00071	005	2025-26	Design Thinking	Engineering Science Courses	1	0	0	60	0	2	0	0	20	80	100
BE01R00081	005	2025-26	Basic Mechanical Engineering	Engineering Science Courses	1	45	0	30	45	4	70	30	50	50	200
BE01R00101	005	2025-26	Basic Civil Engineering	Engineering Science Courses	1	45	0	30	45	4	70	30	50	50	200
BE01R00111	005	2025-26	Basic Electronics Engineering	Engineering Science Courses	1	45	0	30	45	4	70	30	50	50	200
BE01R00121	005	2025-26	Programming for Problem Solving	Engineering Science Courses	1	30	0	60	30	4	70	30	50	50	200
BE01R00131	005	2025-26	Workshop and Manufacturing Practices	Engineering Science Courses	1	0	0	30	0	1	0	0	20	80	100
BE01R00141	005	2025-26	Universal Human Values	Humanities and Social Science, including Management Courses	1	30	0	0	30	2	70	30	30	0	130
BE01R00151	005	2025-26	Contributor Personality Development Program	Humanities and Social Science, including Management Courses	1	30	0	0	30	2	70	30	30	0	130
BE01R00161	005	2025-26	Integrated Personality Development Course	Humanities and Social Science, including Management Courses	1	30	0	0	30	2	70	30	30	0	130

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GUJARAT TECHNOLOGICAL UNIVERSITY
(Established by Government of Gujarat under Gujarat Act No.:20 of 2007)
ગુજરાત ટેકનોલોજીકલ યુનિવર્સિટી
(ગુજરાત સરકારના ગુજરાત અધિનિયમ ક્રમાંક : ૨૦/૨૦૦૭ દ્વારા સ્થાપિત)
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Gujarat Technological University

Student Induction Program (SIP) Guidelines for UG Engineering

w.e.f. Academic Year 2024-25

Student Induction Program (SIP) Guidelines for UG Engineering

Induction training for 3 weeks is mandatory for first year UG Engineering students. The 3-weeks Student Induction Program will help newly admitted undergraduate students for the new stage in their life by facilitating a smooth transition from their home and school environment into the college and university environment through various discussions and activities before formal classes begin. In line with the thoughts expressed in the NEP 2020, the SIP consists of 9 modules – one on Universal Human Values, one on health, five on Indian Knowledge System (modules 4, 5, 7, 8 and 9) and two on skills (modules 3 and 6). The details of modules are mentioned below -

MODULE	Hours
SIP Module 1: Universal Human Values I (UHV I)	**10**
The purpose is to help develop a holistic perspective about life. A universal self-reflective methodology of teaching is adopted. It opens the space for the student to explore his/her role (value) in all aspects of living – as an individual, as a member of a family, as a part of the society and as a unit in nature. Through this process of self-exploration, students are able to discover the values intrinsic in them.	
SIP Module 2: Physical Health and Related Activities	**24**
This module is intended to help understand the basic principles to remain healthy and fit and practice them through a healthy routine which includes exercise, games, sports etc.	
SIP Module 3: Familiarization of Department/ Branch and Innovation	**2**
This module is for introducing and relating the student to the institution/department/branch; how it plays a role in the development of the society, the state, region, nation and the world at large and how students can participate in it.	
SIP Module 4: Visit to a Local Area	**6**
To relate to the social environment of the educational institution as well as the area in which it is situated through interaction with the people, place, history, and politics.	
SIP Module 5: Lectures by Eminent People	**2**
Listening to the life and times of eminent people from various fields like academics, industry etc. about careers, art, self-management and so on enriches the student's perspective and provides a holistic learning experience.	
SIP Module 6: Proficiency Modules	**4**
This module is to help fill the gaps in basic competency required for further inputs to be absorbed. It includes effort to make students proficient in interpersonal communication and expression as well as awareness about linguistics and thereafter NLP.	

SIP Module 7: Literature / Literary Activities including Indian Knowledge System-I (IKS-I)	**16**
Through the exposure of local, national and international literature, this module is aimed at helping the student explore by practicing traditional as well as contemporary values and thought.	
SIP Module 8: Creative Practices	**24**
This module is to help develop the clarity of humanistic culture and its creative, joyful expression through practice of art forms like dance, drama, music, painting, pottery, sculpture etc. Local, national and international case studies, particularly Indian Knowledge Systems, Languages, Culture and Values.	
SIP Module 9: Other Co-curricular Activities	**2**
This is a category under which things that are not placed in any of the above may be placed. Some clubs and hobby groups may be made for each of the above categories, so that students may pursue them even after SIP.	
TOTAL	**90**

SIP Calendar for Bachelor of Engineering

Week	Week 1					Week 2					Week 3				
Session	Mon	Tues	Wed	Thu	Fri	Mon	Tues	Wed	Thu	Fri	Mon	Tues	Wed	Thu	Fri
S- 1	M-3	M-5	M-1	M-1	M-1	M-1	M-1	M-7	M-7	M-7	M-7	M-7	M-7	M-9	M-4
S- 2	M-8	M-8	M-8	M-8	M-8	M-8	M-8	M-8	M-8	M-8	M-8	M-8	M-7	M-7	M-4
S- 3	M-2	M-2	M-2	M-2	M-2	M-2	M-2	M-2	M-2	M-2	M-2	M-2	M-6	M-6	M-4

Note:

- **S-1, S-2 and S-3 are Session 1, 2 and 3 per day.**
- **One session is of two hours.**
- **Mon –Monday, Tues-Tuesday and so on…**
- **M-1, M-2, M-3… are Module 1, 2, 3… and so on…**

Module 1 - Universal Human Value I (UHV I) (10 Hours)

The course is meticulously crafted to nurture students' holistic perspective on life. Our teaching approach is inherently self-reflective, fostering dialogue between students and faculty. It provides a platform for students to delve into their roles and values across various life domains: as individuals, family members, societal contributors, and integral parts of nature. By championing universal human values, the course fosters self-exploration, enhancing comprehension and coherence regarding the universality of human existence. Through this introspective journey, students unearth their intrinsic values, fostering joy in learning, resilience against peer pressure, and the courage to make informed decisions.

This foundational module, integral to the Student Induction Program (SIP), aims to broaden students' understanding of life's complexities, enriching their holistic perspective. Ultimately, these understanding shapes their values, behavior, and quality of life. The curriculum traverse individual, societal, and ecological dimensions, shedding light on diverse interpersonal relationships, human aspirations, and the symbiotic relationship with nature. Emphasizing the paramount importance of health, it underscores the thread that weaves through all endeavors.

The detailed objectives of the Universal Human Values (UHV) module (UHV-I) are as follows:

- Cultivate a holistic life perspective.
- Sensitize students to life's breadth – from individual to societal and ecological realms.
- Foster self-reflection, confidence, and commitment to informed action.

Methodology:

- Embraces a self-reflective teaching approach, facilitating understanding through introspection and dialogue.
- Encourages students to explore their roles and values across life's spectrum.

Session No.	Topic Title	Aspirations and Issues	Basic Realities (underlying harmony)
1	Welcome and Introductions	Getting to know each other	Self-exploration
2	Aspirations and Concerns	Individual academic, career… Expectations of family…	Fixing one’s goals Basic human aspirations Need for a holistic perspective Role of UHV
3 & 4	Self-	Self-confidence, peer	Personality development, self-

Session No.	Topic Title	Aspirations and Issues	Basic Realities (underlying harmony)
	Management	pressure…	improvement… Harmony in the human being
5	Health	Health issues, healthy diet…	Hostel life Harmony of the Self and Body Mental and physical health
6	Relationships	Home sickness, gratitude…	Ragging and interaction Competition and cooperation Peer pressure Harmony in relationship Feelings of trust…
7	Society	Participation in society	Harmony in the society
8	Natural Environment	Participation in nature	Harmony in nature/existence
9	Sum Up	Review role of education Need for a holistic…	Information about UHV-II course, mentor and buddy
10	Self-evaluation	Sharing and feedback	

For comprehensive guidance on content, methodology, and implementation, please consult:

- UHV-I Mentor's Manual for Student Induction Program, Version 2.1 August 2020 https://fdp-si.aicte-india.org/download/G008_Facilitator(Mentor)Manual_Version2.1.pdf
- Presentations for UHV-I (SIP Teaching Material) https://fdp-si.aicte-india.org/SIPTeachMaterialM1.php
- Post UHV-I Feedback and Survey (to be filled by all student participants after they attend UHV-I and submitted to NCC-IP, AICTE /GTU as part of college report) https://fdp-si.aicte-india.org/download/Model Self-Evaluation &Feedback for UHV I Module.pdf

Module 2 - Physical Health and Related Activities (24 Hours)

Course Overview:

This course is designed to provide students with a foundational understanding of the key principles necessary for maintaining health and fitness. Students will apply these principles by establishing a healthy routine that incorporates physical & mental exercise, games, and other activities.

Course Objectives:

- Gaining knowledge of fundamental health and fitness principles
- Applying these principles through activities such as exercise, activities and games
- Engaging with health center personnel, sports coaches, faculties, and students

Relationship Building:

This module provides an exceptional opportunity for students and instructors to form meaningful relationships. By interacting as friends and mentors during and around activities, there is a natural exchange of ideas, making it easier to connect on personal and academic levels.

Lifestyle Practices:

Students will learn to integrate healthy lifestyle choices involving diet, daily routines, and physical activities into their lives. This includes practical tasks such as gardening and farming, which connect students with the broader community and deepen their understanding of real-world challenges and efforts.

Activities Included:

- Team-based and non-competitive games that foster social values and integrity.
- Physical exercises that focus on breathe control and body mechanics.
- Productive physical work, such as creating and maintaining kitchen gardens or plantations, which also provides insights into agricultural challenges.
- By engaging in these activities, students internalize a comprehensive approach to health, transforming these practices into lifelong habits. This course not only improves personal health but also prepares students to contribute positively in various community settings, instilling values of integrity, national pride, and cooperation.

Teaching Methods:

- Health Counselling
- Khel (traditional games)
- Aerobics
- General sports activities
- Yoga

Suggested Modules (2 Hours /Module)

Sr. No.	Module Name	Key Topics Covered	Activities Included
1	Introduction to Health and Fitness Principles	Overview of basic health principles; Setting personal health goals	Discussion and goal-setting exercises
2	Cardio Fitness and Aerobic Exercises	Understanding cardiovascular health; Introduction to aerobic exercises	Guided aerobic exercise session (running, cycling, swimming, etc)
3	Team-Based Sports and Games	Introduction to team-based sports; Teamwork and strategy	Friendly matches in various sports
4	Khel and Traditional Games	Traditional Indian games; Historical significance	Sessions of traditional games
5	Yoga and Breath Control	Basics of yoga and its benefits; Pranayama	Guided yoga and meditation session
6	Diet and Nutrition	Balanced diets and nutritional needs; Role of diet in fitness	Group meal planning activity
7-8	Mental Health and Stress Management	Physical health and mental well-being; Stress management techniques	Mindfulness and relaxation session
9	Role of Sports in Community Building	Social aspects of sports; Inclusivity and teamwork	Team-building games and activities
10	Health Counselling and Goal Setting	One-on-one health counseling; Personal goal setting	Workshop on maintaining healthy habits
11-12	Battery Test	Refer Appendix-A for Detailed Guidelines	

For comprehensive guidance on content, methodology, and implementation, please consult:

- Presentations for Holistic Human Health (SIP Teaching Material) https://fdp-si.aicte-india.org/SIPTeachMaterialM2.php

Appendix-A

A battery test for physical activities typically refers to a series of fitness assessments designed to evaluate different aspects of physical fitness. These tests are used to measure various components like strength, endurance, flexibility, and cardiovascular fitness. Here's an overview of how these tests work and what they typically measure:

Purpose:

The main goal is to comprehensively evaluate an individual's fitness level across different physical capabilities.

The test results help in identifying strengths, weaknesses, and overall fitness levels, and provide guidance for training programs.

Components:

Cardiovascular Endurance:

Assessed through activities like running (e.g., the Cooper test, beep test), cycling, or swimming to measure the efficiency of the heart and lungs.

Muscular Strength:

Measured by tests like the bench press or leg press to assess the maximum force a muscle can exert.

Muscular Endurance: Evaluated through exercises like push-ups, sit-ups, or plank tests to see how long muscles can sustain repeated contractions.

Flexibility:

Often measured with tests like the sit-and-reach test, which gauges the flexibility of the lower back and hamstrings.

Speed and Agility:

Assessed through short sprints or agility drills to measure how quickly an individual can change directions and move.

Body Composition:

Body fat percentage, muscle mass, and BMI are sometimes included in the assessment.

Procedure:

Tests are usually conducted in a structured environment, often by fitness professionals or coaches.

Individuals are guided through a series of exercises with standardized instructions to ensure consistent measurement.

Rest periods between tests ensure accurate results by preventing fatigue from influencing performance on subsequent tests.

Results Interpretation:

Scores or results from each test are typically compared against normative data to assess the individual's fitness level.

Results help in creating personalized fitness programs by targeting areas that need improvement.

Repeated testing at intervals can track progress and evaluate the effectiveness of a training regimen.

Module 3 - Familiarization of Department/ Branch and Innovation (2 Hours)

This module is for introducing and relating the student to the institution/department/branch; how it plays a role in the development of the society, the state, region, nation and the world at large and how students can participate in it.

Sr. No.	Content	Duration
1	Introduction to department, institute and facilities available within and nearby campus (e.g. Faculties, Labs, Major equipment's, clubs, student chapters and nearby research institute and industries).	40 min
2	Role of concern branch of Engineering for the holistic development of the society, nation and world (contribution of branch in Industry sector e.g. Role IC Engineering in automation/agriculture/Process Industry etc. Introduction of prominent alumni from the department and their success journey).	20 min
3	Branch pertaining innovation for sustainable development of society (e.g. E Vehicles for Electrical Engineering, semiconductors for EC Engineering, Nonrenewable for Mechanical Engineering etc.)	30 min
4	Familiarizations with career opportunities (various placement opportunities in government/private sector, scope of entrepreneurship and higher studies).	30 min

Module 4 - Visit to a Local Area (6 Hours)

To relate to the social environment of the educational institution as well as the area in which it is situated through interaction with the people, place, history, politics, provide a brief overview of the day's activities and objectives and assign roles to ensure smooth coordination throughout the day. Below mentioned suggested activities can be followed by the department/ institute located at Ahmedabad city, other institutes can select such places based on their region.

Suggested activities 1: Visit to Gandhi Ashram

- Explore the Gandhi Ashram, also known as Sabarmati Ashram.
- Engage in a guided tour to understand Mahatma Gandhi's philosophy and his contributions to society.
- Reflect on the principles of non-violence, truth, and simplicity.

Suggested activities 2: Heritage Place Visit

- Visit a heritage site such as Adalaj Stepwell or LD Museum.
- Learn about the historical significance and architectural marvels of the site.
- Encourage students to observe and appreciate the cultural heritage of the region.

Suggested activities 3: Visit to Handloom Machineries and Pottery Making

- Experience the traditional craftsmanship of handloom weaving and pottery making.
- Interact with artisans to understand their skills and techniques.
- Participate in a hands-on workshop to create small handicrafts.

Suggested activities 4: Village Visit

- Visit a nearby village to understand rural life and community dynamics.
- Observe various aspects such as agriculture, lifestyle, housing, and social relations.
- Interact with villagers to learn about their daily routines and challenges.

Suggested activities 5: Interaction with Renowned Personalities

- Meet with local personalities who have made significant contributions to society.
- Listen to their experiences and insights on community development and social issues.
- Engage in a Q&A suggested activities to gain valuable knowledge and inspiration.

Concluding remarks:

- Gather for a debriefing suggested activities to reflect on the day's experiences.
- Encourage students to share their thoughts, insights, and newfound perspectives.
- Discuss potential ways to contribute to society and address local challenges.
- Conclude the visit with a group photo and expressions of gratitude.
- Remind students to carry forward the lessons learned and apply them in their lives.
- Provide guidance on further learning opportunities or community engagement initiatives.

By following this schedule, students can gain a holistic understanding of Ahmedabad's cultural heritage, community dynamics, and societal challenges while also fostering empathy, responsibility, and innovative thinking.

Module 5 - Lectures By Eminent People (2 Hours)

Guest lectures by eminent persons from various fields such as academics, industry, sports, business, and technology offer students an exceptional opportunity to broaden their perspectives and gain insight into the practical aspects of life and work. These lectures are not only a source of inspiration but also serve as a valuable platform for students to connect with experienced professionals who have achieved success in their respective areas.

The impact of guest lectures extends far beyond merely listening to accomplished individuals share their stories. Such interactions can profoundly shape students' understanding of the world and equip them with knowledge and skills that are not always covered in traditional classroom settings. Here are several key benefits that students can gain from engaging with guest speakers from different fields:

1. **Inspiration and Motivation**: Eminent persons often share their journey, including the challenges they faced and the strategies they used to overcome them. This can inspire students to pursue their goals with determination and resilience. Hearing about the achievements of these figures can motivate students to strive for excellence in their own endeavours.
2. **Career Guidance**: By learning about the diverse career paths and experiences of guest speakers, students can gain insight into various industries and professions. This exposure can help them make informed decisions about their own career choices and explore opportunities they may not have considered otherwise.
3. **Real-World Insights**: Guest speakers bring a wealth of practical knowledge and experience to the table. Through their lectures, students can gain a deeper understanding of the current trends, challenges, and opportunities in different fields. This real-world perspective can complement theoretical learning and prepare students for the professional world.
4. **Networking Opportunities**: Engaging with guest speakers provides students with the chance to build valuable connections with professionals in their fields of interest. Networking can open doors to internships, mentorships, and potential job opportunities, giving students a head start in their careers.
5. **Exposure to Diverse Perspectives**: Inviting speakers from various backgrounds and fields allows students to encounter a wide range of viewpoints and experiences. This exposure can broaden their horizons and encourage them to think critically and creatively about different topics.
6. **Development of Communication Skills**: Guest lectures offer students the chance to interact with professionals, ask questions, and engage in discussions. This interaction helps students improve their communication skills and gain confidence in expressing their thoughts and ideas.
7. **Learning from Experienced Mentors**: Guest speakers often share valuable advice and insights from their own experiences. Students can benefit from these lessons and apply them to their personal and professional development.

To maximize the benefits of guest lectures, it is important to invite a diverse set of speakers from different fields. This diversity ensures that students are exposed to a wide range of topics and perspectives, enriching their overall learning experience. Additionally, the interactive nature of guest lectures allows students to engage with the speakers and ask questions, fostering a dynamic learning environment.

In conclusion, guest lectures by eminent persons from various fields play a crucial role in enhancing students' education and personal growth. By providing inspiration, guidance, and real-world insights, these lectures contribute to a well-rounded learning experience that prepares students for success in their future endeavours.

Note: Guest lectures are a valuable way to enrich students' perspectives and broaden their understanding of different fields. However, it can be challenging for institutions in rural areas to host eminent speakers in person. Additionally, large institutions may face difficulties in organizing lectures for all classes with a single speaker. To address these challenges, Gujarat Technological University will facilitate a unified online lecture series featuring distinguished speakers, accessible to all affiliated institutes. This online format ensures that students across various locations and institutions can benefit from the insights and experiences shared by the guest speakers. However, institutes are free to host eminent speakers in offline mode, if it can be managed by them.

For further information please refer: SIP Handbook from AICTE.

Module 6- Proficiency Module (4 Hours)

Objective:
This module aims to fill the gaps in basic competencies required for further learning. It focuses on developing proficiency in English Language, Gujarati/Hindi Languages, Communication Skills and relevant Computer Skills. The module is designed to cater to students of diverse backgrounds and help them adapt to the medium of instruction (English) and enhance their overall communication abilities.

Expected Outcome:
Equip the students to develop competencies required in further advancement of their UG studies.

Methodology:

1. Reading of printed materials like Newspaper, short stories, books, articles, drama, periodicals, etc.
2. Use of Web tools
3. Use a variety of methods to engage learning
4. Use of Audio/ Visual Tools
5. Build in work groups
6. Expert Sessions

Session 1: English Proficiency (1 hour)

- Introduction to the importance of English proficiency in academic and professional settings.
- Interactive activities to encourage speaking in English without fear of making mistakes.
- Group discussions on various topics to improve fluency and confidence.
- Watching short videos or movies in English followed by discussions.
- Tips and guidelines for self-improvement in English (e.g., reading newspapers, writing, conversing with friends in English).

or

Session 1: Gujarati / Hindi Proficiency (1 hour)

- Basic introduction to the Gujarati/ Hindi language for students not familiar with it.
- Common phrases and expressions used in Gujarati/Hindi.
- Practice sessions for basic Gujarati/ Hindi conversations.
- Introduction to Indian epics, dramas, and literature in Gujarati/Hindi.
- Watching short videos or movies in Gujarati/ Hindi followed by discussions.
- Tips and guidelines for self-improvement in Gujarati/ Hindi (e.g., reading newspapers, writing, conversing with friends in Gujarati/ Hindi).

Session 2: Communication Skills (1 hour)

- Importance of effective communication in personal and professional life.
- Active listening exercises.

- Role-playing scenarios to practice different communication skills (e.g., assertiveness, empathy).
- Tips for improving non-verbal communication (e.g., body language, eye contact).

Session 3: Computer Skills (1 hours)

- Basic introduction to computers for preparation of presentation, word documents etc.
- Hands-on practice with common software applications (e.g., word documents, spreadsheets, PowerPoint presentation).
- Accessing the internet for learning pronunciation, synonyms and antonyms etc.
- Introduction to coding and digital literacy.
- Introduction to plagiarism software
- Use of NLP tools

Session 4: Expert session (1 hour)

- Introductory session on IELTS and TOEFL
- Effective Speaking Skills, Voice Quality and Purposeful writing
- Body Language and Listening skills
- Hands-on practice with NLP tools

Note:

- The sessions should be interactive and engaging, encouraging active participation from all students.
- Provide a supportive environment where students feel comfortable making mistakes and learning from them.
- Offer additional resources and support for students who need extra help.
- Encourage students to continue practicing and improving their skills beyond the induction module.

Resources:

1. English (or other language) Newspaper, articles, story books, etc.
2. Audio and Video clips
3. Online Vocabulary

Module 7 - Indian Knowledge System (16 Hours)

(भारतीय ज्ञान प्रणाली)

INDIAN civilization has always attached great value to knowledge. In Bhagvad Gita, Shree Krishna says – "न हि ज्ञानेन सदृशं पवित्रमिह विद्यते।" - Indeed, there is nothing purifying here comparable to Knowledge.

The Indian Knowledge System talks about two types of knowledge (विध्या), one अपराविध्या (worldly knowledge) and पराविध्या/ब्रह्मविध्या (knowledge which liberate). However, it is common perception that the body of knowledge represented in our Indian Scriptures are only related to some ritual practices. On the contrary, there is an amazingly large body of intellectual texts, the world's largest collection of manuscripts, its attested tradition of texts, thinkers and schools in so many domains of knowledge.

It is an interesting and fascinating aspect of knowledge in India that it prevails in diverse ways and is expressed at varied levels. In many areas such as Medicine, Mathematics, Science and Technology, Psychology, Philosophy, Agriculture, Grammar, Language, Dance, Music and Astrology, to name just a few, there is wide and extensive knowledge both at the level of the classical texts and the folk traditions. Quite commonly, they are referred to as "Shastra" and "Lok Parampara" respectively.

This module is aimed at introducing this great tradition of knowledge to the engineering students. This module will introduce scientific and technological aspects of the great Indian Knowledge System.

The Learning Objectives of this module is as follows:

After completing this module students will be able to discuss about –

1. Various texts and traditions of Indian Knowledge System
2. Scientific aspects of Sanskrit and its Grammar
3. Indian contribution in mathematics, science, technology, philosophy, health and psychology.

This module is planned in 16 hours of teaching – learning activities as below -

Session No.	Topic Title	Hours
1	Introduction to IKS	1
2	The Vedic Corpus	1
3	Indian Philosophical System	1

Session No.	Topic Title	Hours
4	Scientific Foundation in Linguistics (Sanskrit)	1
5	Computational Concept in Panini	1
6	Indian Number System	1
7	Ancient Indian units of measurements	1
8	Indian Mathematics	1
9	Indian Mathematics	1
10	Metals and Metalworking	1
11	Metals and Metalworking	1
12	Various other applications	1
13	Various other applications	1
14	Town planning and architecture	1
15	Health, Wellness and Psychology	1
16	Health, Wellness and Psychology	1

Reference study materials:

1. Introduction to Indian Knowledge System: Concepts and Applications by B. Mahadevan, Vinayak Rajat Bhat, and Nagendra Pavana R.N.; Publisher: Prentice Hall India
2. Set of five books published by School of IKS (धरोहर), GTU.

Module 8 - Creative Practices (24 Hours)

Course Overview:

This module is designed to enhance an appreciation for humanistic culture through the lens of engineering, encouraging students to explore and integrate creative expressions with technical disciplines. Students can have the opportunity to select a skill from a variety of domains that complement their engineering studies. Additionally, literary activities such as reading, writing, and debating are included to foster critical thinking and articulate expression, essential skills for any engineer.

Course Objectives:

The program's goals are to establish a dynamic and collaborative environment that enhances social interactions and skill development, while also fostering an appreciation for creative arts as a complementary aspect to engineering education. Participants will engage in various activities including group projects and competitions. These will culminate in a showcase where students can display the innovative skills they have acquired. Engineering societies and clubs may assist in organizing these activities, providing a bridge between technical and creative disciplines.

Furthermore, professionals from fields that intersect with both the arts and engineering, such as industrial design, sound engineering, and architectural design, may be invited to lead workshops. These sessions will provide students with the opportunity to develop creative and practical solutions to challenges that are relevant both in artistic and engineering contexts.

Throughout the program, students will commit daily time to explore and integrate artistic disciplines into their engineering projects. While a central theme—such as sustainability, innovation, the history of engineering, or technology's impact on society—may guide these activities, participation in this thematic exploration is not mandatory. This approach is designed to deepen students' engagement, encouraging them to apply artistic expressions such as design, modelling, or conceptual installations to enhance their understanding of engineering principles. This thematic involvement is intended not only to enrich students' technical and creative skills but also to heighten their social and ethical awareness as future engineers.

Activities Included:

Recognize the Role of Creativity in Engineering: Students will identify and understand how creative thinking contributes to technological innovation and problem-solving in engineering contexts.

Develop Creative Problem-Solving Skills: Students will learn to apply creative problem-solving techniques to tackle complex engineering problems, integrating unconventional solutions and innovative approaches.

Enhance Observational Skills: Students will improve their ability to observe and analyze everyday objects and systems, fostering the ability to see potential improvements and innovations.

Practice Ideation Techniques: Students will practice various ideation methods such as brainstorming, mind mapping, and SCAMPER to generate new ideas and approaches for engineering projects.

Experiment with Design Thinking: Students will engage in design thinking processes to empathize with users, define problems, ideate solutions, prototype, and test, emphasizing user-centered design in engineering.

Cultivate Interdisciplinary Thinking: Students will explore how concepts from other disciplines can be integrated into engineering solutions, encouraging a broader perspective and versatile problem-solving skills.

Apply Creative Tools and Technologies: Students will learn to use modern tools and technologies that facilitate creative design and engineering, such as CAD software, 3D printing, and digital simulation tools.

Develop Reflective Practices: Students will engage in reflective practices to critique and evaluate their creative processes and outcomes, leading to continuous improvement in their creative endeavours.

Encourage Collaboration and Teamwork: Students will participate in group projects that require creative collaboration, learning how diverse perspectives can contribute to innovative solutions.

Promote the Presentation of Creative Work: Students will develop skills in effectively communicating their innovative ideas and creative projects to diverse audiences, including peers, instructors, and industry professionals.

Professional Development: Hosting exhibitions and performances where industry professionals are invited can provide networking opportunities and expose students to potential career paths that combine engineering and the arts.

Workshops and Masterclasses: Organize workshops led by professionals in different fields such as painting, music, dance, and drama. These can provide hands-on experiences and deepen students' skills.

Suggested Modules (2 Hours /Module)

Sr. No.	Module Name	Key Topics Covered	Activities Included
1	Introduction to Creative Arts in Engineering	Basics of creativity in engineering with arts focus	Discussion on the intersection of arts and engineering
2	Creative Writing for Engineers	Basics of creative writing; Writing for technical audiences	Short writing exercises; peer feedback
3	Visual Arts and Design Thinking	Design thinking basics; Drawing and visual design	Guided drawing and visual design exercises
4	Observation and Creative Inspiration	Observational skills; Finding inspiration in daily life	Sketching and journaling activities
5	Basics of Collaboration through Theatre	Importance of collaboration; Acting basics	Improv games and collaborative acting exercises
6	Storytelling through Technology	Digital storytelling; Simple digital media tools	Creating digital stories using basic media tools
7	Art and Engineering Concepts	Exploring how art intersects with engineering	Group discussions and practical activities exploring artistic concepts
8	Reflective Practices through Literature	Importance of self-reflection; Literature analysis	Short readings and reflective journaling
9	Team Projects in Creative Arts and Engineering	Planning and executing interdisciplinary projects	Group projects combining art and engineering
10	Basic Presentation Skills	Introduction to presenting creative work	Group presentations and feedback sessions
11	Career Paths in Creative Arts and Engineering	Overview of careers blending arts and engineering	Guest talks from professionals in creative fields
12	Beginner Workshops in Creative Skills	Guided skill-building in arts and engineering	Hands-on workshops with creative professionals

For comprehensive guidance on content, methodology, and implementation, please consult:
Presentations for creative practices: https://fdp-si.aicte-india.org/SIPTeachMaterialM8.php

Module 9 - Extra Curricular Activities (2 Hours)

This is a category under which things that are not placed in any of the above may be placed. This has suggestions for sessions or activities that can be conducted like some clubs and hobby groups may be made for each of the above categories, so that students may pursue them even after SIP.

Anti-Ragging Briefing: With the advent of college years for students, fear of ragging creeps inside them. With a picture of ragging borrowed from the cinema in their minds, they enter the premises, and hence it becomes essential to introduce them to the rules of the institution against ragging. Many students are away from their homes for the first time, and it is the responsibility of the institute to make them feel welcomed and safe within the boundaries of the institute Both formal and informal sessions can be organized informing the entrants about the anti-ragging policies of the institution, along with answering some principal questions like, "What comes under ragging?", "Whom to approach if you witness ragging?", etc.

Wellness Sessions: In this ever-growing competitive world, statistics of mental issues like depression and anxiety are overwhelming, and yet people choose to overlook these issues. "Mental awareness/wellness sessions" provide an answer to this ignorance. The institute can have tie-ups with mental wellness organizations that, in-return, can send in their professionals to deliver lectures on mental health and its importance. Informal sessions by specialists can be organized involving fun yet, affective activities (self-control activities, music therapy activities, discussion activities, or relaxation activities like games to release stress and have a bonding with the peers) to maintain a healthy state of mind. Because of the stigma around mental health, the information of the student approaching for help shall be confidential, and a team of students themselves can be set up to hear out issues of their juniors and help them out professionally.

Informal Interactions: A fresher, oblivious to the college culture and environment, requires informal interactions with seniors to clear their queries regarding the workload of the branches, different clubs, excelling in exams, opportunities provided by the institute to pursue their interests, and maybe even professors. Seniors, accompanied by faculty members, should visit the hostels of freshers post dinner to make them feel welcomed and comfortable. Seniors accordingly may choose to sit in the corridors or grounds to share their experiences of their freshmen year and to answer the questions raised by the freshers. Faculties shall be roaming through the hostels to ensure no cases ragging take place. Occasionally refreshments could be taken by the faculties to bond and interact with the freshers. The faculty members shall make sure that all the seniors are out of the fresher's hostels at the end of these sessions.

Club/Council/Committee Briefings: Clubs/Council/Committee are a vital part of a college's ecosystem and it is thus imperative that students are well briefed regarding them. The details of the briefing will vary from college to college, but the brief outline has been described here, along with the reasons that

make such a briefing essential. It would be advisable to have the Secretaries/Presidents and other position holders draft a welcome address for the new entrants. This should serve as an advertisement for the club's activities, scope and culture. A member of the Debate Club, for example, should go through an analysis of why learning how to debate is a useful/interesting skill and how the club members would help the new entrant learn and develop these skills. Similarly, a member of the Design Club could have the club members showcase their skills through a quick extempore portrait creation. This would be quite engaging and entertaining for the spectators. If there are any committees which are not student-run, the people in charge could take it upon themselves to organize this presentation for the students. The main objective would be to ultimately ensure that every student goes into the academic year with a very strong basic idea of what to expect from a club and whom he or she could contact in order to have a better idea of what to do. Intra Fresher Competitions: Care must be taken to have as relaxed a schedule as possible so that any student can freely participate in as many events as possible without having to pick and choose between different interests.

One suggestion would be to introduce a points system and have a competition among different branches on the basis of that. The ones who end up on the podium in a particular event will contribute a certain number of points to their branch and will get some personal rewards as well. Broadly speaking, there could be three categories of competitions held: Cultural, Technical and Sports. For example under Cultural, activities like Debate, Dance, Singing, etc. can be conducted.

A. General Regulations:

1. Every student has to maintain a daily diary. Format of the diary is given.
2. After completion of the Induction program student has to prepare a report based on activities performed during the Induction program. Diary will be attached as Appendix in Report.
3. 75% Attendance is required during the Induction Program.
4. This program will be a noncredit subject but it will reflect in the 1st Semester Marksheet as PASS or FAIL.
5. The Institute should appoint a mentor for a group of 20 to 30 students. Mentors can take help from senior students.
6. If a student gets an admission transfer in another college during the Induction Program, the diary will be continued from previous college to new college.
7. If a student gets admission in the middle of the Induction Program or student gets admission after the Induction Program, it is the responsibility of the institute to fulfill the criteria of the Induction Program.
8. If a student fails in the Induction program, the student has to clear the same during subsequent Semester.

B. Evaluation Pattern:

1. The Induction Program is Mandatory course for each branch of UG Engineering.
2. It is mandatory for each student to clear the Induction Program with PASS grade.
3. Grades for the Induction Program are either PASS or FAIL and have no credits. Evaluation for the Induction Program is based on the Induction Program Report prepared by a student from the student diary and the student will be declared PASS or FAIL.
4. Students have to submit the Induction Program Report at the end of first semester duly approved by Mentor and HOD.
5. Evaluation of the Induction Program will be done along with the first Semester Term-Work Submission.
6. The evaluation is carried out by the Internal Examiner from the institute itself. The entry on the GTU portal will be PASS or FAIL, not marks.
7. The students who will FAIL have to reappear again after every 6 months as a remedial exam.

C. Guidelines for Program Report:

1. Report should have a minimum of 20 pages.
2. Report must have One Photograph per Activity.
3. Report consists of Certificate, Index and Diary as Appendix.
4. Report should be duly signed by Mentor and HOD.
5. Index will have following sequence:

Sr. No.	Name of Modules
Module 1	Universal Human Values I (UHV I)
Module 2	Physical Health and Related Activities
Module 3	Familiarization of Department/ Branch and Innovation
Module 4	Visit to a Local Area
Module 5	Lectures by Eminent People
Module 6	Proficiency Modules
Module 7	Literature / Literary Activities including Indian Knowledge System-I (IKS-I)
Module 8	Creative Practices
Module 9	Other Co-curricular Activities

D. Format of Diary

Format of Diary is attached as Annexure- 01.

GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: ALL

Subject Code : BE01R00021

Subject Name : Physics

w. e. f. Academic Year:	2024-25
Semester:	Ist Year
Category of the Course:	BSC

Prerequisite:	Basic understanding of Calculus, Physics and Mathematics course on Differentiate equations
Rationale:	The basic science - physics program is to prepare students for careers in engineering where physics principles can be applied to the advancement of technology. This education at the intersection of engineering and physics will enable students to seek employment in engineering upon graduation while, at the same time, provide a firm foundation for the pursuit of graduate studies in engineering.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	The student will apply theoretical and mathematical concepts to solve problems related to properties of matter.	Apply
02	The student will apply basic principles, properties, and applications associated with Waves, Motion, and Acoustics to practical situations	Apply
03	The student will apply basic principles, properties, and various methods of production techniques in Optics to solve real-world problems.	Apply
04	The student will apply fundamental principles of Quantum Physics to analyze and interpret quantum phenomena.	Apply
05	The student will apply the principles of Lasers to understand their properties and applications in science, engineering, and medicine..	Apply
06	The student will apply knowledge of new engineering materials, including semiconductors, superconductors, and nanomaterials, to practical engineering problems.	Apply

**Revised Bloom's Taxonomy (RBT)*

GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: ALL

Subject Code : BE01R00021

Subject Name : Physics

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL*	TH		ESE (E)	PA (M)	PA/ (I)	PBL(I)	ESE (V)	
45	0	30	45	120	04	70	30	20	30	50	200

**** Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.***

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, PA = Progressive Assessment, ESE = End-Semester Examination

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**PROPERTIES OF MATTER** • Stress – Strain – Hooke's law – • Elastic Behaviour of Material – • Young's modulus by cantilever depression – • Non-uniform bending – • Uniform bending- • Application -I-shaped girders. • Torsional Pendulum – Couple per unit twist of a wire, Time period, • Application- Determination of Rigidity Modulus.	**6**	**13**
2.	**WAVES, MOTION AND ACOUSTICS** • Simple Harmonic motion, Free, forced, Resonance, • Damped and undamped vibration, • Damped harmonic motion, • Force vibration and amplitude resonance, • Velocity resonance and energy intake, • Wave motion, transverse and longitudinal vibration, • Sound absorption and reverberation, • Sabine's formula and usage (excluding derivation), • Acoustic of building,	**8**	**18**

	• Ultrasonic waves - Properties - Generation – Piezoelectric method – Detection- Kundt's tube • Application of Ultrasonics in industries – NDT.		
3.	**OPTICS** • Huygens' Principle: Fundamental principle for wave propagation. • Superposition of Waves: Basic principle for understanding interference and diffraction. • Explanation of constructive and destructive interference. • Applications in thin film interference, such as soap bubbles and oil films. • Young's double slit experiment. • Newton's rings, • Michelson Interferometer • Anti-reflection coating. • Fresnel and Fraunhofer diffraction– diffraction due to 'n' slits-plane transmission grating. • Rayleigh criterion for limit of resolution - resolving power of grating.	**8**	**18**
4.	**QUANTUM PHYSICS** • Black body Radiation-Planck's law • Energy distribution function, • Wave-particle duality-de Broglie matter waves • Concept of the wave function and its physical significance – Heisenberg's Uncertainty Principle • Schrodinger's wave equation – Time-independent and Time-dependent equations – • Particle in a one-dimensional rigid box – tunneling (Qualitative) – Scanning Tunnelling Microscope.	**8**	**18**
5.	**LASERS** • Properties of Laser, Einstein's theory of matter radiation: A and B coefficients, • Amplification of light by population inversion,	**8**	**18**

	• Different types of lasers, • Gas lasers (He-Ne), • Solid-state lasers (Ruby laser), • Properties of laser beams: Mono-chromaticity, coherence, directionality and brightness, laser speckles, • Applications of lasers in science, engineering, and medicine.		
6.	**NEW ENGINEERING MATERIALS** SEMICONDUCTOR MATERIALS: • Introduction of Group IV elements, • Properties, • Concept of carriers, • Concept of bands and band gap, • P-type, N-type materials • Introduction to P-N Junction Diode and I-V characteristics, • Zener diode and its characteristics SUPERCONDUCTING MATERIALS: • Introduction – Properties • Meissner effect • Type I & Type II superconductors • Applications. NANOMATERIALS: • Introduction • Synthesis of nano materials – Top down and Bottom up approach • Ball milling • PVD method • Applications.	**7**	**15**
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
30	**40**	**30**	**0**	**0**	**0**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Engineering Physics by Dattu R Joshi, McGraw hill Publications
2. Engineering Physics by Shatendra Sharma & Jyotsan Sharma, Pearson Publication
3. Optics by Subramaniam N & Brij Lal, S Chand & Co. Pvt. Ltd., New Delhi
4. Optics by R.Agarwal, S. Chand
5. Fundamentals of Optics by Jenkins A Francis and White E Harvey, McGRaw Hill Inc., New Delhi,
6. Concepts of Modern Physics by Arthur Beisser, McGraw Hill
7. Modern Physics by R Murugeshan, Kiruthiga, Sivaprasath S Chand
8. Quantum Mechanics by V. Devanathan, Narosa, Chennai
9. Quantum Mechanics by Sathyaprakash, Pragati Prakashan, Meerut
10. Engineering Physics by M.N.Avadhanulu, S.Chand & Company
11. Engineering Physics – Bhattacharya, Bhaskaran – Oxford Publications
12. Engineering Physics I & II – G. Senthilkumar, VRB publications
13. Applied Engineering Physics – Rajendran & Marikani (Tata McGraw Hill)
14. Applied Physics for Engineers – K.Venkatramanan, R.Raja, M.Sundarrajan (Scitech)
15. Principles of Electronics by V.K.Mehta, (S.Chand)
16. Basic Electronics by B.L.Theraja, S.Chand
17. Mechanics of Materials, Barry J. Goodno, James M. Gere, Published
18. Fundamentals of Physics, D. Halliday, R. Resnick and J. Walker, John Wiley and Sons, New York.

(b) Open source software and website:

1. https://nptel.ac.in/
2. https://www.vlab.co.in/

Suggested Course Practical List: If any

List of Experiments:

1. Diffraction and interference experiments (from ordinary light or laser pointers); measurement of the speed of light on a tabletop modulation; minimum deviation from a prism.
2. Measurement of the Distance using Ultrasonic Sensors.
3. Study of Object Detection using Ultrasonic Sensors.
4. Melde's Experiment Transverse and Longitudinal Modes
5. To determine the frequency of a given laser source.
6. Frequency of AC Supply-Sonometer method
7. Wavelength of Light -Diffraction Grating using LASER
8. Acoustic grating method set up for measurement of the velocity of ultrasonic waves in liquid
9. Melde's experiment Resonator
10. Study of Damped Simple Harmonic Motion
11. Newton's rings, Determination of using sodium light.
12. Calibration of Spectrometer & determination of unknown wavelength
13. Dispersive curve of a prism
14. Study of Fabry-Perot Etalon
15. Study of Lloyd's Mirror
16. Study of Double Refraction in Calcite Prism
17. Virtual Heat & Thermodynamics Lab
18. Virtual Advanced Mechanics Lab
19. Virtual Laser Optics Lab
20. Virtual Harmonic Motion & Waves Lab
21. Virtual Optics Lab
22. Virtual Modern Physics Lab
23. Virtual Lab on oscillations
24. Virtual Physical Sciences Lab

- **List of suggested activities for Problem Based Learning:**

Sl. No.	Name of the activity	No. of hours	Evaluation Criteria
1.	Multimedia based conceptual learning of topics related to Physics	Duration = 5h Report preparation = 3h **Total = 8h**	Report /presentation based on the learning outcomes.
2.	Assignment writing (Numericals based assignment is preferable)	6 assignments of 2h each. **Total = 12h**	Based on the assignment submitted.

3.	Self-learningthrough virtual lab experiments(2 Experiments)	Performance = 4 h Report preparation = 2 h **Total = 6 h**	Assessment based on report and viva
4.	Poster/chart preparation on technical topics	**Total = 4 h**	Based on poster/chart preparation
5.	Working model on technical topics and report writing	Idea = 2 h Execution =6 h Report + Presentation = 4 h **Total = 12 h**	Based on inter department/external evaluation
6.	Assembly of Circuit on the bread board	Duration = 3 h Report preparation = 3 h **Total = 6 h**	Based on circuit and clarity of components used
7.	power point preparation on technical topics and presentation	Preparation = 4 h Presentation = 2 h **Total = 6 h**	Based on ppt prepared, presentation and viva
8.	Study of different physics principles involved in technical industrial equipment/ tools/ processes	Survey/ study = 4 h Report preparation = 4 h **Total = 8 h**	Based on report
9.	Study of units, conversion and use	Preparation = 4 h Quiz = 1 h **Total = 5 h**	Based on performance in quiz

Note:
1. All the suggested activity should be related to the subject.
2. The number of hours is suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
3. Rubrics for the evaluation can be prepared by the faculty.

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Degree

Branch: All branches

Course / Subject Code : BE01R00031

Course / Subject Name : Chemistry

w. e. f. Academic Year:	2024-25
Semester:	Ist Year
Category of the Course:	BSC

Prerequisite:	Basic knowledge of general chemistry.
Rationale:	Every material is made up of atoms. Material is deeply integrated with engineering, therefore, basic chemistry is essential to understand the nature and properties of material. The selection, characterization, and suitability assessment of natural raw materials essentially requires principles and concepts of basic chemistry. Successful completion of this course content will enable engineers to understand, ascertain and analyze the various new materials and enable to solve engineering problems.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Define chemical properties of atom, molecule, metal, alloys and energy sources.	R
02	Relate atomic and molecular structure with their reactivity	U
03	Solve the engineering problems related to fuel, water and corrosion	A
04	Compare recent Nano-material, ecofriendly materials and energy storage devices	E
05	Analyze properties of materials by various tools.	N

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	TW/ SL	TH		ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
45	0	30	45	120	04	70	30	20	30	50	200

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, PA = Progressive Assessment, ESE = End-Semester Examination

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Basic chemistry:** Wave mechanical concept of structure of atom; de Broglie's concept, Heisenberg's uncertainty principle, Schrodinger's wave equation. Shape and structure of diatomic molecules; types of hybridization (sp, sp^2, sp^3, sp^3d and sp^3d^2). Hard soft acids and bases concept and its applications.	8	18
2.	**Water technology:** Hardness of water, softening of water, boiler problems; caustic embrittlement, sludge, scale, priming and foaming. **Corrosion:** Introduction to corrosion, theories of corrosion, types of corrosion, protective measurements against corrosion; organic and inorganic materials, inhibitors, cathodic protection.	10	22
3.	**Material chemistry:** Properties and applications of fullerenes, fullerols, carbon nanotubes, nanowires and metal nanoparticles. Top down and bottom up approaches for synthesis of nanomaterials. Biodegradable polymers. Bio-based feedstock. **Metals and Alloys:** properties and applications. Heat treatments of steel. Types of alloys, Alloys of copper, aluminum and nickel.	10	22
4.	**Fuel and batteries:** Refining of petroleum, determination of calorific value by bombs calorimeter, Knocking and octane number. Ultimate and proximate analysis of coal. Biofuels; Biodiesel and biomass briquettes. Introduction to rechargeable cells, lithium batteries; construction and working. Photolysis of water. **Fermentation:** Synthesis of ethanol, acetic acid and pharma products by fermentation.	10	22
5.	**Instrumental analysis:** Principle and working of UV-Visible, Infra-Red, and NMR spectroscopy and their applications. Introduction to chromatographic techniques; thin layer chromatography, gas chromatography, liquid chromatography.	7	16
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
16	**16**	**36**	**11**	**21**	**0**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Engineering Chemistry, Willey-India.
2. Engineering Chemistry by Jain and Jain, Dhanpat Rai Publishing Co.
3. Engineering Chemistry by Marry Jane Shultz, Cencage Learning.
4. Engineering Chemistry by N. Krishnamurthy, P. Vallinaygam and D. Madhavan, PHI Learning.
5. Engineering Chemistry by K. Sesha Maheswaramma and Mridula Chugh, Pearson India Education Pvt Ltd.
6. Engineering Chemistry by B K. Sharma, Krishna, Prakashan Media (P) Ltd.
7. A textbook of Engineering Chemistry by Shashi Chawla, Dhanpat Rai Publishing Co. Ltd.
8. Fundamentals of Biotechnology by B D Singh, Kalyani Publisher. New Delhi.
9. Essential of Physical Chemistry by Bahl and Tuli., S Chand & Co. Ltd, New Delhi.
10. Introduction to Nano Science by N N. Lindsay, Oxford University Press.
11. NANO: The Essentials by T Pradeep Tata McGraw-Hill Publishing Company, New Delhi.

(b) Open source software and website:

1. https://nptel.ac.in/
2. https://chem.libretexts.org/Courses/Remixer_University/Download_Center
3. https://ocw.uci.edu/collections/open_chemistry.html#
4. https://ocw.mit.edu/courses/5-111sc-principles-of-chemical-science-fall-2014/

Suggested Course Practical List:

1. To determine the total hardness of the given samples by EDTA titrimetric method.
2. To estimate moisture content in the given coal sample.
3. To determine the amount of alkalinity present in the given samples.
4. To determine the amount of chloride present in the given water sample by Mohr's method.
5. To determine the saponification value of an oil sample.
6. To determine the concentration of unknown solution by spectrophotometer.
7. To determine the percentage of iron in the given steel sample.

8. To determine the amount of copper in a given brass sample.
9. To study the rate of corrosion by weight loss method.
10. To carry out analysis of pyrolusite ore.
11. To determine the R_f value of given sample by TLC method.
12. To synthesis of metal nanoparticles (silver, gold or copper etc.)

(Minimum 8 experiments to be performed)

List of Laboratory/Learning Resources Required:

1. Spectrophotometer.
2. Laboratory oven.
3. Melting point Instrument.
4. Electronic balance
5. TLC plates
6. Various chemicals and glassware

Suggested Project List:

1. Construction of bio-reactor
2. Construction of Li-cell
3. Set-up for photolysis of water
4. Synthesis of bio-degradable polymers
5. Design concept based on circular economy

Any other suitable project suggested by mentor or students.

Suggested Activities for Students:

1. Industrial visit
2. Organizing seminar and workshop
3. Participate in technical events
4. Participate and involve in startup

- **Self –Learning activity**

Sr. No.	Description	No. Of hours	Total Hrs.
1	Students will have to undergo industrial visit related to any one of the content mentioned in syllabus and submit the report for the same.	Visit = 5 hrs Report Preparation = 5 hrs	**10**
2	Students will have to undergo technical video based learning related to subject and have to present it or prepare a report of that learning.	Duration of video = 5 hrs Report Preparation = 5hrs	**10**
3	Students will have to submit assignment work assigned to them. Numerical base assignment is preferable.	5 assignments of 2 hrs each.	**10**
4	Self learning on-line course.	Min. Duration of the course should be 10 hrs	**10**
5	Discussion on research papers based on relevant subject. Summarize research papers and evaluation critical parameters.	5 research papers can be included. Each one has 5 hrs	**25**
6	Students will have to prepare posters, charts or PowerPoint presentations on technical topics related to subject content.	Duration of each activity = 6 hrs Max. two topics can be considered.	**12**
7	Students will have to do Group Discussion on emerging, Trending technical topics based on the subject.	Preparation and discussion on one topic	**5**
8	Flipped Classroom Activity	Preparation and discussion on one topic	**5**

9	Hands-On Experiments and Virtual Labs	Duration of video = 4 hrs Journal Preparation = 4hrs	**8**
10	Identification and remediation of the chemical processes that lead to pollution, climate change.	Research=3 hrs Report preparation=2 hrs	**5**
11	Working/ Non working models on technical topics.	Working= 12 hrs Non working = 8 hrs	**12/8**
12	Online Technical Quizzes/Simulations.	Multiple quizzes summing up to 10 hrs	**10**
Max. Hours to be allotted			**45**

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Degree

Branch: All

Course / Subject Code : BE01R00041

Course / Subject Name : Mathematics – 1

w. e. f. Academic Year:	2024-25
Semester:	Ist semester
Category of the Course:	BSC

Prerequisite:	Basic Algebra, Geometry, Trigonometry and Calculus
Rationale:	The goal of this course is to achieve conceptual understanding and to retain the best traditions of traditional calculus. This is a foundation course which mainly deals with topics such as single variable and multivariable calculus and plays an important role in the understanding of science, engineering, economics and computer science, among other disciplines.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	To apply differential and integral calculus to improper integrals. Apart from some other applications they will have a basic understanding of Beta and Gamma functions.	A
02	The fallouts of Taylor's and Maclaurin's Theorem that is fundamental to application of analysis to Engineering problems.	A
03	The tool of Sequences and Infinite series for learning advanced Engineering Mathematics.	A
04	To deal with functions of several variables that is essential in most branches of engineering.	A
05	To acquaint the student with mathematical tools needed in evaluating multiple integrals and their usage.	A

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	TW/ SL	TH		ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
30	30	00	60	120	04	70	30	00	30	00	130

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, PA = Progressive Assessment, ESE = End-Semester Examination

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Module 1: Basic Calculus:** Evaluation of improper integrals of Type-I and Type-II, Beta and Gamma functions and their properties; Applications of definite integrals to evaluate surface areas and volumes of revolutions	9	20%
2.	**Module 2: Single-variable Calculus (Differentiation):** Taylor's and Maclaurin's theorem for a function of one variable, Taylor's and Maclaurin's series of a function using statement of the theorems; Extreme values of functions; Indeterminate forms and L' Hospital's rule.	9	20%
3.	**Module 3: Sequences and series:** Sequence of numbers and its convergence, Infinite series; Tests for convergence (Telescoping series, Geometric series test, Integral test, p-test, comparison test, D' Alembert's ratio test, Cauchy's root test), Alternating series test; Power series, Radius and interval of convergence, Conditional and Absolute convergence of a power series	9	20%
4.	**Module 4: Multivariable Calculus (Differentiation):** Limit, Continuity and Differentiation for function of two or more variables, total derivative, gradient, directional derivatives; Tangent plane and Normal line to the surface $f(x, y, z) = c$; Extreme values for function of two variables (Maxima, minima and saddle points); Method of Lagrange multipliers.	9	20%
5.	**Module 5: Multivariable Calculus (Integration):** Multiple Integration: Double integrals (Cartesian, Polar), change of order of integration in double integrals, Change of variables (Cartesian to polar), Applications: areas and volumes, Center of mass and Gravity (constant and variable densities); Triple integrals (Cartesian, Cylindrical, Spherical).	9	20%
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
20	35	15	0	0	0

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.
2. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
3. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010.
4. AICTE's Prescribed Textbook: Mathematics-I (Calculus & Linear Algebra), Khanna Book Publishing Co.
5. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint, 2010.

(b) Open source software and website:

1. MIT Open Courseware (https://ocw.mit.edu/search/?s=department_course_numbers.sort_coursenum)
2. NPTEL Open Courseware (https://nptel.ac.in/)

Suggested Self-Learning Activities

Activity	No. of Hours	Total Hours Claimed	Evaluation Criteria
Assignments on topics like Improper integrals, beta -gamma function, application of integration, Taylor's and Maclaurin's series, Infinite sequence and series, Partial differentiation, application of partial differentiation and multiple integrals, application of multiple integration etc	Completing ten assignments (2h each)	20	Evaluated based on assignment submission
Online Video based learning	Duration of video = 20h	30	Report or presentation based on learning

	Report preparation = 10h		through video
Online participation in two Quizzes	4 hours for preparation of each quiz and 1 hour for participation in each quiz,	10	Quiz Scores
Online Course (MOOC/NPTEL/SWAYAM/edX, etc.) on Calculus	Minimum course duration of 10 hours	10	Assessment through an examination at the end of the course. Certificate submission required
AI based content development on Subject related topics	5 hours per unit	20	Review based on evaluation of content
Prepare project on Subject related topics	10 hours per project	10	Review based on evaluation of project .
Developing Posters, Charts, or PowerPoint Presentations on Subject related topics	Designing and presenting visual content	20	Assessed based on creativity, clarity, and presentation skills

Guidelines for Faculty:

- The activities listed above are suggestive and faculty members have the flexibility to select and modify them as needed.
- The total self-learning hours remain fixed at 60 hours, ensuring comprehensive coverage of topics of Mathematics -I through at least 3 activities.
- Faculty can adjust the distribution of hours across different activities while maintaining a balanced learning approach.
- All records pertaining to the evaluation and assessment of self-learning activities must be properly maintained and preserved at the institute level. These records should be made available to the university upon request.
- Institutes are encouraged to utilize digital platforms, such as Microsoft Teams, for effective record keeping and to ensure transparency in the evaluation and assessment of self-learning activities.

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: ALL
Course / Subject Code: BE01R00051
Course / Subject Name: Basic Electrical Engineering

w. e. f. Academic Year:	2024-25
Semester:	Ist Year
Category of the Course:	ESC

Prerequisite:	NA
Rationale:	Electricity has been the main source of energy for the developing and developed countries. Per capita consumption of electricity of a country can be considered as an indicator of the development of the country. In view of this, it is essential for all engineering graduates to know the basic aspects of electrical engineering. This subject deals with basic circuit solution methods, introduction to electrical machines and basics of domestic electrical installations.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Apply fundamental electrical laws and circuit theorems to electrical circuits.	Application
02	Analyze single phase and three phase AC circuits.	Analyze
03	Describe operating principle and applications of static and rotating electrical machines.	Understand
04	Understand the wiring methods, electricity billing, and working principles of circuits protective devices and personal safety measures.	Read & Understand
05	Understand the electrical safety and purpose, types and scope of earthing systems	Read & Understand

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	TW/SL	TH		ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
45	0	30	45	120	04	70	30	20	30	50	200

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, PA = Progressive Assessment, ESE = End-Semester Examination

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**DC Circuits:** Electrical circuit elements (R, L and C), voltage and current independent sources, Kirchoff's current and voltage laws, analysis of simple circuits with dc excitation, Superposition, Thevenin and Norton Theorems, Star-delta/Delta-Star conversion, Time-domain analysis of first-order RL and RC circuits.	7	15
2.	**AC Circuits** Representation of sinusoidal waveforms, peak, RMS and average values of different signals, form factor and peak factor, Phasor representation of AC quantities, real power, reactive power, apparent power, power factor. Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel), Series and parallel resonances, Three phase balanced circuits, voltage and current relations in star and delta connections, Power measurement in three phase balanced circuits.	9	20
3.	**Magnetic Circuits & Transformers** Magnetic effect of electrical current, cross and dot convention, right hand thumb rule and cork screw rule, Concepts of m.m.f, flux, flux density, reluctance, permeability and field strength, Analogy between electric and magnetic circuits, Magnetic Circuits, B-H Curve, Hysteresis Loop, Hysteresis and Eddy current losses, Construction and working principle of single-phase transformers: Construction, principle of working, voltage and current ratios, losses, definition of regulation and efficiency, Ideal and practical transformer.	8	15
4.	**Fundamentals of Electrical Machines** Generation of rotating magnetic fields, Construction and working of Single-phase induction motors (Split phase, Capacitor start, Permanent split capacitor, Capacitor start/capacitor run). Single phase induction motor applications: pumps, refrigerators, fans, compressors, and portable drills. Construction and working of brushless DC motors and its application: Electrical Vehicle, washing machines, Blowers, Computers/Laptops	9	20

5.	**Electrical Wiring and Installations** Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB. Types of lamps, fixtures & reflectors, illumination schemes for domestic, industrial & commercial premises, Lumen requirements for different categories. Earthing – Types of earthing and its importance. Safety precautions for electrical appliances. Types of Batteries, Characteristics of Batteries (Voltage, storage capacity, discharge curve, cycle life). Elementary calculations for energy consumption of home appliances and electricity bill. Basic electrical measurements with Ammeter, Voltmeter, Wattmeter and Energy meter (working principle and circuit connection).	12	30
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
40	20	20	20	0	0

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1) D. C. Kulshreshtha, "Basic Electrical Engineering", McGraw Hill, 2009.
2) Basic Electrical Engineering - Nagsarkar and Sukhija, Oxford University Press
3) B. L. Theraja, "Electrical Technology – Part I and II", S. Chand and Co. 2012
4) D. P. Kothari and I. J. Nagrath, "Basic Electrical Engineering", Tata McGraw Hill, 2010.
5) J. B. Gupta " Basic Electrical Engineering", S.K. Kataria & Sons,2023.
6) A Chakrabarti,S Nath and C K Chanda "Basic Electrical Engineering",TATA McGraw Hill,
7) S.L. Uppal "Electrical Wiring Estimating and Costing", Khanna Publisher, 1987
8) Irving M. Gottlieb ""Practical Electric Motor Handbook"Newnes,1997
9) L. S. Bobrow, "Fundamentals of Electrical Engineering", Oxford University Press, 2011.
10) E. Hughes, "Electrical and Electronics Technology", Pearson, 2010.
11) V. D. Toro, "Electrical Engineering Fundamentals", Prentice Hall India, 1989.

Open source software and website:

1. https://nptel.ac.in/

Suggested Course Practical List:

1) Introduction of Resistors, Capacitors and Inductors and usage of measuring instruments – voltmeter, ammeter, multi-meter, oscilloscope.
2) To verify the Kirchoff's current and Kirchoff's voltage laws.
3) To verify the Thevenin's and Norton's theorems.
4) To verify Superposition's theorems
5) To obtain sinusoidal steady state response of R-L and R-C circuits – impedance calculation and verification phasor relationships between voltage and current and to observe the phase differences between current and voltage phasors
6) To obtain steady-state and transient time-response of R-L, R-C, and R-L-C circuits to a step change in DC input voltage (transient may be observed on a Digital Storage Oscilloscope)
7) To verify the phasor relationships between currents and voltages for resonances in R-L-C circuits
8) To measure the power in three phase balanced circuits using two wattmeter method
9) To verify the current phasor and voltage phasor relationships in three phase star and delta connections
10) Demonstration of cut-section models and charts of various machines
11) Demonstration of domestic switch gears like MCB, ELCB, MCCB etc. of different ratings
12) Understanding of various safety precautions for electrical installations
13) Demonstration of various types of wires, fuses and cables
14) To Calculate energy consumption of various appliances and house hold electricity bills
15) To verify the power factor improvement in single phase AC circuit
16) Study the different types of domestic wiring
17) To obtain Hysteresis loop of a magnetic material on CRO/DSO

List of Laboratory/Learning Resources Required:

Ammeters, Voltmeters, Wattmeters, Resistors, Capacitors and Inductors of appropriate rating. Multimeters, Digital storage oscilloscope, Cut section models/charts of various machines, Demo units for MCB, ELCB, MCCB etc, Samples of wires and cables. Charts for earthing and safety precautions.

- **Self-Learning Activity Plan for BE01000051 – Basic Electrical Engineering**

Total Self-Learning Hours: 45

No.	Activity Name	Units Mapped	Hours	Brief Description	Evaluation Criteria/Remarks
1	Technical Video-Based Learning	Unit 1, 2, 3	10 (5+5)	Watch curated videos (e.g., NPTEL/MIT OCW) on DC circuits, AC power,	Report + Oral Presentation

				Transformers. Submit a reflective report.	
2	Numerical Assignment Writing	Unit 1, 2, 3	10 (5 × 2h)	Solve 5 numerical assignments covering Theorems, Power factor, AC analysis, and Transformer calculations.	Correctness, method, clarity
3	Simulation & Problem Solving Using Software (Scilab, Tinkercad, LTSpice)	Unit 1, 2, 3	10 (5 × 2h)	Simulate basic circuits (RLC, transformer equivalent), transient analysis, and AC load behavior.	Report + Screenshot + Output sheet
4	Case Study: Domestic Wiring & Electricity Billing	Unit 5	5 (2.5+2.5)	Study household wiring layout and energy bills. Estimate load, usage, and suggest efficiency improvements.	Report + Practical Recommendations
5	Poster / PPT Preparation	Unit 4, 5	4	Topic examples: “BLDC Motor in EV”, “Earthing Methods”, “Difference between MCB & MCCB”	Technical clarity + Visual appeal + Presentation
6	Group Discussion / Seminar on Electrical Safety & Earthing	Unit 5	2	Discuss safety norms, role of protective devices, and earthing types.	Technical depth, articulation
7	Online Technical Quiz / Interactive Simulation (Electrical4U / vlab.co.in)	Unit 1 to 5	2	Attempt at least 3 online quizzes with screenshot of scores and a 100-word learning reflection.	Quiz scores + Reflection Note
8	Maintenance / Troubleshooting Logbook (Lab Based)	Unit 1, 2, 4, 5	2	Record at least 5 issues encountered during lab sessions and how they were resolved.	Clarity of issue, resolution steps
9	Annotated Concept Video (Optional – Higher Bloom’s	Unit 2, 3	Extra (Optional 5)	Make a 5–6 minute video explaining topics like phasor relationships or transformer working.	Clarity, technical accuracy, originality

	level)				
10	Mini Project	Unit 1		1.Design & build a small DC lighting circuit for a room with switches & fuses, calculate load & test functionality. 2. Create a Portable Power Supply 3. Star-Delta Conversion Demonstration Board	1)Students design and wire a small DC circuit with multiple switches and a fuse. 2)Measure total current & voltage at different load configurations. 3) Document calculations & measurements 1)Design and build a small DC power supply (e.g., 6V/12V) using batteries, resistors, and regulators. 2)Test output voltage under varying loads. Mini-Project:Star-Delta Conversion Demonstration Board
11	Mini Project	Unit 2		Construct & test a power factor correction circuit using capacitors for a given inductive load	1) Build a circuit with inductive loads and capacitors to improve the power factor. 2) Measure before and after power factor.
12	Mini Project	Unit 4		Prepare a report on motors	Identify and

				used in a household appliance (e.g., washing machine) and demonstrate working with a model or simulation	document the types & ratings of motors used in 5–6 household appliances. 2)Suggest improvements for energy efficiency.
13	Mini Project	Unit 5		Design a safe, energy-efficient wiring layout for a small house/shop including earthing & protective devices	1.House Wiring Model Design and build a functional model of electrical wiring for a 1-room house with proper earthing & protection devices. 2.Energy Audit & Bill Calculation Measure energy consumption of typical home appliances and calculate monthly electricity bill. Suggest ways to reduce the bill. 3.Safety Demo Board Create a board demonstrating MCB, ELCB, MCCB operation with faulty & safe scenarios.

Unit-Wise Mapping of Self-Learning Activities – BE01000051

Unit	Topic	Relevant Activities
1	DC Circuits	Activities 1, 2, 3, 7, 8, 10
2	AC Circuits	Activities 1, 2, 3, 7, 8, 9, 11

3	Magnetic Circuits & Transformers	Activities 1, 2, 3, 9,
4	Electrical Machines	Activities 1, 5, 8,12
5	Electrical Wiring, Safety & Billing	Activities 4, 5, 6, 7, 8,13

Note:

- **All the suggested activity should be related to the subject.**
- **The number of hours is suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.**
- **Rubrics for the evaluation can be prepared by the faculty.**
- **All records pertaining to the evaluation and assessment of self-learning activities must be properly maintained and preserved at the institute level. These records should be made available to the university upon request.**
- **Institutes are encouraged to utilize digital platforms, such as Microsoft Teams, for effective record-keeping and to ensure transparency in the evaluation and assessment of self-learning activities.**

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: UG

Branch: All

Course / Subject Code : BE01R00061

Course / Subject Name : Engineering Graphics & Design

w. e. f. Academic Year:	2024-25
Semester:	Ist Year
Category of the Course:	Engineering Science

Prerequisite:	Zeal to learn the subject
Rationale:	Engineering Drawing is an effective language of engineers. It is the foundation block which strengthens the engineering & technological structure. Moreover, it is the transmitting link between ideas and realization.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT level
1	Apply the conventions and the methods of engineering drawing also interpret engineering drawings	Application
2	Construct basic and intermediate geometry and comprehend the theory of projection.	Application
3	Dissect the objects in three dimensions with different orientation.	Analyze
4	Make use of computer software for engineering drawings.	Application

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	TW/SL	TH		ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
15	0	30	15	60	02	70	30	20	30	50	200

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, PA = Progressive Assessment, ESE = End-Semester Examination

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Introduction to Engineering Graphics:** Drawing instruments and accessories, BIS – SP 46. Use of plane scales, Diagonal Scales and Representative Fraction.	*	10
2.	**Engineering Curves:** Classification and application of Engineering Curves, Construction of Conics, Cycloidal Curves, Involutes andSpirals	*	10
3.	**Projections of Points and Lines:** Introduction to principal planes of projections, Projections of the points located in same quadrant and different quadrants, Projections of line with its inclination to one reference plane and with two reference planes. True length and inclination with the reference planes.	4	20
4.	**Projections of Planes:** Projections of planes (polygons, circle and ellipse) with its inclination to one reference plane and with two reference planes	2	20
5.	**Projections of Solids, Section of Solids:** Classification of solids. Projections of solids (Cylinder, Cone, Pyramid and Prism) along with frustum with its inclination to one reference plane and with two reference planes, Section of such solids and the true shape of the section.	6	20
6.	**Orthographic Projections:** Fundamental of projection along with classification, Projections from the pictorial view of the object on the principal planes for view from front, top and sides using first angle projection method and third angle projection method, full sectional view.	3	20
7.	**Computer Aided Drawing:** Introduction to AutoCAD, Basic commands for 2D drawing like : Line, Circle, Polyline, Rectangle, Hatch, Fillet, Chamfer, Trim, Extend, Offset, Dim style, etc.	*	
	Total	15	**100**

* Chapter/Topics must be taught during laboratory sessions.

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
25	**30**	**30**	**15**	-	-

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. A Text Book of Engineering Graphics by P.J.Shah S.Chand & Company Ltd., New Delhi.
2. Elementary Engineering Drawing by N.D.Bhatt Charotar Publishing House, Anand.
3. A text book of Engineering Drawing by R.K.Dhawan, S.Chand & Company Ltd., New Delhi.
4. A text book of Engineering Drawing by P.S.Gill, S.K.Kataria & sons, Delhi.
5. Engineering Drawing by B. Agrawal and C M Agrawal, Tata McGraw Hill, New Delhi.

(b) Open-source software and website:

1. AutoCAD

Suggested Course Practical List:

Students must prepare sketch book and drawing sheets on the following topics.

1. Practice sheet (which includes dimensioning methods, different types of line, construction of different polygon, divide the line and angle in parts, use of stencil) – 2 Hrs.
2. Plane scale and diagonal scale – 2 Hrs.
3. Engineering curves- 4 Hrs.
4. Projection of point and line – 4 Hrs.
5. Projection of plane – 4 Hrs.
6. Projection of solid, section of solid - 4 Hrs.
7. Orthographic projection – 6 Hrs.
8. At least one orthographic drawing (three views) using above mentioned AutoCAD commands. – 4 Hrs.

List of Laboratory/Learning Resources Required:

Suggested Project List:

1. Students must prepare at least one model using cardboard/paper to understand the fundamentals of topic no. 1 to 6. This project work will be considered for practical evaluation.

Activities suggested under self-learning:

Sl. No.	Name of the activity	No. of hours	Evaluation Criteria
1.	Industry/Research laboratory visit	Visit = 5hrs., Report preparation = 5hrs. Total = 10hrs.	Based on report submitted. Report should contain observations and calculations

			based on industry/ lab data.
2.	Technical Video based learning related to the subject	Duration of video = 5hrs. Report preparation = 5hrs. Total = 10hrs.	Report /presentation based on the video learning outcomes.
3.	Assignment writing. Numericals based assignment is preferable.	5 assignments of 4hrs. each. Total = 20hrs.	Based on the correctness of submittedassignment.
4.	Problem solving/Coding using C, C++, MATLAB, Python, SCILAB,modeling and Analysis software or any other software	5 small coding-based assignment of 2hrs. each. Total = 10hrs.	Based on the coding solution submitted.
5.	Self-learning online course	Minimum duration of the course should be 10hrs.	Examination based assessment at the end of course. Based on the certificate produced.
6.	Identification and solution of Complex problem	Maximum 2 problems. Study of the problem and solution finding, Total = 10hrs.	Based on the depth of the solution submitted.
7	Videos on Industrial safety/Disaster Management aspects based on subject	Duration of video = 5hrs. Report preparation = 5hrs. Total = 10hrs.	Based on quiz/report submitted
8	Technical paper reading and summarization of research papers based on relevant subject	5 research papers = 20 hrs.	Summarize research paper and evaluation critical parameters
9.	Poster/chart/power point preparation on technical topics	Duration = 6 hrs.	Based on poster/chart preparation and presentation skills
10	Working/non-working model on technical topics	Working = 12 hrs. Non- working = 8 hrs.	Based on inter department/external evaluation
11	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment/health/sustainability/any other issue	Duration = 15 hrs. for industrial exposure Problem identification and tentative solution = 10 hrs. Total = 20 hrs.	Based on evaluation of critical problems and solutions
12	Group Discussion on emerging/trending technical topics based on subject	Duration = Min. 1 hr.per subject. Max. 3 hrs. per subject	Based on performance in group discussion, technical depth, knowledge etc.
13.	Real world case studies-	Duration of data collection/study =	Based on in-depth study,

	based learning	5hrs. Report preparation = 5hrs. Total = 10hrs.	technical depth, data collected, fact finding, etc.
14.	Application/Software development	Duration = 10 hrs.	Depending on the complexity of the Application/Software
15.	Research paper publication	Duration = 10 hrs.	Based on submission of proof of publication
16.	Upgradation/Reverse engineering studies of existing equipment of the laboratory	Duration 10 hrs.	Based on the performance of the equipment
17.	Expert lecture/session	Duration 3 hrs. For attending the lecture/session– 2 hrs. and for report writing 1 hr.	Based on the proof of attendance and report submitted
18.	Annotated Video Explanation of Concept/Problem	10h (Preparation + Recording + Submission)	Based on accuracy of explanation, clarity, and presentation style.
19.	Patent Search and Innovation Gap Identification	10h (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.

Note:

1. All the suggested activity should be related to the subject.
2. The number of hours are suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
3. Rubrics for the evaluation can be prepared by the faculty.
4. Subject teacher can add the relevant activities other than those listed above, with the consent of head of the department and DQAC.

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: ALL

Course / Subject Code : BE01R00071

Course / Subject Name : Design Thinking

W. e. f. Academic Year:	2024-25
Semester:	Ist Year
Category of the Course:	ESC

Prerequisite:	**NIL**
Rationale:	This course is designed for students from all disciplines who seek to understand design thinking for brand, product, and service development. It covers essential concepts, methods, and techniques of design thinking, empowering students to drive innovation in both business and the social sector.

Course Outcome:

After Completion of the Course, the Student will be able to:

No	Course Outcomes	RBT Level
01	Understand the fundamental principles and importance of Design Thinking in fostering innovation and its relevance in engineering.	UN
02	Apply systematic problem identification, problem framing-articulation, and problem-solving approaches in the context of Design Thinking.	AP
03	Analyze and evaluate different tools and methodologies used in Design Thinking, such as observation, ethnographic research, and mind mapping, to gain insights into user unmet needs.	AN
04	Develop and refine product concepts by preparing product development canvases (PDC) that consider product experience, functions, features, and components. (Synthesis level)	AP
05	Create a final working prototype or an alternative prototype for projects with limitations, showcasing the functionality and features, Viability, Impact, Sustainability, Scalability, Costing, and Resources for the Creation	CR

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	TW/SL	TH		ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
00	00	60	00	60	02	00	00	20	00	80	100

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, PA = Progressive Assessment, ESE = End-Semester Examination

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Introduction to Design Thinking for Engineers** What Sets Design Thinking Apart? Essential Design Thinking Skills, Core Principles of Design Thinking, Foundations of Design Thinking, Building an Effective Design Thinking Team, Design Thinking Workshops and Meetings Exercises and Case-Based Discussions	08	13
2.	**Stages of the Design Thinking Approach** Class Exercise: Review the Case Study **Observation:** Role of observation in understanding product and process challenges, Techniques for effective product and process observation **Exercise:** Based on the AEIOU Framework **Empathize** with Customers/Users **Exercise:** Engage with Customers/Users **Define the Problem,** Exercise: Review and Follow-Up, Define the Point of View **Ideate** Exercise: Develop Potential Solutions **Prototype Alternate Solutions** Exercise: Create a Prototype of the Solution **Test the Solutions** Exercise: Prepare and Conduct Tests of the Prototype and Solution	14	23

	Exploring Design Thinking in Innovation: Understanding the Role of Design Thinking in Product and Process Innovation, Differentiating Engineering Design and Design Thinking Contrasting Approaches: Engineering Design vs. Design Thinking Stanford Design thinking process and Double Diamond model		
3.	**Design Thinking Techniques** Understanding Listening and Empathizing Techniques: Exploring observation methods, Utilizing a structured, open-ended approach for effective communication, Ideation Tools: Brainstorming techniques for idea generation, Applying innovation heuristics to foster creativity. **Introduction to SCAMPER technique:** Explanation of SCAMPER (Substitute, Combine, Adapt, Modify, put to another use, Eliminate, Reverse) and its application in diverse innovation contexts (product, system, process) Practical exercises and case studies demonstrating SCAMPER's effectiveness in idea generation Prototype and Test Techniques: Type of Prototype (PoC), Forms of testing in Design Thinking, Prepare and A/B Test of the prototype	14	23
4.	**Methods and Tools for Design Thinking Practice** Empathize: Ask five why questions, Empathy map, storytelling, critical items diagram, mind map, journey map Ideate: Brainstorming, 2X2 matrix, NABC Methods Prototype: Exploration map, Minimum Viable Product (MVP), Feasibility Testing, Viability Testing, Sustainability Testing Test: Collet Feedback, iterate and improve the ideas	14	23
5.	**Adopt and Adapt Design Thinking** Cautions and Pitfalls: Assumptions Exercise: Assumptions Pitfalls and Cautions in Design Thinking Workgroups Application of Design Thinking in Academic Projects Across Disciplines	10	18
	Total	**60**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
0	**15**	**40**	**15**	**20**	**10**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Pavan Soni (2020), Design Your Thinking: The Mindsets, Toolsets, and Skill Sets for Creative Problem-solving, Penguin Random House India Private Limited
2. Gasparini, Andrea. "Perspective and use of empathy in design thinking." In ACHI, the Eight International Conference on Advances in Computer-Human Interactions, pp. 49-54. 2015.
3. Defining a Problem Statement — Design Thinking by Priyanka Jeph in QED42
4. Scamper: How to Use the Best Ideation Methods by Rikke Friis Dam and Teo Yu Siang in Interaction Design Foundation
5. Design: Creation of Artifacts in Society by Prof. Karl Ulrich, U. Penn
6. Tim Brown, "Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation."
7. Jeanne Liedtka, Tim Ogilvie, and Rachel Brozenske, "Design Thinking for the Greater Good: Innovation in the Social Sector."

(b) Open-source software and website:

1. Google Workspace: Docs, Sheets, & Slides
2. Google Jamboard
3. Storyboard
4. Any other Relevant Tools

(c) Suggestive MOOC Course

1. B.K. Chakravarthy, Design Technology and Innovation, SWAYAM NPTEL (Online)
2. B.K. Chakravarthy, Innovation by Design, SWAYAM NPTEL (Online)
3. Nina Sabnani, Understanding Design, SWAYAM NPTEL (Online)
4. R T Krishnan and V Dhabolkar, Managing Innovation, SWAYAM NPTEL (Online)

Note:

1. Based on Design Thinking, individual BoS may propose mini projects in the relevant subject in higher semesters.

GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: UG

Branch: All

Course / Subject Code : BE01R00081

Course / Subject Name : Basic Mechanical Engineering

w. e. f. Academic Year:	2024-25
Semester:	1st Year
Category of the Course:	ESC

Prerequisite:	Nil
Rationale:	Knowledge of basic principles of Mechanical Engineering is required in various fields of engineering.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT level
1	Explain the various sources of energy and basic terminology of Mechanical engineering	Understand
2	Make calculations for commonly used working fluids i.e. ideal gases and steam	Apply
3	Make use of various heat engine cycles and explain construction and working of IC engines	Apply
4	Explain working and applications of steam boilers and various energy conversion systems	Understand
5	Explain various power transmission elements, construction and working of various clutches; couplings and brakes, and properties of various engineering materials with their applications	Understand

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	TW/SL	TH		ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
45	0	30	45	120	04	70	30	20	30	50	200

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, PA = Progressive Assessment, ESE = End-Semester Examination

GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: UG

Branch: All

Course / Subject Code : BE01R00081

Course / Subject Name : Basic Mechanical Engineering

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Basic Terminology and Energy:** Prime movers and its types, Concept of Force, Pressure, Energy, Work, Power, System, Heat, Temperature, Specific heat capacity, Process, Cycle, Internal energy, Enthalpy, Statements of Zeroth law and First law Applications of Energy sources like Fossil fuels, Nuclear fuels, Hydrogen fuel, Hydro, Solar, Wind, and Bio-fuels, Environmental issues like Global warming and Ozone depletion	8	14
2.	**Properties of gases:** Boyle's law, Charles's law, Gay-Lussac's law, Avogadro's law, Combined gas law, Gas constant, Relation between cp and cv, Various non-flow processes like constant volume process, constant pressure process, Isothermal process, Adiabatic process, Polytropic process **Properties of Steam:** Steam formation, Types of steam, Enthalpy, Specific volume, Internal energy and dryness fraction of steam, use of steam tables, steam calorimeters	12	22
3.	**Heat Engines:** Heat engine cycle and Heat engine, working substances, Classification of heat engines, Description and thermal efficiency of Carnot; Rankine; Otto cycle and Diesel cycles **Internal Combustion Engines:** Introduction, Classification, Engine details, four-stroke/ two-stroke cycle Petrol/Diesel engines, Indicated power, Brake Power, Efficiencies	10	20
4.	**Steam Boilers:** Introduction, Classification, Cochran, Lancashire and Babcock and Wilcox boiler, Functioning of different mountings and accessories	-	10
5.	**Air compressors and pumps:** Types and operation of Reciprocating and Rotary air compressors, significance of Multistage, Types and operation of Reciprocating, Rotary and Centrifugal pumps, Priming	6	10
6.	**Refrigeration & Air Conditioning:** Refrigerant, Vapor compression refrigeration system, Vapor absorption refrigeration system, Domestic Refrigerator, Window and split air conditioners	4	8

7.	**Couplings, Clutches and Brakes:** Construction and applications of Couplings (Box; Flange; Pin type flexible; Universal and Oldham), Clutches (Disc and Centrifugal), and Brakes (Block; Shoe; Band and Disc) **Transmission of Motion and Power:** Shaft and axle, Different arrangement and applications of Belt drive; Chain drive; Friction drive and Gear drive	-	10
8.	**Engineering Materials:** Types, properties and applications of Ferrous & Nonferrous metals, Timber, Abrasive material, silica, ceramics, glass, graphite, diamond, plastic and polymer	5	6
	Total	**45**	**100**

Note: Topic No. 4 and 7 of the above syllabus must be covered in Practical Hours.

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
20	**40**	**40**	**-**	**-**	**-**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Elements of Mechanical Engineering by N M Bhatt and J R Mehta, Mahajan Publishing House
2. Basic Mechanical Engineering by Pravin Kumar, Pearson Education
3. Fundamental of Mechanical Engineering by G.S. Sawhney, PHI Publication New Delhi
4. Elements of Mechanical Engineering by Sadhu Singh, S. Chand Publication
5. Introduction to Engineering Materials by B.K. Agrawal, McGraw Hill Publication, New Delhi

(b) Open source software and website:

1. https://nptel.ac.in
2. www.vlab.co.in

Suggested Course Practical List:

1. To understand construction and working of various types of boilers.
2. To understand construction and working of different boiler mountings and accessories.

3. To understand construction features of two/four stoke petrol/diesel engines
4. To determine brake thermal efficiency of an I. C. Engine.
5. To understand construction and working of different types of air compressors.
6. To demonstrate vapor compression refrigeration cycle of domestic refrigerator OR window air conditioner OR split air conditioner.
7. To understand construction, working and application of clutches, couplings and brakes
8. To understand different arrangement and application of various power transmission drives

List of Laboratory/Learning Resources Required:

Models of Cochran, Lancashire and Babcock and Wilcox boilers, models of various mountings and accessories, Models of various types of IC engines, Single cylinder two stroke /four stroke petrol/ diesel engine, models of pumps, compressors, Domestic refrigerator/window air conditioner/split air conditioner, models of various types of brakes, coupling, clutches, drives

- **Activities suggested under self-learning:**

Sl. No.	Name of the activity	No. of hours	Evaluation Criteria
1.	Industry/Research laboratory visit	Visit = 5hrs., Report preparation = 5hrs. Total = 10hrs.	Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
2.	Technical Video based learning related to the subject	Duration of video = 5hrs. Report preparation = 5hrs. Total = 10hrs.	Report /presentation based on the video learning outcomes.
3.	Assignment writing. Numericals based assignment is preferable.	5 assignments of 4hrs. each. Total = 20hrs.	Based on the correctness of submitted assignment.
4.	Problem solving/Coding using C, C++, MATLAB, Python, SCILAB,modeling and Analysis software or any other software	5 small coding-based assignment of 2hrs. each. Total = 10hrs.	Based on the coding solution submitted.
5.	Self-learning online course	Minimum duration of the course should be 10hrs.	Examination based assessment at the end of course. Based on the certificate produced.
6.	Identification and solution of Complex problem	Maximum 2 problems. Study of the problem and solution finding, Total = 10hrs.	Based on the depth of the solution submitted.
7	Videos on Industrial safety/Disaster Management aspects based on subject	Duration of video = 5hrs. Report preparation = 5hrs. Total = 10hrs.	Based on quiz/report submitted
8	Technical paper reading and summarization of research papers	5 research papers = 20 hrs.	Summarize research paper and evaluation critical parameters

	based on relevant subject		
9.	Poster/chart/power point preparation on technical topics	Duration = 6 hrs.	Based on poster/chart preparation and presentation skills
10	Working/non-working model on technical topics	Working = 12 hrs. Non- working = 8 hrs.	Based on inter department/external evaluation
11	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment/health/sustainability/any other issue	Duration = 15 hrs. for industrial exposure Problem identification and tentative solution = 10 hrs. Total = 20 hrs.	Based on evaluation of critical problems and solutions
12	Group Discussion on emerging/trending technical topics based on subject	Duration = Min. 1 hr.per subject. Max. 3 hrs. per subject	Based on performance in group discussion, technical depth, knowledge etc.
13.	Real world case studies-based learning	Duration of data collection/study = 5hrs. Report preparation = 5hrs. Total = 10hrs.	Based on in-depth study, technical depth, data collected, fact finding, etc.
14.	Application/Software development	Duration = 10 hrs.	Depending on the complexity of the Application/Software
15.	Research paper publication	Duration = 10 hrs.	Based on submission of proof of publication
16.	Upgradation/Reverse engineering studies of existing equipment of the laboratory	Duration 10 hrs.	Based on the performance of the equipment
17.	Expert lecture/session	Duration 3 hrs. For attending the lecture/session– 2 hrs. and for report writing 1 hr.	Based on the proof of attendance and report submitted
18.	Annotated Video Explanation of Concept/Problem	10h (Preparation + Recording + Submission)	Based on accuracy of explanation, clarity, and presentation style.
19.	Patent Search and Innovation Gap Identification	10h (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.

Note:

1. All the suggested activity should be related to the subject.
2. The number of hours are suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
3. Rubrics for the evaluation can be prepared by the faculty.
4. Subject teacher can add the relevant activities other than those listed above, with the consent of head of the department and DQAC.

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: ALL

Course / Subject Code: BE01R00101

Course / Subject Name: Basic Civil Engineering

w. e. f. Academic Year:	2024-25
Semester/Year	Ist Year
Category of the Course:	ESC

Prerequisite:	**NA**
Rationale:	Infrastructure development has been the main focus area for developing country like India. Housing, Road, bridges, public transportation systems and sanitation can be considered as indicators for development of the country. In view of this, it is essential for all engineering graduates to know the basic aspects of civil engineering. This subject deals with planning and construction of building, construction materials, surveying, quality parameters of water and wastewater, water shed management and overview of other infrastructural needs of a city.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Apply the basic knowledge of different building materials used in construction.	U
02	Interpret plans, components and methods of construction for the building.	A
03	Identify quality of water and wastewater and methods of water conservation.	U
04	Know the use of basic equipment required for linear and angular measurements	A
05	Comprehend need and types of mass transportation systems and advances in civil engineering.	U

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching - Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	TW/SL	TH		ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
45	0	30	45	120	04	70	30	20	30	50	200

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End-Semester Examination, PA = Progressive Assessment

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Introduction of Civil Engineering and Building materials:** Introduction, branches of civil engineering, scope, role of a civil engineer, units of measurements and its conversion. Type, properties and applicability of building materials: cement, aggregate, brick, steel, concrete, stone, soil, mortar, timber, plastic, epoxy, fly-ash, metal slags, bitumen, optical fiber, pipes, wires and cables, FRP and emerging smart and recycled materials.	7	16
2.	**Building planning and construction:** Definitions of terminologies related to building plan, working drawings, principles of planning, types of building, preparation of plan elevation and section of a residential building, symbols used for electrical and sanitary services, building components and its functions, loads acting on the building, elementary concepts of brick and stone masonry. Town planning, necessity and principles, Origin of town, Growth of town, Land use, Principles and objects of zoning, Advantages of zoning, Low-cost housing, Building automation	12	27
3.	**Quality parameters of water and wastewater and sanitary systems** Sources of water, quality characteristics of drinking water and domestic wastewater, drinking water standards, methods for disposal of wastewater, types of sewerage system, types of building services like plumbing & sanitation, water supply & drainage system, house drainage system, elementary concepts of solid waste management.	8	17
4.	**Introduction to surveying and levelling:** Introduction to surveying, fundamental principles, classification. **Linear measurement**: Instruments used, chaining on plane ground, offset, ranging. **Angular measurement:** Types of compass, meridian and bearing, local attraction, traverse surveying. **Leveling:** Instrument used, terminology, types of leveling, methods of leveling, contours and its characteristics. **Modern tools:** Introduction to theodolite, auto-level, total-station, EDM. Introduction to GPS survey and Drone survey	12	27
5.	**Advances in Civil Engineering** Smart city and it's features, green building, earthquake resistant structures, mass transportation systems (BRTS, metro, mono rail,), bullet train, watershed management, Sardar Sarovar dam, Kalpsar	6	13

	project, Narmada canal network, Water conservation, and rain water harvesting, river front development		
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
35	**40**	**25**	**-**	**-**	**-**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Surveying volume I and II by Dr. B.C. Punmia, Laxmi Publications.
2. Surveying and levelling by N.N. Basak, Tata Mcgraw Hill Education.
3. Building Construction by Dr. B.C. Punmia, Laxmi Publications.
4. Engineering Materials by R.C. Rangwala, Charotar Publications.
5. Building planning, designing and scheduling by Gurucharan Singh, Standard Publisher.
6. Environmental Engineering volume I and II by S.K.Garg, Khanna Publishers.
7. Basic Civil Engineering by S. Ramamrutham, Dhanpatrai Publication.
8. Basic Civil Engineering by M.S.Palanichamy, McGraw Hill
9. Basic Civil Engineering by Satheesh Gopi, Pearson Publisher

(b) Open source software and website:

1. http://nptel.ac.in/courses/105107122/
2. http://nptel.ac.in/courses/105107157/
3. http://nptel.ac.in/courses/105101087/
4. http://nptel.ac.in/courses/105104100/

Suggested Course Practical/Assignment List:

1. Unit conversation exercise.
2. Assignment based on building material and field visit for material identification.
3. Identification of components of building (field visit/models) and assignment related to it.
4. Planning of a residential building (plan, elevation & section of a residential building)

5. Linear and angular measurements (Chain and Compass) (in field with instrument)
6. Determination of R.L of a given point by Dumpy level/auto-level. (in field with instrument)
7. Assignment based on numerical of surveying and levelling.
7. Introduction to Theodolite & total station.
8. Presentation on BRTS/Metro/Monorail/Bullet train.
9. Seminar on green building & smart city.

List of Laboratory/Learning Resources Required:

Chain, tape, compass, dumpy level, auto-level, theodolite, total station, EDM, models related to building components and services.

Suggested Project List:

1. Chain and Compass Traverse Survey
2. Profile leveling

Suggested Activities for Students:

Explore web content related to smart cities, green building, mass transportations systems, emerging building materials etc.

- **Activities suggested under self-learning:**

Sl. No.	Name of the activity	No. of hours	Evaluation Criteria
1.	Industry/Research laboratory/Village/Places of National Importance visit	Visit = 5h, Report preparation = 5h Total = 10h	Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
2.	Technical Video based learning related to the subject	Duration of video = 5h Report preparation = 5h Total = 10h	Report /presentation based on the video learning outcomes.
3.	Assignment writing. Numerical based assignment is preferable.	5 assignments of 2h each. Total = 10h	Based on the assignment submitted.
4.	Problem solving/Coding using C, C++, Python, SCILAB, MATLAB, MS-EXCEL or any	5 small coding-based assignment of 2h each. Total =	Based on the coding solution submitted.

	other relevant software	10h	
5.	On-line courses related to the subjects	Minimum duration of the course should be 10h.	Examination based assessment at the end of course. Based on the certificate produced.
6.	Videos on Industrial safety aspects based on subject	Duration of video = 5h Report preparation = 5h Total = 10h	Based on quiz/report submitted
7.	Poster/chart/power point preparation on technical topics	Duration = 6 h	Based on poster/chart preparation and presentation skills
8.	Working/non-working model on technical topics	Working = 12 h Non- working = 8 h	Based on inter department/external evaluation
9.	Group Discussion on emerging/trending technical topics based on subject	Duration = 1 h each	Based on performance in group discussion, technical depth, knowledge etc.
10.	Real world case studies-based learning	Duration of data collection/study = 5h Report preparation = 5h Total = 10h	Based on in-depth study, technical depth, data collected, fact finding, etc.
11.	Field survey of 1 to 2 days	Duration = 10 h Data collection, representation & interpretation	Based on need of the data for various societal/governance/Industry scheme/project

Note:
1. All the suggested activity should be related to the subject.
2. The number of hours are suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
3. Minimum 03 activities shall be covered per subject.
4. Rubrics for the evaluation can be prepared by the faculty.

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w. e. f. Academic Year:	2024-25
Semester:	1st Year
Category of the Course:	ESC

Prerequisite:	• Basic Computer Skills • Logical Thinking and Problem-Solving Abilities • Understanding of mathematical logic and problem-solving strategies
Rationale:	The "Programming for Problem Solving" course is a foundational skill that significantly enhances an engineer's problem-solving abilities, career prospects, and capacity for innovation. Integrating programming into the curriculum ensures that engineering programs prepare students to meet the challenges of the modern technological landscape and contribute effectively to their respective fields.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Identify fundamental programming constructs such as variables, data types, operators, expressions, control structures, functions and basic data structures	Remember
02	Explain the principles of programming and software development, including the structure and operation of algorithms, flowcharts, and pseudocode.	Understand
03	Develop simple programs using appropriate data structures and standard libraries.	Apply
04	Apply programming constructs such as loops, conditional statements, and functions to solve basic engineering problems.	Apply
05	Debug and troubleshoot programming errors by systematically testing and refining code.	Analyze

Teaching and Examination Scheme:

Teaching Scheme(in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
02	00	04	04	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Introduction to Programming** • **Basics of Computers**: Overview of computer systems, hardware, andsoftware. • **Introduction to Programming Languages**: Types of programminglanguages, language translators (compilers, interpreters). • **Flowcharts and Algorithms**: Basics of creating flowcharts and writingalgorithms for problem-solving.	03	10
2.	**Basics of C Programming** • **Structure of a Program**: Basic syntax, semantics, and structure of C programs. • **Data Types and Variables:** Primitive data types, variables, and constants. • **Operators:** Arithmetic, relational, logical, bitwise, and assignment operators.	03	10
3.	**Control Structures** • Conditional Statements: if, if-else, nested if-else, switch-case. • Loops: for, while, do-while loops. • Break and Continue Statements: Usage in loop control.	03	10
4.	**Functions and Modular Programming** • Defining Functions: Syntax, return types, and parameter passing. • Library Functions: Standard library functions and header files (for C). • Recursion: Basic concepts and examples.	03	10
5.	**Arrays and Strings** • Arrays: One-dimensional and multi-dimensional arrays, array operations.	03	10

	• Strings: String handling functions, basic string operations.		
6.	**Pointers** • Pointers: Basics of pointers, pointer arithmetic, pointers and arrays, pointers tofunctions (for C).	03	10
7.	**Structures and Unions** • Structures: Defining and using structures, array of structures, pointer tostructures. • Unions: Basics and usage.	03	10
8.	**File Handling** • File Operations: Opening, closing, reading, writing files. • File Pointers: File pointers and basic file operations (for C).	03	10
9.	**Dynamic Memory Allocation** • Memory Allocation: malloc, calloc, realloc, and free functions. Usage and examples.	03	10
10.	**Debugging and Testing** • Debugging Techniques: Common debugging practices, use of debugging tools. • Testing: Writing test cases, unit testing.	03	10
	Total	**30**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
20	20	40	20	00	00

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as perRevisedBloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. C Programming Language by Brian W. Kernighan and Dennis M. Ritchie**,** Latest Edition (for C programming)
2. Let Us C by Yashavant Kanetkar, Latest Edition (for C programming)
3. Problem Solving and Program Design in C by Jeri R. Hanly and Elliot B. Koffman**,** Latest Edition **(**for Cprogramming)

(b) Open-source software and website:

1. OnlineGDB : GDB online Debugger | Compiler - Code, Compile, Run, Debug online C, C++ (onlinegdb.com)
2. Compiler Explorer (Godbolt): Compiler Explorer (godbolt.org)
3. JDoodle: JDoodle - Free online cloud coding platform IDE to practice, teach and learn programming

Suggested Course Practical List:

1. Write a program that performs basic arithmetic operations (addition, subtraction, multiplication, and division)and demonstrates the use of different data types.
2. Create a program that uses if, else, and switch statements to implement a simple menu-driven application. Useloops (for, while, and do-while) to repeat tasks.
3. Develop a program that calculates the factorial of a number using both iterative and recursive functions.
4. Write a program to perform various operations on arrays (e.g., sorting, searching) and strings (e.g.,concatenation, comparison).
5. Implement a program that uses pointers to create and manipulate dynamic arrays, demonstrating the use of malloc, calloc, realloc, and free.
6. Design a student record system using structures that store and display information such as name, roll number,and grades.
7. Write a program to read from and write to files, such as creating a simple text editor that performs basic fileoperations.
8. Implement a singly linked list with operations like insertion, deletion, and traversal.
9. Develop programs to simulate stack operations (push, pop, peek) and queue operations (enqueue, dequeue)using arrays and linked lists.
10. Provide students with a program containing intentional errors and inefficiencies. Have them use debuggingtools (like gdb) to find and fix the errors and optimize the code for better performance.

List of Laboratory/Learning Resources Required:

1. Computer System/Laptop with latest configurations.
2. Internet Connectivity

Suggested Project List:

1. **Library Management System** with the Objectives of
   - Practice basic C syntax and operations,
   - Use control structures effectively,
   - Implement functions and modular programming,
   - Manipulate arrays and strings,
   - Handle file operations for data storage and retrieval

2. **Institute Hall Management System,** Project Objectives:
   - To manage the allocation of halls for different events.
   - To maintain records of bookings, cancellations, and availability of halls.
   - To provide an interactive user interface for managing hall reservations.

Suggested Activities for Students:

- To enhance the programming skills of students in a C Programming and Problem-Solving course, the instructor can assign various activities that progressively build their understanding and ability to applyconcepts.

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Bachelor of Engineering

Branch: ALL

Course / Subject Code : BE01R00131

Course / Subject Name : Workshop and Manufacturing Practices

w. e. f. Academic Year:	2024-25
Semester:	Ist Year
Category of the Course:	Engineering Science

Prerequisite:	**Nil**
Rationale:	Workshop practice is the backbone of the real industrial environment which helps to develop and enhance relevant technical hand skills required by the technician working in the various engineering industries and workshops. Irrespective of branch, the use of workshop practices in day to day industrial as well domestic life helps to dissolve the problems.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
CO -1	Perform basic operations of fitting and Carpentry.	A
CO -2	Demonstrate Casting, Welding and Plumbing work.	U
CO -3	Practice on Plumbing work and Smithy work	A
CO -4	Explain applications of Plastic, Glass and Ceramic processes.	U
CO -5	Explain basic concepts of digital fabrication.	U

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	TW/SL	TH		ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
00	00	30	00	30	01	00	00	20	00	80	100

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, PA = Progressive Assessment, ESE = End-Semester Examination

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1	**Fitting Shop** Demonstration on different tools used, Hands on Practice and job making in Fitting shop.	05	17
2	**Carpentry** Demonstration on different tools used, Hands on Practice and job making in Carpentry shop.	06	20
3	**Welding and Casting shop** 1. Hands on Practice and job making using Electric arc Welding/ Resistance welding process. 2. Hands on Practice and job making in Smithy/ Tin smithy Shop 3. Demonstration of Pattern making and Sand molding	05	17
4	**Plumbing and its fitting** (1) Types of Pipes and Fittings, (2) Joints (PVC and Metal), (3) Plumbers tools and equipment's, (4) Cutting and bending of different mental pipes (5) Pipe fitting, (6) Plumbing symbols, (7) Plumbing services (8) Sanitary Pipes and Fittings, (9) Joints	04	13
5	**Introduction to Plastic, Glass and Ceramic technology:** Plastic materials, Types of Plastics and application. Plastic molding processes, Describe the characteristics and application of the following glasses: - a) Borosilicate glass b) Pyrex glass c) Heat resisting glass d) Colored glass e) Ruby glass f) Laminated glass. Definition & scope of ceramics and ceramic materials, classification of ceramic materials – conventional and advanced, Areas of applications.	06	20
6	**Digital Fabrication**: Introduction to digital fabrication tools: 3D Printers (FDM, SLS, SLA) CNC tools etc., Procedural steps to start with digital fabrication. Design for digital fabrication, demonstration of 3 D Printing. Application and Advantage of Digital Fabrication	04	13
	Total	**30**	**100**

Suggested Specification Table with Marks (Theory):

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

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Hajra Choudhury S.K., Hajra Choudhury A.K. and Nirjhar Roy S.K., "Elements of Workshop Technology", Vol. I 2008 and Vol. II 2010, Media promoters and publishers private limited, Mumbai.
2. Rao P.N., "Manufacturing Technology", Vol. I and Vol. II, Tata McGraw Hill House, 2017.
3. Workshop Technology Vol. 1 and 2 by Raghuvanshi B.S. Dhanpat Rai & Sons1998.
4. Workshop Technology by Chapman W.A. J and Arnold E. Viva low priced student edition, 1998.
5. Workshop Practices, H S Bawa, Tata McGraw-Hill,2009.
6. Hand book of glass manufacturers Vol I & II F.V Tooley Ogden Publishing co. New York
7. Modern Glass Practice Samuel R. Scholes CBI Publishing Co. INC
8. Industrial ceramics Singer and Singer Oxford & IBH
9. Elements of ceramics F.H. Norton Longman Higher Education
10. J. A. Brydson, "Plastics Materials", Butterworth- Heinemann - Oxford, 7th Ed., 2001.
11. Irvin. I. Rubin, "Hand Book of Plastic Materials and Technology", Wiley Interscience, NY, 1990.
12. HMT Production Technology, Tata Mc Graw Hill (India), 1992
13. Introduction to Ceramics - W.D Kingery

(b) Open source software and website:

1. http://nptel.iitm.ac.in/courses.php

Suggested Course Practical List:

Workshop Practice:

1. Fitting shop
2. Carpentry
3. Welding shop
4. Casting
5. Smithy
6. Plastic molding & Glass Cutting
7. Plumbing and its fitting
8. Digital Fabrication: 3D printer and CNC

List of Laboratory/Learning Resources Required: Suggested as per above

Suggested Project List: As per availability at Institute, if not demonstration or by video session

Suggested Activities for Students: As per above listed in Workshop practice

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: All
Subject Code: BE01R00151
Subject Name: Contributor Personality Development Program

w. e. f. Academic Year:	2024 - 2025
Semester:	Ist Year
Category of the Course:	HSMC-01

Type of course: Work-Personality Development

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 confidence with which they can go into any job and contribute meaningfully.
- Improve their ability to engage better in the workplace and to be able to handle the challenges that come up there.
- Build their career-worthiness and help them develop into future-ready contributors with ability tonavigate a career in a volatile, changing world.
- 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.
- Enable them to recognize how they, as technical professionals, can participate and make a positive contribution to their communities and to their state.

Towards this goal, the Contributor Program has been designed to awaken and strengthen students from within, in terms of building positive self-esteem, increasing their confidence level and I-can attitude, improving their aspirations, giving them new methods of thinking, building their cognitive capacities, exposing them to the skills and practices associated with being contributors in the workplace (not mere employees).

The Program content is also designed to expose students to real-world workplace scenarios and sensitize them to some of the challenges faced in society around them, especially in the local communities around them and in their own state of Gujarat.

The Contributor Program syllabus has been evolved and fine-tuned over several years, (a) to address the changing need and contemporary challenges being faced by industry and what employers of today are looking for in the people they hire and (b) by working extensively with universities and students building an appreciation of their challenges and concerns. At the core, the program is guided by the higher ideas and principles of practical Vedanta in work.

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	TW/ SL	TH		ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
30	00	00	30	60	02	70	30	00	30	00	130

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, PA = Progressive Assessment, ESE = End-Semester Examination

Note:

- Classroom facilitated sessions are planned which include Solutioning and Self- discovery sessions.
- In addition, there will be individual/ team projects as part of Practicals. Students can do this on their own, with faculty as guide.

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.

Content:

Sr. No.	Content	Total Hrs.
1.	**The Contributor Work Ideal** In this topic, students explore what is their "ideal" of work - is the ideal to be a "worker" or to be a "contributor"? For example, an employee who has the ideal of a "worker" goes to work to pass time, earn a living, get benefits; in contrast to an employee with the ideal of a "contributor" who wants to make a difference, get things done well, create value for the company. This enables students to transform their expectation of themselves in work	5
2.	**Identity & Self-esteem** In this topic, students engage with the question "who am I?" or on whatbasis do they define themselves. Is their identity defined by what others think of them (extrinsic self-esteem) or by what they think of themselves (intrinsic self-esteem)? Further, they discover positive identities that lead to intrinsic self-esteem, such as an I-can identity based on one's capacity and inner strength. This enables them to build confidence and self-esteem.	5

3.	**Become a Creator of one's destiny** In a "victim stance", we see the career environment as full of difficultiesand 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 of destiny stance" to challenges and situations. This stance frees them to try out new things, open up new possibilities, take on responsibility, see the opportunity hidden in their environment.	5
4.	**Achieving Sustainable Success** In this topic, students discover how to achieve sustainable or lasting success, by building one's "engine of success", making them success-worthy. Where their focus shifts to building one's "engine of success" rather than being 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. And with a strong engine of success, fruits come to them in time.	5
5.	**Career Development Models** In this topic, students explore a range of diverse "career development models" and the possibilities for contribution each opens up to them (e.g. start-up career model, change-maker career model, etc.). This opens their mind to different and even unconventional career models possible, beyond the usual (such as "stable large company career model" where one gets an engineering degree, then MBA, then get a job in a large company). This frees them from a herd mentality when makingcareer choices.	5
6	**Expanding contribution in every role** In this topic, students explore the many roles they can play in their life & discover the power they have to expand the contribution possible in any role. (E.g. role of student, role of manager, role of a project site engineer). So, the potential of a role is in the individual's hands. This opens their mind to an alternative way of career growth.	5
	Total Hours	**30**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks (for B.Pharm)					
R Level	U Level	A Level	N Level	E Level	C Level

-	**15**	**20**	-	**25**	**20**

Distribution of Theory Marks (for B.E., Diploma, MCA)					
R Level	U Level	A Level	N Level	E Level	C Level
-	**15**	**15**	-	**20**	**20**

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

Reference resources:

A. Basic reference for both students and teachers

1. Contributor Personality Program textbook cum workbook developed by Illumine.
2. Web-based ActivGuide™ for self-exploration of rich media resources to vividly understand many of the ideas, watch role models, learn from industry people, get reference readings – that help them enrich the understanding they gained in the class published by Illumine Foundation

B. Advanced reference for teachers

1. On Contributors, Srinivas V.; Illumine Ideas, 2011
2. Enlightened Citizenship and Democracy; Swami Ranganathananda, Bharatiya Vidya Bhavan,1989
3. Eternal Values for a Changing Society – Vol I-IV, Swami Ranganathananda; Bharatiya VidyaBhavan
4. Karma Yoga, Swami Vivekananda; Advaita Ashrama
5. Vivekananda: His Call to the Nation, Swami Vivekananda; Advaita Ashrama
6. Six Pillars of Self Esteem, Nathaniel Branden; Bantam, 1995
7. Mindset: The New Psychology of Success, Carol S. Dweck; Random House Publishing Group,2007
8. Lasting Contribution: How to Think, Plan, and Act to Accomplish Meaningful

Work, TadWaddington; Agate Publishing, 2007
9. Why not?: how to use everyday ingenuity to solve problems big and small, Barry Nalebuff, IanAyres; Harvard Business School Press, 2003
10. The value mindset: returning to the first principles of capitalist enterprise (Ch 8 & 9); ErikStern, Mike Hutchinson; John Wiley and Sons, 2004
11. 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
12. Creating Shared Value, Michael E. Porter and Mark R. Kramer; Harvard Business Review;Jan/Feb2011, Vol. 89 Issue 1/2
13. The Speed of Trust: The One Thing That Changes Everything, Stephen M. R. Covey, Rebecca R. Merrill, Stephen R. Covey; Free Press, 2008
14. The Courage to Meet the Demands of Reality, Henry Cloud; HarperCollins, 2009
15. Responsibility at work: how leading professionals act (or don't act) responsibly, HowardGardner; John Wiley & Sons, 2007

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
Outcome of theory sessions		
CO-1	Students will be able to recognize & appreciate two alternative ideals of work – ideal of a "worker" and ideal of a "contributor". And why organizations of todayexpect people they employ to be contributors and not just workers.	10-12%
CO-2	Students will be able to recognize & appreciate alternative ways in which they could define themselves or "who am I" (their identity) – and which are positive identities that will lead to building intrinsic self-esteem and confidence in oneself; in contrast to identities that will lead to extrinsic self-esteem that makes them more dependent on their environment.	10-12%
CO-3	Students will be able to recognize & appreciate a "victim" stance as distinct froma "creator of destiny" stance in the way people approach challenges and situations; and how the latter frees individuals to take on challenges and open up opportunities.	10-12%
CO-4	Students will be able to differentiate between two alternative approaches to success - 'building one's engine of success' and 'chasing the fruits of success'; they also appreciate the payoffs/ consequences of both and which is more likely to lead to sustainable or lasting success in the long run.	10-12%
CO-5	Students will be able to recognize & appreciate different career models and their value; to help them make more informed career-related choices.	10-12%

CO-6	Students will be able to recognize & appreciate how one can expand the contribution possible in any role, thereby opening up an alternative way of career growth to them.	10-12%
Outcome of practical sessions		
CO-7	Students learn to re-interpret their life and college experiences to showcase their contribution affinities which are relevant for employers.	15%
CO-8	Students learn to apply contributor thinking to real-world or career relevant challenges.	15%

- **Activities suggested under self learning**

Sl. No.	Name of the activity	No. of hours	Evaluation Criteria
1	Identify one habit to be transformed and ask student to execute it for 21 days	Activity duration =21 day. Duration= 5 hours	Based on report /Chart/Poster/Presentation submitted
2	Track social media usage: Decide one social media app to be uninstalled from your phone for 15 days.	Activity duration =15 day. Duration= 5 hours	Based on report /Chart/Poster/Presentation submitted
3	To do seva activities at old age home, orphanage home, ,hospital, Cleanliness at school,society,college	Duration =5 hours	Based on report /Chart/Poster/Presentation submitted
4	Prepare a chart of famous failures.	Duration = 5 hours	Based on report /Chart/Poster/Presentation submitted
5	Make a team of 2-3 members .Plan the overall activities to be carried out for tech fest at your college, Make detailed list of activities to be done and budget plan.	Duration =5 hours	Based on report /Chart/Poster/Presentation submitted
6	Introspect and identify at least five scenario where you feel that your actions could be updated based on learning from listening and understanding	Duration =5 hours	Based on report /Chart/Poster/Presentation submitted
7	Sit with your family for 15 minutes a day discuss and share each other's activities(for Total 20 days)	Duration= 5 hours	Based on report /Chart/Poster/Presentation submitted
8	A well-organized plan for managing a **college tech fest** with a **team of 2–3 members**, including a **detailed list of activities** and a **budget plan**.	Duration =5 hour	Based on report submitted.
9	Sitting with your family for just **15 minutes a day** share each other's activities	Activity time = 5 hours (20 days) Report time = 5 hours	Based on report /Chart/Poster/Presentation submitted.
10	Group discussion: *What do I owe to my parents?* Write a Gratitude Letter to a parent/sibling/friend.	Duration= 1 hour	Based on report /Chart/Poster/Presentation submitted.

11	Prepare a "Personal Vision Statement" or "My Code of Living" booklet	Duration =1 hour	Based on report /Chart/Poster/Presentation submitted.
12	Role-play or skit on miscommunication in relationships and solutions	Duration = 1 hour	Based on report /Chart/Poster/Presentation submitted
13	Community Seva (Service Activity): cleaning, helping elderly, teaching kids, etc. + reflection	Duration= 5 hours	Based on report /Chart/Poster/Presentation submitted
14	Self-Observation Diary: Record thoughts/emotions/actions for 10 days.	Duration = 1 hour	Based on report /Chart/Poster/Presentation submitted
15	Life Vision Journal: Write your 5-year vision—career, health, relationships, contribution. "My Life Compass" Poster: Personal motto, core values, role models, goals.	Duration =1 hour	Based on report /Chart/Poster/Presentation submitted
16	Avoid all social media for 24 hours. Reflect: *What did I miss? What did I gain?*	Duration =1 hour	Based on report /Chart/Poster/Presentation submitted
17	Review and clean your social media: Unfollow toxic or negative accounts. Follow value-based, positive pages. Reflect: *What did I miss? What did I gain?*	Duration =1 hour	Based on report /Chart/Poster/Presentation submitted
18	Maintain a log of daily screen/social media usage for 3–5 days. Categorize it into productive vs unproductive time.	Duration =1 hour	Based on report /Chart/Poster/Presentation submitted
19	Organize a physical or virtual tour to a local museum, heritage site, or historical monument.	Duration = 5 hour	Based on report /Chart/Poster/Presentation submitted
20	Students create weekly factsheets or digital posts sharing unknown facts from India's past (science, ethics, literature, and education).	Duration = 5 hour	Based on report /Chart/Poster/Presentation submitted
21	Watch a documentary (e.g., *Bharat Ek Khoj*, *Science in Ancient India*) and write a reflection on what surprised or inspired them.	Duration =1 hour	Based on report /Chart/Poster/Presentation submitted

Note:
1. All the suggested activity should be related to the subject.
2. The number of hours are suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
3. Rubrics for the evaluation can be prepared by the faculty.

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TEACHING SCHEME / DETAIL SYLLABUS

Home

BE

05 - CHEMICAL ENGINEERING

2

2024-25

Select Elective / Non-Elective

Subject Code

Enter Subject Name

Search

*L=lectures,T=tutorial,P=Practical,E=TheoryExternal,M=TheoryInternal,I=Practical Internal,V=Practical External,On Job Training(OJT) is equivalent to Practical

							Hours			Credit	Max Marks					
Exp.	Subcode	Branch code	Eff_from	SubjectName	Category	Sem /Year	L.	T.	P.	PBL	Total	E	M	I	V	Total
⊞	BE02000011	005	2024-25	Mathematics – 2	Basic Science Courses	2	3	1	0	NA	4	70	30	0	0	100
⊞	BE02000021	005	2024-25	English for Technical Communication	Humanities and Social Science, including Management Courses	2	2	0	2	NA	3	70	30	20	30	150
⊞	BE02000031	005	2024-25	Intellectual Property Rights	Multidisciplinary Open Professional Electives Courses	2	2	0	0	NA	2	70	30	0	0	100
⊞	BE02000041	005	2024-25	Fundamental of AI	Multidisciplinary Open Professional Electives Courses	2	2	0	0	NA	2	70	30	0	0	100
⊞	BE02000061	005	2024-25	Industrial Safety and Standards	Multidisciplinary Open Professional Electives Courses	2	2	0	0	NA	2	70	30	0	0	100
⊞	BE02R00011	005	2025-26	Mathematics – 2	Basic Science Courses	2	45	15	0	60	4	70	30	30	0	130
⊞	BE02R00021	005	2025-26	English for Technical Communication	Humanities and Social Science, including Management Courses	2	30	0	30	30	3	70	30	50	50	200

	BE02R00031	005	2025-26	Intellectual Property Rights	Multidisciplinary Open Professional Electives Courses	2	30	0	0	30	2	70	30	30	0	130
	BE02R00041	005	2025-26	Fundamental of AI	Multidisciplinary Open Professional Electives Courses	2	30	0	0	30	2	70	30	30	0	130
	BE02R00061	005	2025-26	Industrial Safety and Standards	Multidisciplinary Open Professional Electives Courses	2	30	0	0	30	2	70	30	30	0	130
	BE02R00071	005	2025-26	Standardization and Quality Ecosystem	Multidisciplinary Open Professional Electives Courses	2	30	0	0	30	2	70	30	30	0	130

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Web Site Visit Count

00353205 9

GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Degree

Branch: All

Course / Subject Code : BE02000011

Course / Subject Name : Mathematics – 2

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	BSC

Prerequisite:	Basic Algebra, Complex Algebra, Calculus.
Rationale:	Mathematics fundamental necessary to formulate, solve and analyze engineering problems. Complex analysis not only provides insight into mathematical theory but also has practical applications in engineering, physics and many other forms.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	The essential tool of matrices and linear algebra in a comprehensive manner.	A
02	The effective mathematical tools for the solutions of differential equations that model physical processes.	A
03	The tools of differentiation and integration of functions of a complex variable that are used in various techniques dealing engineering problems.	A
04	To find Laurent's series, poles. residues, and apply Cauchy Residue theorem in evaluating some real integrals.	A

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	1	0	4	70	30	0	0	100

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Module 1: Matrices:** Linear Independence; Row Echelon form (REF)and Reduced Row Echelon form(RREF) of a Matrix, Rank of a Matrix using REF/RREF; Inverse of a matrix using Gauss-Jordan method; Solution of System of linear equations by elementary row operations; Symmetric, skew-symmetric and orthogonal matrices; Eigen values and eigenvectors; Diagonalization of matrices; Inverse of a Matrix by Cayley-Hamilton Theorem.	10	22%
2.	**Module 2: First order ordinary differential equations:** Exact differential equations, Integrating factors for non-Exact differential equations, linear and Bernoulli's equations. Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type.	8	18%
3.	**Module 3: Ordinary differential equations of higher orders:** Higher order linear differential equations with constant and variable coefficients, Euler-Cauchy equations, solution by variation of parameters, method of undetermined coefficients; Classification of Ordinary and Singular points, Power series solutions for ordinary points.	10	22%
4.	**Module 4: Complex Variables (Differentiation):** Differentiation, Cauchy-Riemann equations, analytic functions, harmonic functions, finding harmonic conjugate; analyticity of elementary functions (exponential, trigonometric, logarithm) and their properties;	9	20%
5.	**Module 5: Complex Variables (Integration):** Contour integrals, Cauchy-Goursat theorem (without proof), Cauchy Integral formula (without proof); Taylor's series, zeros of analytic functions, singularities, Laurent's series; Residues, Cauchy residue theorem (without proof), Rouche's theorem.	8	18%
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
20	35	15	0	0	0

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, John Wiley & Sons, 2006.
2. W. E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, 9th Edn., Wiley India, 2009.
3. D. Poole, Linear Algebra: A Modern Introduction, 2nd Edition, Brooks/Cole, 2005.
4. S. L. Ross, Differential Equations, 3rd Ed., Wiley India, 1984.
5. E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India, 1995.
6. E. L. Ince, Ordinary Differential Equations, Dover Publications, 1958.
7. J. W. Brown and R. V. Churchill, Complex Variables and Applications, 7th Ed., Mc-Graw Hill, 2004.
8. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010.
9. Howard Anton, Irl Bivens, Stephens Davis, Calculus, 10e, Wiley, 2016.
10. AICTE's Prescribed Textbook: Mathematics-II (Calculus, Ordinary Differential Equations and Complex Variable), Khanna Book Publishing Co.

(b) Open source software and website:

1. MIT Open Courseware (https://ocw.mit.edu/search/?s=department_course_numbers.sort_coursenum)
2. NPTEL Open Courseware (https://nptel.ac.in/)

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Degree

Branch: All

Course / Subject Code : BE02000021

Course / Subject Name : English for Technical Communication

w. e. f. Academic Year:	2024 - 2025
Semester:	2nd Semester
Category of the Course:	HSMC-02

Prerequisite:	Zeal to learn the subject
Rationale:	The rationale of the curriculum is to help students acquire knowledge of English language and Technical Communication Skills needed for academics and workplace

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Understand the process of communication, types of communication and difference between technical and general communication.	U
02	Use diverse vocabulary and knowledge of grammar in both spoken and written communication for clarity and coherence.	C
03	Prepare formal content and professional documents with precision and conciseness.	C
04	Communicate in group, deliver effective presentations, grasp phonetics, employ active listening, and enhance reading across various genres.	N
05	Analyze and interpret different literary texts to understand and appreciate the use of language in various contexts and thereby gain a deeper understanding of different cultures, themes, and writing styles.	C

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
2	0	2	3	70	30	20	30	150

GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Degree

Branch: All

Course / Subject Code : BE02000021

Course / Subject Name : English for Technical Communication

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Introduction to Technical Communication:** Communication : Definition, purposes Process of communication Types of communication Technical Communication : Definition, Purposes, Characteristics Difference between Technical and General Communication	5	17
2.	**Vocabulary Building & Grammar:** One-word substitutes, Foreign and Technical Words, Introduction to Word Formation, Types of word formation processes: compounding, clipping, blending, derivation, creative respelling, coining and borrowing Acquaintance with prefixes and suffixes Synonyms, antonyms, and standard abbreviations and acronyms **Grammar:** Parts of speech, Tenses, Articles, Subject-Verb Agreement, Active Passive. (Suggestive list of One-word Substitutes, Synonyms & Antonyms, Foreign & Technical words, Standard Abbreviation and Acronyms is available in the link provided.)	6	20
3.	**Developing Basic Writing Skill:** Styles of Writing Paragraph Writing: elements and Practice Object / Picture / Scene Description Précis writing Proof Reading Completion of given story Letter Writing (Formats, Asking for leave, Apology, Appreciation, acknowledgement	6	20
4.	**Speaking skills:** Introduction to Phonetics IPA Place of articulation, transcription Presentation skills- an Introduction Analyzing audience and locale Organizing a presentation Introduction to group communication Conversations, Debates, dialogues, and GDs	5	17

	(Suggestive list of words for Phonetic Transcription is available in the link. provided.)		
5.	**Listening & Reading Skills:** Meaning, importance and purpose of listening Listening Vs. Hearing Types of listening Barriers to effective listening Traits of a good listener Introduction, Meaning and Purpose of reading Tips for improving reading skills Techniques for effective reading : Skimming, Scanning, Structure of text, Punctuation, Author's & Reader's point of view Reading Comprehension	4	13
6.	**Enhancing Language through Literature:** The Red Rice Granary by Sudha Murty The Gift of Magi by O. Henry The World-Renowned Nose by V.M.Basheer The Lady or, The Tiger? by Frank R. Stockton	4	13
	Total	**30**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
25	30	15	10	5	15

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Wren P. C. and Martin H., *High School English Grammar & Composition*, S. Chand Publication, 2023
2. Raman M. and Sharma S., *Technical Communication*, OUP, New Delhi, 2017
3. Lata P. and Kumar S., *Communication Skills*, OUP, New Delhi, 2018
4. Kansakar T. R., *A Course in English Phonetics*, Orient Longman, 1998
5. Bansal R. K. and Harrison J. B., *Spoken English*, Orient Longman, 2013
6. Murty Sudha, *How I taught my Grandmother to Read and Other Stories*, Puffins Books, 2015

7. *Gems of Wisdom - An anthology of short stories*, Macmillan Publishers India Ltd., 2013
8. Sudharshana N. P. and Savitha C., *English for Engineers*, Cambridge University Press, 2018
9. Richards Jack C., Hull Jonathan, Proctor Susan, *Interchange Intro, 1, 2, 3*, 5th Edition, Cambridge University Press, 2017
10. Hart Steve, Nair Aravind R, Bhambhani Veena, *Embark – English for Undergraduates*, Cambridge University Press, 2016

(b) Open source software and website:

1. https://drive.google.com/drive/folders/1sAjxiU1X3u47M7xSJDRy5roFISyMJodo?usp=drive_link - (Suggestive list of One-word Substitutes, Synonyms & Antonyms, Foreign & Technical words, Standard Abbreviation and Acronyms is available as well as words for phonetic transcription is available in this link.)

Suggested Course Practical List:

Sr. No.	List of Practical	No. of Hours
1	Short Speeches	2
2	Paragraph Writing and expansion of story	2
3	Listening Comprehension, Podcasts, Audio Books , Ted Talks	2
4	Vocabulary and Grammar practice	4
5	Reading comprehension and Précis Writing	2
6	Role Play	4
7	Letter Writing	2
8	Object / Picture / Scene Description	2
9	Debate	4
10	GDs	4
11	Phonetics (read aloud, accent imitation, articulation practice) (Unit 4)	2
12	Practical Assessment	2

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch:

Course / Subject Code : BE02000031

Course / Subject Name : Intellectual Property Rights

w. e. f. Academic Year:	2024-25
Semester:	2nd Semester
Category of the Course:	MOPEC

Prerequisite:	**None**
Rationale:	An IPR introductory course equips students with essential knowledge about protecting intellectual assets, fostering innovation, and contributing to the knowledge-driven paradigm of the twenty-first century.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Learn fundamental concepts of intellectual property (IP), including patents, copyrights, trademarks, GIs and trade secrets	R
02	Understand Intellectual Property (IP) types and characteristics	U
03	Understand the general procedures of obtaining IPR rights	U
04	Apply knowledge of IP principles to real-world scenarios	A
05	Analyze the impact of IP on the economies	N

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
2	0	0	2	70	30	0	0	100

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	Introduction: Concept of Intellectual Property (IP), Introduction of Intellectual Property Rights (IPRs), Significance of IP and IPR, History of IPR, Advantages & Disadvantages of IPR.	4	10
2.	Introduction to different types of IPR patents, Industrial Designs, copyrights, trademarks, trade secrets, Geographical Indications and Plant Varieties. Real world case studies highlighting the economic impact of each type of IPRs.	9	30
3.	Introduction to different IPR regulation authorities in India: Official Machinery, Controller/ Governing bodies, Powers and Functions. Filing procedure of each type of IPR in India.	5	20
4.	Introduction to WIPO & WTO, Treaties, conventions and agreements pertaining to each type of IPR 1: Paris convention, Madrid, Hague, Nice, PCT, Lisbon, Locarno, Strasbourg, Vienna Agreement, Budapest Treaty, Nairobi Treaty	6	20
5.	Treaties, conventions and agreements pertaining to each type of IPR 2: Trademark Law Treaty, Patent Law Treaty (PLT), Berne Convention, Rome Convention, Geneva Convention, Beijing Treaty, Marrakesh Treaty, TRIPS. Filing procedure of PCT application.	6	20
	Total	**30**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
40	**30**	**20**	**10**		

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. D.P. Mittal (Taxman Publication), Indian Patents Law and Procedure
2. B.L. Wadera, Patents, trademarks, copyright, Designs and Geographical Indications.
3. P. Narayanan (Eastern Law House), Intellectual Property Law
4. W. Cornish (Universal Publication), Intellectual Property Law
5. R.K. Nagarjan, Intellectual Property Law

6. Ronan Deazley, Martin Kretschmer, Lionel Bently, Privilege and Property: Essays on the History of Copyright (Open Book Publishers 2010).
7. Sidney Diamond, 'Historical Development of Trademarks, (1983) 73 Trademark Representative 222.

(b) Open source software and website:

1. https://www.wipo.int/edocs/pubdocs/en/intproperty/442/wipo_pub_442.pdf
2. https://worldwide.espacenet.com/
3. https://www.wipo.int/patentscope/en/

Suggested Course Practical List: If any: Not Applicable

List of Laboratory/Learning Resources Required:

1. https://onlinecourses.swayam2.ac.in/cec20_hs18/preview
2. https://onlinecourses.nptel.ac.in/noc23_hs55/preview
3. https://www.wipo.int/academy/en/

Suggested Project List: Not Applicable

Suggested Activities for Students:

1. Read minimum three granted patents on a chosen subject and prepare a summary report.
2. Study patent filing forms.
3. Prepare a brief report on patent search engines.
4. Study design patent filing form(s).
5. Study copyright filing form(s).
6. Prepare a survey report on at least one geographical indication.
7. Collect data about patent filed in India over a period of last ten years. Analyze the data and prepare a report.

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w. e. f. Academic Year:	2024-25
Semester:	2nd Semester
Category of the Course:	MOPEC

Prerequisite :	• Basic of computing and fundamental knowledge of problem solving techniques. • Understanding of key concepts related to algorithms.
Rationale:	The "Fundamental of AI" course is designed to provide undergraduate students with a comprehensive foundation in crucial domains of Artificial Intelligence. This interdisciplinary course aims to equip students with fundamental concepts and techniques that are essentially a pre-requisite in today's technology-driven world.

Course Outcome:

After Completion of the Course, Student will be able to:

No	Course Outcomes	RBT Level
01	Learn and enable them to discuss and comprehend AI-related topics.	Remember
02	Understand the fundamental concepts and terminology of Knowledge representation.	Understand
03	Understand the Machine Learning concepts and models to study fundamental problems of computing.	Understand
04	Understand the Deep Learning concepts and its applications for AI.	Understand
05	Apply various AI techniques to study real world scenarios and use cases.	Apply

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				
				Theory		Tutorial / Practical		Total Marks
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
02	00	00	02	70	30	-	-	100

Course Content:

Unit No.	Content	No. of Hours	% of Weigh tage

1.	**Introduction:** • History & overview of Artificial Intelligence • Definition of Artificial Intelligence • Artificial Narrow Intelligence, Artificial General Intelligence, Artificial Super Intelligence • Concepts of Production, Agents and Environments • Characteristic of Intelligent Agents, Concept of Rationality, Nature of Environments.	08	30
2.	**Knowledge Representation:** • Concept of Knowledge representation • Introduction to Natural Language processing • Concept of Pattern recognition • Introduction to Expert systems	06	20
3.	**Basics of Machine Learning:** • Learning from examples • Forms of Learning -Supervised learning, Unsupervised learning, Reinforcement learning • Simple Models –Linear regression, Logistic regression, Support Vector Machines (SVM) etc.	06	20
4.	**Deep Learning:** • Concept of Deep Learning • Introduction to Neural Networks. • Types of Deep Learning models. • Deep leaning applications.	06	20
5.	**Modern Artificial Intelligence**: • Large Language Models (LLMs) • Use-cases: ChatGPT, Gemini, Bhashini, Krutrim etc. • Current Issuess & Future Challenges of AI.	04	10
	Total	**30**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
30	50	20	00	00	00

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

1. Artificial Intelligence: Concepts and Applications by Lavika Goel, Latest Edition, Wiley.
2. Artificial Intelligence by Kevin Knight, Elaine Rich, Shivashankar B. Nair, Latest Edition, Mc-Graw Hill.

3. Understanding Artificial Intelligence: Fundamentals and Applications by Albert Chun-Chen Liu, Oscar Ming Kin Law, Iain Law, Latest Edition Wiley-IEEE Press.
4. Fundamentals of Artificial Intelligence by K.R. Chowdhary, Latest Edition, Springer.
5. Artificial Intelligence A Modern Approach by Stuart J. Russell and Peter Norvig, Latest Edition, Pearson.

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: ALL

Course / Subject Code : BE02000061

Subject Name : Industrial Safety and Standards

WEF Academic Year :	2024-25
Semester :	2
Category of the Course :	MOPEC

Prerequisite :	High School Physics, Chemistry, Mathematics
Rationale :	The course is intended to give knowledge of various safety management principles, various safety systems, hazards, types, causes and preventive steps in an industrial environment. It will prepare the students to understand the importance of periodic and preventive maintenance in an industrial environment and to find faults in various machine tools.

Course Outcome :

After Completion of the Course, Student will able to :

No	Course Outcomes	RBT Level*
01	Understand the concept of industrial safety and industrial hazards	UN
02	Understand the importance of Periodic and Preventive maintenance	UN
03	Apply the fault finding methods in machine tools	AP

*RM: Remember, UN: Understand, AP: Apply, AN: Analyze, EL: Evaluate, CR: Create

Teaching Scheme and Examination Scheme :

Teaching Scheme			Total Credits	Assessment Pattern and Marks				Total Marks
				Theory		Practical		
L	T	PR	C	ESE (E)	PA(M)	ESE (V)	PA (I)	
2	0	0	2	70	30	0	0	100

Course Content :

Sr. No.	Course Content	No. of Hours	% of Weightage
1	**Unit-I: Industrial safety**: Need for safety. Safety and productivity, Accident: causes, types, results and control. Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Reportable accidents. Theories of accident causation. Mechanical and electrical hazards: types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, washrooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Monitoring Safety Performance: Frequency rate, severity rate, incidence rate, activity rate. Safety policy and safety standards for Industry and organization.	8	20
2	**Unit-II: Hazard identification and analysis:** Hazard and risk, Types of hazards –Classification of Fire, Types of Fire extinguishers, fire explosion and toxic gas release, Structure of hazard identification and risk assessment. Identification of hazards: Inventory analysis, Fire and explosion hazard rating of process plants - The Dow Fire and Explosion Hazard Index, Preliminary hazard analysis, Hazard and Operability study (HAZOP)) – methodology, criticality analysis, corrective action and follow-up. Control of Chemical Hazards, Hazardous properties of chemicals, Material Safety Data Sheets (MSDS)	4	10
3	**Unit-III: Fundamentals of maintenance engineering**: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.	4	10
4	**Unit-IV: Wear and Corrosion and their prevention**: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.	4	20
5	**Unit-V: Fault tracing:** Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, Types of faults in machine tools and their general causes.	4	20

6	**Unit-VI: Periodic and preventive maintenance**: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance.	6	20
	Total	**30**	**100**

Reference Book :

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. R.K Jain (2000) Industrial Safety, Health and Environment management systems, Khanna Publications.
4. Paul S V (2000), Safety management System and Documentation training Programme handbook, CBS Publication.
5. Krishnan, N.V. (1997). Safety management in Industry. Jaico Publishing House, New Delhi.
6. John V. Grimaldi and Rollin H.Simonds. (1989) Safety management. All India Traveller Book Seller, Delhi.

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: All branches
Subject Code: BE02R00071
Subject Name: Standardization and Quality Ecosystem

w. e. f. Academic Year:	2025-26
Semester:	2
Category of the Course:	Multidisciplinary Open Professional Electives Courses

Prerequisite:	NA
Rationale:	The Standardization and Quality Ecosystem course introduces students to the principles, processes, and institutions that define quality infrastructure at national and international levels. It familiarizes learners with the roles of BIS, global standardization bodies, conformity assessment, and certification schemes in ensuring product safety, reliability, and market competitiveness. The subject emphasizes the integration of sustainability and UN SDGs into standardization practices, preparing students for socially and environmentally responsible engineering. Through case studies, lab exposure, and project-based learning, students gain practical skills in developing and applying standards. This knowledge equips graduates to contribute effectively to industry, research, policy, and the vision of "One Nation One Standard."

Course Outcomes:

Sr. No.	CO statement	Marks% weightage
CO-1	**Explain** the structure and functions of international, regional, and national standardization bodies, and their role in the quality ecosystem of India.	25
CO-2	**Apply** principles of standardization, conformity assessment, and certification processes in various engineering and industrial contexts.	25
CO-3	**Analyze** the role of laboratories, hallmarking, and registration schemes in ensuring quality compliance and consumer protection.	20
CO-4	**Integrate** sustainability concepts, UN Sustainable Development Goals (SDGs), and environmental considerations into the development and application of standards.	20
CO-5	**Develop** draft standards and project-based solutions aligned with BIS guidelines, demonstrating the ability to work with industry, academia, and regulatory frameworks.	10

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL*	Total No. of hours per Semester		ESE (E)	PA / CA (M)	PA/ CA (I)	PBL (I)	ESE (V)	
30	0	0	30	60	2	70	30	0	30	0	130

**** Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.***

Content:

Sr. No.	Content	Total Hrs
1	**Quality Ecosystem in India** • **Accreditation:** 1. International Accreditation Forum (IAF) – Introduction and Structure 2. ISO/IEC 17011 -Conformity assessment — Requirements for accreditation bodies accrediting conformity assessment bodies • **International Standardization Bodies:** 1. ISO (International Organization for Standardization) 2. IEC (International Electro technical Commission) 3. ITU (International Telecommunication Union) 4. Regional Standardization 5. National Standards Bodies • **Standardization:** ISO/IEC Guide 2 - Standardization and related activities — General vocabulary	3
2	**Principles of Standardization:** Good Standardization Practices (including WTO-TBT Code of Good Practices) **Basic Concepts of Standardization:** 1. What is a STANDARD? 2. Need, Aims and Benefits of Standards 3. Types of Standards **Standardization – The Essence of Civilization:** 1. What is STANDARDIZATION? 2. History of Standardization – international level and national level 3. National Quality Ecosystem 4. BIS – The National Standards Body 5. Concept of 'One Nation One Standard' and Standard Developing Organization (SDO)	3
3	**National Standardization and Quality Ecosystem and Bureau of Indian Standards (BIS):** 1. About Bureau of Indian Standards (its establishment, roles and objectives w.r.t. standardization) 2. Overview of BIS and its activities. 3. Organizational Structure and Mandate of BIS envisaged under BIS Act **Mission Driven Standardization:** 1. Aligning standards formulation with GoI missions with relevant examples 2. INSS (Indian National Strategy for Standardization) **3.** SNAP (Standards National Action Plan) **World of Indian Standards:** 1. Standards Formulation Departments 2. Special Publications and Reference Handbooks.	3

	3. Important Publications (National Building Code, National Electrical Code, National Lighting Code **Basic Standards** 1. SI Units, Preferred Numbers, Standard Atmospheric Conditions, Limits and Fits Statistics in standardization – including sampling plans	
4	**Standardization at Bureau of Indian Standards** • **National Standardization** 1. Standardization activity at BIS (Structural hierarchy and current structure) 2. Technical Committees – constitution, appointments, roles and responsibilities 3. Standardization Process in BIS 4. Standard Formulation Process - Explanation on each stage 5. Review of Indian Standards. 6. Process Reforms in Standardization • **Important Department Specific Standards**	**3**
5	**Standards and External Trade** 1. Participation in International Standardization (ISO/IEC) 2. WTO-TBT Agreement and WTO-TBT Enquiry Point 3. CASCO (ISO committee for conformity assessment) **Conformity Assessment** 1. What is CERTIFICATION? 2. Key Pillars of Certification **Conformity Assessment at BIS** 1. Overview of BIS Conformity Assessment Schemes 2. Voluntary and Mandatory Certification 3. Quality Control Orders and their implementation 4. Product Certification Schemes 5. Overview of schemes in operation (Scheme I, II, IV, X) 6. Foreign Manufacturer's Certification Scheme 7. BIS Conformity Assessment Legal Framework ISO/IEC 17020 Conformity assessment — Requirements for the operation of various types of bodies performing inspection ISO/IEC 17040 Conformity assessment — General requirements for peer assessment of conformity assessment bodies and accreditation bodies IS/ISO 31000 Risk management – Guidelines, principles, framework and process for managing risk in the context of the recent developments in the Product Certification Scheme	**3**
6	**Laboratory Operations** 1. Basics of Laboratory Operations 2. Role of Labs in conformity assessment 3. IS/ISO/IEC 17025 General requirements for the competence of testing and calibration laboratories a. Introduction and application in lab operations	**3**

	b. Important provisions of the standard - Management Requirements, General, Structural and Process Requirements & Accreditation and Calibration 4. Calibration & Traceability 5. Method and Equipment Validation 6. Measurement of Uncertainty **Laboratory Operations at BIS** 1. Laboratory Operations of BIS 2. BIS Testing Labs 3. Inter Laboratory Comparison and Proficiency Testing 4. Overview – including provisions in BIS Act, Rules and Regulations 5. Type of testing and Services **Laboratory Recognition Scheme (LRS)** 1. Basic Concept and Procedure Utilizing services of BIS recognized outside labs and empaneled labs	
7.	**Hallmarking Scheme of BIS** 1. Hallmarking Scheme 2. Introduction to Hallmarking Scheme of BIS 3. Procedures for licensing of Jewelers and drawl of samples 4. Recognition of Assaying and Hallmarking centers 5. Mandatory Hallmarking Order 6. Testing and Hallmarking of precious metal jewelry 7. Indian Standards (IS 1417, IS 2112, IS 1418, IS 2113, IS 15820) 8. Process of Hallmarking	**3**
8	**Registration Scheme of BIS** **Standards in Daily Life:** Faculty purview **Management Systems Certification (MSC)** 1. Principles and Basic Concepts 2. Brief Overview of MSC Schemes of BIS 3. Operation and Procedures	**3**
9	**Complaint handling** 1. Provisions for actions on non-compliance to QCOs, misuse of standard mark 2. Complaint handling mechanisms and Enforcement Activities **Sustainability: Sustainability Framework for Standardization** 1. Concept of Sustainability 2. Need for Sustainability and Role of Standards 3. United Nation Sustainable Development Goals (UN SDGs) 4. ISO Guidelines for addressing Sustainability and Climate Change in Standards	**3**

10	**Addressing Sustainability through Standards** 1. Consultative Groups on Sustainability 2. Approach to address Sustainability in Standards **BIS Institutional Mechanisms to support Standardization** 1. Project Based Approach 2. Research based standardization - R&D Projects and Action Research Projects 3. Annual Program for Standardization 4. Standardization Cells 5. State Level Committee on Standardization (SLCS) 6. Partnering with Academic Institutes 7. Manak Manthan and Manak Mantrana 8. Industry Meet 9. BIS Academia Collaboration through MoUs and its key initiatives Exercise on drafting of Indian Standard as per IS 12 - Guide for Drafting and Presentation of Indian Standards	**3**
	TOTAL	**30**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
20	20	20	20	10	10

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Modules on Basics of standardization, prepared by Bureau of Indian Standards, New Delhi

List of Open-Source Software/learning website:

1. www. bis.gov.in
2. https://www.services.bis.gov.in/php/BIS_2.0/bisconnect/get_is_list_by_category/

- **List of suggested activities for Problem Based Learning: (30 hours)**

(Students taking the course to be mandatorily members of BIS Student Chapters)

Sr.no.	Activity	description	Outcome	Suggested hours
1	Case Study on Standardization in Industry	Select **one sector** relevant to the student's branch (e.g., Civil – construction materials, Mechanical – automotive components, Electrical – cables & appliances, IT – data security). Study **key Indian & international standards**, their benefits, and industry challenges.	Detailed case study report (5–7 pages) with references.	10 hrs
2	BIS Structure & Processes Research	Deep dive into the **BIS standard formulation process**: proposal, drafting, committee approval, publication, and review. Include **real examples of recently published Indian Standards**.	Flowchart with explanations & example list.	5 hrs
3	Conformity Assessment & Certification Project	Select a product under **mandatory BIS certification**. Document the full **certification process**, costs, testing requirements, and enforcement mechanisms.	Process documentation (2–3 pages) + sample forms/templates.	5 hrs
4	Laboratory Operations Exploration	Visit a **local testing/calibration lab** (or virtual tour if not feasible). Compare their operations with **ISO/IEC 17025** requirements. Include findings on equipment, calibration, traceability, and quality control.	Field visit/virtual tour report with comparison table.	5 hrs
5	Standards & Sustainability Analysis	Map **5 UN Sustainable Development Goals (SDGs)** to at least **10 Indian Standards** that contribute to them. Explain how these standards support environmental, social, and economic sustainability.	SDG–Standard mapping chart with explanations.	5 hrs
6	Drafting an Indian Standard	Using **IS 12 guidelines**, prepare a **mock standard** for an everyday or engineering-related product (e.g., water bottle, electric fan, building brick). Include scope, references, definitions, requirements, and test methods.	Draft standard document (3–4 pages).	5 hrs
7	Exposure Visit / Virtual Industry Interaction	Participate in an **exposure visit to BIS labs, hallmarking centers, or industry sites** OR attend an online BIS/ISO webinar. Prepare a learning reflection report.	Reflection report (2-3 pages) + key takeaways.	10 hrs

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TEACHING SCHEME / DETAIL SYLLABUS

Home

BE

05 - CHEMICAL ENGINEERING

3

2024-25

Select Elective / Non-Elective

Subject Code

Enter Subject Name

Search

*L=lectures,T=tutorial,P=Practical,E=TheoryExternal,M=TheoryInternal,I=Practical Internal,V=Practical External,On Job Training(OJT) is equivalent to Practical

							Hours			Credit	Max Marks				
Exp.	Subcode	Branch code	Eff_from	SubjectName	Category	Sem /Year	L.	T.	P.	PBL	Total	E	M	I	V	To
	BE03000051	005	2025-26	Professional Communication and Ethics	Humanities and Social Science, including Management Courses (Elective)	3	30	0	30	0	2	70	30	20	50	17
	BE03000061	005	2025-26	Indian Constitution	Core Courses	3	30	0	0	30	2	50	0	30	0	8
	BE03000241	005	2025-26	Indian Knowledge System for Engineering	Humanities and Social Science, including Management Courses (Elective)	3	30	0	30	0	2	70	30	20	50	17
	BE03005011	005	2025-26	Chemical Engineering Thermodynamics-1	Professional Core Courses	3	45	15	0	60	4	70	30	50	0	15
	BE03005021	005	2025-26	Chemical Process Technology	Professional Core Courses	3	45	0	30	45	4	70	30	50	50	20
	BE03005031	005	2025-26	Material and Energy Balance Computation	Professional Core Courses	3	60	15	0	45	4	70	30	50	0	15
	BE03005041	005	2025-26	Numerical Methods in Chemical Engineering	Basic Science Courses	3	45	15	0	60	4	70	30	50	0	15

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Subject Code : BE03000051

Subject Name : Professional Communication and Ethics

w. e. f. Academic Year:	2024 - 2025
Semester:	3
Category of the Course:	HSMC

Prerequisite:	Students must have knowledge of basic English
Rationale:	The rationale of the curriculum is to equip students with the knowledge, skills and ethical frameworks necessary for academic and professional success. The curriculum fosters effective communication, critical thinking and responsible decision-making in diverse real-world contexts.

Course Outcome:

After completion of the course, students will be able to:

No	Course Outcomes	RBT Level
01	Understand and apply the fundamentals of professional communication and relate it to real life situations	R,U,A,N,E
02	Compose essential formal documents in appropriate formats for various professional situations	R,U,A,C
03	Demonstrate advanced communication skills in presentation, public speaking, and contribute effectively in group communication	R,U,A,N,E,C
04	Practice professional manners and etiquette and imbibe people skills for professional communication	R,U,A,N,E,C
05	Understand professional ethics and ethical dilemmas to devise solutions	R,U

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching - Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	TW/SL	TH		ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
30	0	30	0	60	02	70	30	20	0	50	170

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Professional Communication:** • Fundamentals of Communication: Definition, concept and models (Linear Model, Shannon and Weaver Model) • Characteristics of Language • Levels of Communication: Intrapersonal, Interpersonal, Extra personal, Organizational, Mass, Cultural Communication • Flow of Communication • Barriers of Communication • Nonverbal Communication: Kinesics, Proxemics, Paralinguistic features, Chronemics, Haptics, Olfactics, Oculesics	5	20
2.	**Professional Documentation:** • Business Letter Writing (Inquiry, Reply, Order, Complaint, Adjustment, Sales, Requesting purchase on Credit, Accepting or Rejecting the Credit request) • Memo writing as an internal organizational Communication • Report Writing (Memo format, Letter format) • Preparing Agenda, Notice and Minutes of Formal Meeting • Email Writing • Professional Resume writing • Technical Proposal (Solicited / Unsolicited) • Technical Description Note*Only practical and application type questions shall be asked from this unit.	5	15

3.	**Advanced Public Speaking Skills:** **1. Presentation:** • Organizing Professional Presentations: Structuring the speech effectively, Outlining key points, Developing compelling introductions and conclusions • Delivery Techniques: Extemporaneous, Memorization, Impromptu, Manuscript • Using Presentation Aids: Integrating presentation aids into speeches, Designing effective presentation aids **2. Public Speaking:** • Mediated public speaking • Informative speaking • Persuasive speaking and methods of persuasion • Special occasion speaking • Motivational Speaking **3. Interview Skills:** • Objectives of interviews • Types of interviews (telephonic, face-to-face - campus and on-site) • Stages of job interviews **4. Group Discussions:** • Organizational Group Discussions (Nominal, Delphi, rainstorming) • Group discussions as part of the selection process **5. Group Communication:** • Meetings, Conferences, Symposia and Seminars	6	20
4.	**Professional Etiquette: Essential Guidelines (Requirements, Dos & Don'ts):** • Concept of Social Manners, Morals and Etiquette • Etiquette for Small Talks • Workplace Etiquette • Mobile Etiquette • Internet & Social Media Etiquette • Etiquette for Foreign Business Trip • Etiquette for the Visit of Foreign Counterpart	5	15
5.	**People Skills for Professional Communication:** • Time Management • Stress Management • Respecting Privacy • Learning to Say 'No'	5	15

	• Team Building • SWOT Analysis • Creative and Critical thinking • Physical Quotient, Intelligence Quotient, Emotional Quotient, Spiritual Quotient		
6.	**Professional Ethics** • Concept of Ethics • Importance of Ethics in Life • Principles of Ethics • Engineering Ethics • Understanding and Resolving Ethical Dilemmas • Corporate Social Responsibility (CSR)	4	15
	Total	**30**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
25	25	20	10	10	10

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Ramesh and Ramesh, *The Ace of Soft Skills,*Pearson, 2019
2. Raman M. and Sharma S., *Technical Communication: Principles and Practice,* OUP, New Delhi, 2017
3. Lata P. and Kumar S., *Communication Skills,* OUP, New Delhi, 2018
4. Dan O' Hair, Rubenstein Hannah and Stewart Robert, *A Pocket guide to Public Speaking,*5th Edition, Bedford/st.Martins,2015
5. Mitra B., *Personality Development and Soft Skills,*1st Edition, OUP, 2011,
6. Fraleigh D. and Joseph T.*Speak Up!: An Illustrated Guide to Public Speaking,*5th Edition, Bedford/st.Martins,2019
7. Pillai S. and Fernandez A., *Soft Skills and Employability Skills,* Cambridge University Press, 2017
8. Shinde, *Life Skills and Personality Development,* Cambridge University Press, 2022
9. Alex K., *Soft Skills – Know Yourself and Know the World,* 3rdEdition, S. Chand, 2014
10. Seebauer Edmund G. and Barry Robert L., *Fundamentals of Ethics for Scientists and Engineers,* Oxford University Press, 2008

11. Harkut Dinesh G. and Bamnote Gajendra R., *Professional Ethics for Engineers*, Notion Press, 2023

(b) Open source software and website:

1. https://www.scu.edu/ethics/focus-areas/more-focus-areas/engineering-ethics/engineering-ethics-cases/

Suggested Course Practical List/ List of Laboratory Activities:

Sr. No.	List of Practical	No. of Hours	Preferably to be conducted in
1	Communication game by passing message to understand the barriers	2	Classroom/Lab
2	Letter Writing	4	Classroom/Lab
3	Preparing Professional Resume	2	Classroom/Lab
4	Notice, Agenda and Minutes of Meeting	2	Classroom/Lab
5	Email writing	2	Classroom/Lab
6	Report Writing	2	Classroom/Lab
7	Technical Proposals	2	Classroom/Lab
8	Case Studies on Ethical Dilemmas and Solving them	4	Classroom/Lab
9	Mock Interviews, GDs	4	Classroom/Lab
10	Book Review	2	Classroom/Lab
11	Preparing content for popular Digital Platforms (Advertisement, Digital Brochure, Digital Portfolio, Website, Academic Use of AI, Blog - Podcast - Vlog etc)	4	Classroom/Lab
12	Presentations(online and offline)	2	Classroom/Lab
	Total Hours:	32	

Suggested Books List for Book review:

1. You Can Win by Shiv Khera
2. How to win friends and influence people by Dale Carnegie
3. Getting things done: The art of stress free productivity by David Allen
4. Quiet: The Power of Introvert in the World they can't stop talking by Susan Cain
5. The Alchemist by Paulo Coelho
6. The 7 habits of highly effective people by Stephen Covey
7. What to say when you talk to yourself by Dr. Shad Helmstetter
8. The big leap by Gay Hendricks
9. Thinking fast and slow by Daniel Kahneman
10. The art of thinking clearly by Ralf Dobelli

11. Upside –Down King by Sudha Murthy
12. Born to be happy by Pramod Batra
13. Ikigai: The Japanese Secret to a Long and Happy Life By by Héctor García & Francesc Miralles
14. Poor little rich slum by Rashmi Bansal
15. Most and more by Mahatria Ra
16. The Old Man and the Sea by Ernest Hemingway
17. Rich Dad Poor Dad by Robert Kiyosaki
18. The Monk Who Sold His Ferrari by Robin Sharma
19. Who Moved My Cheese? By Dr. Spencer Johnson
20. The Business of the 21st Century by Robert Kiyosaki
21. My Experiments with Truth by Mahatma Gandhi
22. Five Point Someone by Chetan Bhagat
23. The Secret by Rhonda Byrne
24. The Power of Positive Thinking by Norman Vincent Peale
25. The Power of Your Subconscious Mind by Joseph Murphy
26. The 5 AM Club by Robin Sharma
27. Who will cry when you die? By Robin Sharma
28. Discover Your Destiny by Robin Sharma
29. The Wing of Fire by A.P.J. Abdul Kalam
30. I have a Dream by Rashmi Bansal
31. The 5 Steps to Success by Yandamoori Veerendranath
32. You Are Born To Blossom by A.P.J. Abdul Kalam
33. Tiya: A Parrot's Journey Home by Samarpan
34. The God of Small Things by Arundhati Roy
35. How to develop a 'Never Give up' Attitude by Dr. Hardik Joshi
36. Three Thousand Stitches: Ordinary People, Extraordinary Lives by Sudha Murthy
37. Chanakya in Daily Life by Radha Krishnan Pillai
38. Siddhartha by Hermann Hesse
39. Kiss that Frog by Brian Tracy
40. Eat That Frog!: 21 Great Ways to Stop Procrastinating and Get More Done in Less Time by Brian Tracy

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w. e. f. Academic Year:	2024-25
Semester:	3
Category of the Course:	Core Courses

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Enhance human values , create awareness about law enactment and importance of Constitution	10%
CO-2	To Understand the Fundamental Rights and Fundamental Duties of The Indian Citizen to instill morality, social values, honesty, dignity of life and their social Responsibilities.	30%
CO-3	Create Awareness of their Surroundings, Society, Social problems and their suitable solutions while keeping rights and duties of the Citizen keeping in mind.	20%
CO-4	Understand distribution of powers and functions of Local Self Government.	20%
CO-5	Understand the National Emergency, Financial Emergency and their Impact on Economy of the country.	20%

Teaching and Examination Scheme:

Teaching - Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	TW/SL	TH		ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
30	00	00	30	60	02	50	00	00	30	00	80

Contents:

Sr. No.	Topics	Total Hours
1	Meaning of the constitution law and constitutionalism	01
2	History of Indian Constitution	02
3	Salient features and characteristics of the Constitution of India	01
4	Fundamental rights	02
5	Right to Equality under Article – 14	02

6	Right to certain Freedom under Article 19	02
7	Scope of the Right to Life and Personal Liberty under Article 21	02
8	Fundamental Duties and its legal status	02
9	The Directive Principles of State Policy – Its importance and implementation	02
10	Federal structure and distribution of legislative and financial powers between the Union and the States	03
11	Parliamentary Form of Government in India – The constitution powers and status of the President of India	02
12	Powers and Procedure for Amendments in Indian Constitution	01
13	History of amendments in Indian Constitutional	02
14	Emergency Provisions : National Emergency, President Rule, Financial Emergency	03
15	Local Self Government – Constitutional Scheme in India	03

Reference Books:

1. Constitutional Law of India, Dr. J.N. Pandey, Central Law Agency
2. Introduction to the Consitution of India, Durga Das Basu, LexisNexis.
3. Indian Constitutional Law, M.P. Jain, LexisNexis
4. V.N.Shukla's Constitution of India, Mahndra Pal Singh, Eastern Book Company
5. Constitutional Law – I Structure, Udai Raj Rai, Eastern Book Company

Self-Learning Activities under Term Work / Self Learning

Each topic includes an exploratory and a reflective/creative activity, mapped to course outcomes.

Topic No.	Topic Title	Activity Details	Video Link / Reading Material Link	Estimated Time	Mapped COs
1	Meaning of Constitution, Law & Constitutionalism	1. Watch: Intro to Constitution – NPTEL After watching, list 5 key differences between Constitution, law, and constitutionalism in your own words. 2. Create a **concept map** showing relationships between Constitution, laws, and constitutionalism.	Intro to Constitution – NPTEL	2 hours	CO-1
2	History of Indian Constitution	1. Watch: https://www.youtube.com/watch?v=0U9KDQnIsNk 2. After watching, note 5 key	https://www.youtube.com/watch?v=0U9KDQnIsNk	2 hours	CO-1

		events that shaped India's Constitution and explain their significance. 3. 2. Create a **timeline chart** from 1857 to 1950 showing key constitutional developments.			
3	Salient Features of the Constitution	1. Watch: Salient Features – SBR ✎ After watching, list at least 8 salient features and mention their relevance today. 2. Prepare a **comparison table** between India's Constitution and UK/US Constitution on at least 5 points.	Salient Features – SBR ✎	2 hours	CO-1
4	Fundamental Rights	1. Watch: https://www.youtube.com/watch?v=cAjq_8JcUNw 2. After watching, write 1 paragraph summarizing the purpose of Fundamental Rights. 3. 2. Create a **flipbook or digital slides** explaining each Fundamental Right with real-life examples.	https://www.youtube.com/watch?v=cAjq_8JcUNw	2 hours	CO-2
5	Right to Equality (Art. 14)	**1 Public Policy in Action: Anti-Discrimination Notices Activity** To identify and analyze visible government or institutional efforts to promote equality and prevent discrimination in public spaces, and to connect these initiatives to the constitutional principle of equality under Article 14.	https://indiankanoon.org/doc/367586/ Article 14 in Constitution of India	2 hours	CO-2

		Task: 1. **Choose a Public Place:** Visit a public place such as a government office (e.g., Post Office, Municipal Corporation), a hospital, a transport hub (bus stand, railway station), a bank, a college, or a market area. 2. **Search for Notices/Posters:** Actively look for any official notices, posters, signboards, or information displays that reflect government policies or legal provisions aimed at preventing discrimination, promoting equality, or ensuring inclusive access. **Think broadly:** Look for signs related to: ✓ Prohibition of discrimination (e.g., against caste, gender, religion). ✓ Accessibility for persons with disabilities (e.g., ramps, special counters, accessible toilets). ✓ Equal opportunity statements. ✓ Anti-harassment policies (e.g., sexual harassment at workplace). ✓ Rights of specific vulnerable groups (e.g., women, children, senior citizens, transgender persons). ✓ Information about helplines or grievance redressal mechanisms for discrimination.			

		3. **Document Your Finding:** ➢ If possible, take a clear photo of the notice/poster (ensure no people are identifiable in the background for privacy). ➢ Note down the exact text or key message of the notice. ➢ Note where you found it (e.g., "On the notice board near the reception in X Hospital," "Near the accessible ramp at Y Bus Stand"). 4. Write a short reflection in **100-150 words** **2. Creative Poster** Design a poster or digital collage with the theme: **"Equality Before Law – Everyone Counts."** Include visuals, quotes, or examples that promote fairness, accessibility, and inclusion.			
6	Freedom Rights (Art. 19)	1. Watch: https://www.youtube.com/watch?v=l2fN9pbpa_s After watching, list 3 limitations on freedom of speech explained in the video. 2. Write a **debate script or essay** discussing whether hate speech should be protected under freedom of speech.	https://www.youtube.com/watch?v=l2fN9pbpa_s	2 hours	CO-2
7	Right to Life & Personal Liberty (Art. 21)	1. Study: Puttaswamy case. 2. After reading, explain in 100 words how the case expanded the meaning of Art. 21. 3. 2. Create a **privacy & liberty chart** with 5 examples of rights protected under Article 21.	https://indiankanoon.org/doc/91938676/ (**Justice K.S.Puttaswamy (Retd) And Anr. vs Union Of India And Ors. on 24 August, 2017**)	2 hours	CO-2
8	Fundamental	1. Watch: Fundamental Duties		2 hours	CO-2

	Duties & Legal Status	Explained After watching, list at least 5 Fundamental Duties and explain their significance briefly. 2. Design a **poster or infographic** titled "My Duties as a Citizen".	Fundamental Duties Explained		
9	Directive Principles of State Policy (DPSP)	1. Study any one DPSP-related cases where courts directed policy change. 2. After reading, summarize in 150 words how DPSPs guided the court's decision. 3. Write a **blog-style policy note** on any one unfulfilled DPSP in India and how it can be implemented.	1. https://indiankanoon.org/doc/40715/ (Mohini Jain v. State of Karnataka (1992) 1. ps://indiankanoon.org/doc/1775396/ Jnni Krishnan v. State of Andhra Pradesh (1993)) 2. https://indiankanoon.org/doc/1939993/ (Minerva Mills Ltd. vs Union of India (1980)	2 hours	CO-2, CO-3
10	Federal Structure & Power Distribution	1. Watch: https://youtu.be/jN_IVXQr3DQ?si=7rTGTlwMY2HU0eED 2. After watching, list 3 major disputes between Centre & States discussed. 3. Create a **color-coded chart** comparing Union, State, and Concurrent Lists with examples.	https://youtu.be/jN_IVXQr3DQ?si=7rTGTlwMY2HU0eED	2 hours	CO-3
11	Parliamentary Government & President's Role	1. Watch: https://www.youtube.com/watch?v=t-uMxrplttM 2. After watching, explain in 5 bullet points how the President and PM interact in government. 3. 2. Prepare a **role-play script or PPT** depicting how decisions are made between President, PM, and Parliament.	https://www.youtube.com/watch?v=t-uMxrplttM	2hours	CO-3
12	Amendment	1. Watch:	https://www.youtube.c	2 hours	CO-3

	Process	https://www.youtube.com/watch?v=yVp5QZQzYH0 2. After watching, write a short summary explaining what "Basic Structure Doctrine" means. 3. 2. Create a **timeline infographic** showing 5 major constitutional amendments and their impacts.	om/watch?v=yVp5QZQzYH0		
13	History of Constitutional Amendments	1. Read about the evolution of constitutional amendments from 1951 onward. 2. After reading, summarize key trends and changes in one page. 3. Mock amendment proposal preparation. **Task:** Think of a **current national issue or gap** (e.g., climate rights, digital privacy, mental health in education). • Write one page mock **constitutional amendment proposal**: ○ Title of the amendment ○ Proposed text ○ Why it is needed ○ How it fits into the Constitution's values	https://lawblend.com/articles/constitutional-amendments-list/ Wikipedia: Constitutional Amendments of India (well-sourced)	2 hours	CO-3
14	Emergency Provisions	1. Watch: https://www.youtube.com/watch?v=vBmPFPIm7Fk 2. After watching, explain in 150 words why Emergency provisions are considered controversial. 3. 2. Write a **reflective essay** discussing the long-term impact of the Emergency on democracy.	https://www.youtube.com/watch?v=vBmPFPIm7Fk	2 hours	CO-5
15	Local Self Government	1. Interview/visit a local	https://www.youtube	2 hours	CO-4

		Panchayat/Corporator or watch a video on Panchayati Raj functioning. https://www.youtube.com/watch?v=V24GhpZ-Mpo After the activity, write 3 key observations about challenges faced by local self-governments. 2. Write a **field report** with improvement suggestions for the Panchayat or ULB system.	.com/watch?v=V24GhpZ-Mpo		

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Subject Code: BE03000241
Subject Name: Indian Knowledge System for Engineering

w. e. f. Academic Year:	2024-25
Semester:	3
Category of the Course:	Humanities and Social Science, including Management Courses (Elective)

Prerequisite:	The course remains accessible to all engineering disciplines, regardless of specific technical background.
Rationale:	To provide an in-depth understanding of the evolution of engineering practices in India, from ancient times to the modern period, highlighting key contributions, technological advancements, and the integration of engineering concepts with cultural, social, and economic contexts. The course also aims to connect historical developments with contemporary engineering challenges and future prospects.
Pedagogy	The course employs a blended pedagogical approach combining lectures, storytelling, case studies, and multimedia presentations to enhance student engagement and understanding. Historical engineering practices and developments are explored through archaeological evidence, textual references, and documentary resources. Interactive discussions will be encouraged to critically reflect on India's indigenous knowledge systems and their relevance in modern engineering contexts. Students will be guided to connect historical examples with contemporary engineering challenges and innovations. NPTEL resources, archival material, and visual documentaries will supplement classroom teaching, promoting contextual and interdisciplinary learning.

Course Outcomes:

Sr. No.	CO statement	Bloom's Taxonomy Level	Marks% weightage
CO-1	Describe the evolution of engineering practices in India from ancient to modern times.	UN	20
CO-2	Explain major engineering innovations and technological developments in various historical periods of India.	UN	20
CO-3	Analyze the influence of socio-political and economic factors on the development of engineering and infrastructure across dynasties and regimes.	AN	20
CO-4	Evaluate the role of engineering in India's industrialization, modernization, and nation-building efforts.	EL	20
CO-5	Assess contemporary engineering advancements and propose sustainable solutions for future challenges.	CR	20

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	SL	Total no of hours per semester		ESE (E)	PA / CA (M)	PA/CA (I)	TW/SL (I)	ESE (V)	
30	00	30	00	60	2	70	30	20	00	50	170

Content:

Sr. No.	Content	Total Hrs
1	**Introduction to the Indian History of Engineering** Overview and importance of the study of engineering history in India. Historical context of engineering practices across different periods of Indian civilization. Relationship between engineering, architecture, and technological innovations. Overview of India's contributions to global engineering knowledge. Methodologies for studying historical engineering practices (archaeological, literary, and architectural sources).	**3 hours**
2	**Ancient Engineering Innovations** **Indus Valley Civilization** Urban planning and architectural marvels (e.g., drainage systems, granaries, town layouts). Water management systems, wells, reservoirs, docks (e.g., Lothal). Metallurgy and craftsmanship (tools, pottery, bead-making, seals). **Vedic and Post-Vedic Periods** Early construction of temples, fortifications, fire altars. Developments in water harvesting and irrigation techniques. Application of geometry and mathematics in construction (Sulba Sutras). **Scientific and Engineering Thought in Ancient Texts** Arthashastra, Manusmriti: Engineering guidelines, civic planning, metallurgy. Principles of town planning, building design, resource management.	**3 hours**

3	**Classical and Early Medieval Engineering** **Engineering during the Gupta Period** Advances in construction techniques for temples, monuments (e.g., Dashavatara Temple). Rock-cut architecture, structural temples, use of iron pillars. **Medieval India – Sultanate and Early Mughal Period** Fort architecture (e.g., Golconda Fort), palatial structures. Hydraulic engineering: Stepwells (vavs), baolis, irrigation tanks. **Water Management and Agricultural Engineering** Techniques for sustainable agriculture and irrigation across different regions. Case studies: Chola irrigation systems, Delhi Sultanate canal systems.	**3 hours**
4	**Engineering and Technology in the Late Medieval and Mughal Periods** Monumental engineering projects (e.g., Taj Mahal, Fatehpur Sikri). Advances in construction materials (lime mortar, sandstone, marble). Urban planning in Mughal cities (e.g., Shahjahanabad). Water supply and drainage systems in Mughal forts and cities.	**3 hours**
5	**Early Colonial Period and Transformation of Indian Engineering** **British Influence on Indian Engineering** Introduction of Western surveying, mapping, civil engineering practices. Establishment of Thomason College of Civil Engineering (Roorkee). **Growth of Infrastructure under Colonial Rule** Railways, bridges, ports, telegraph networks. Canal building and irrigation projects (e.g., Ganges Canal). **Indian Engineers under British Rule** Contributions of Indian engineers (e.g., Sir M. Visvesvaraya). Challenges faced by indigenous engineers.	**3 hours**
6	**Rise of Modern Engineering Post-Independence** **Institution Building** Founding of IITs, NITs, engineering research centers. **Civil Engineering Achievements** Key projects: Bhakra Nangal Dam, Hirakud Dam, Sardar Sarovar Project. Development of national highways (Golden Quadrilateral). **Agricultural and Irrigation Engineering** Green Revolution technologies. Role of engineering in rural development and food security.	**3 hours**

7	**Industrialization and the Engineering Sector in India** **Early Industrialization** Steel plants (TISCO), textile mills, chemical plants. Machine tool development and mechanical engineering initiatives. **Public Sector Enterprises and Engineering Innovations** Establishment of Bharat Heavy Electricals Limited (BHEL), Hindustan Aeronautics Limited (HAL). **Technological Modernization of Industry** Automation, manufacturing advancements, materials engineering.	**3 hours**
8	**Modern Technological Advancements** **Space Technology** Formation and growth of ISRO. Major achievements: Aryabhata, SLV-3, PSLV, Chandrayaan, Mangalyaan. **Nuclear Engineering** Role of Bhabha Atomic Research Centre (BARC). Development of nuclear energy for power generation. **IT and Software Engineering** Growth of IT hubs (Bengaluru, Hyderabad). Impact of software exports and services. Role of Indian engineers in global tech innovation.	**3 hours**
9	**Emerging Frontiers and Sustainability in Indian Engineering** **Biotechnology and Biomedical Engineering** Advances in pharmaceutical research, genetic engineering, and medical devices. **Green Engineering and Sustainable Technologies** Renewable energy (solar, wind, hydropower initiatives). Engineering solutions for climate change mitigation. Environmental sustainability projects.	**3 hours**
10	**Challenges and the Future of Indian Engineering** **Contemporary Challenges** Infrastructure gaps, urbanization pressures, rural engineering needs. Challenges in engineering education and innovation ecosystem. **Future Trends** AI, robotics, IoT, smart city projects. India's role in global collaborations (e.g., QUAD tech initiatives, space cooperation). Policy frameworks: "Make in India", "Atmanirbhar Bharat", National Education Policy (NEP) 2020 initiatives.	**3 hours**
TOTAL		**30 Hours**

Suggested Specification table with Marks (Theory): (For B.E. only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**20**	**20**	**10**	**10**	**20**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. *Engineering in India Through the Ages*, INSA, INSA New Delhi, 2004
2. *Science and Technology in Ancient India* by Debiprasad Chattopadhyaya, People's Publishing House, 2022
3. *India's Ancient Past* by R. S. Sharma, Oxford University Press, 2020
4. *History of Science, Philosophy and Culture in Indian Civilization* edited by D. P. Chattopadhyaya, Centre for Studies in Civilizations, 2000–2010
5. *From Temples to Dams: Engineering and Civilizations in India* by R. Balasubramaniam, Aryan Books International, 2021
6. *Sir M. Visvesvaraya: The Builder of Modern India* by N. K. Dikshit, National Book Trust, 2018
7. *India After Gandhi* by Ramachandra Guha, HarperCollins India, 2017

List of Experiments: NA

Major Equipment: NA

List of Open Source Software/learning website:

- **NPTEL Courses:**
  - History of Science and Technology in India (IIT Madras)
  - Science, Technology and Society
- **YouTube / Documentary Channels:**
  - *Pradhanmantri Series* (by ABP) – for post-1947 policy
  - *History Channel India* – for ancient technology features
- **Web Portals:**
  - INSA India – Publications on Indian Science History
  - Vigyan Prasar Digital Library – Rich source of science communication and heritage

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Chemical Engineering
Subject Code: BE03005011
Subject Name: Chemical Engineering Thermodynamics – I

w. e. f. Academic Year:	2024-25
Semester:	3
Category of the Course:	PCC

Prerequisite:	None
Rationale:	Knowledge of thermodynamics from a chemical engineering view point is essential to study principles and applications of laws of thermodynamics to real systems. This subject is also useful to calculate thermodynamic properties of any chemical species and their mixtures.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Relate fundamentals of thermodynamics with chemical engineering.
02	Utilize basic principles of chemical engineering thermodynamics for PVT behavior of fluid.
03	Analyse exergy transformation problem of thermodynamic system.
04	Predict thermodynamic properties of fluids in homogeneous phase
05	Apply thermodynamics laws to chemical engineering processes.

Teaching and Examination Scheme:

Teaching - Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	TW/ SL	TH		ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
45	15	0	60	120	04	70	30	20	30	00	150

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End-Semester Examination, PA = Progressive Assessment

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**INTRODUCTION AND FIRST LAW OF THERMODYNAMICS:** The scope of thermodynamics, Dimensions and units, Measures of amount or size, Force, temperature, pressure, work, energy, heat, etc. Internal Energy, Enthalpy, The first law of thermodynamics, Thermodynamic	6	13
	state, state functions, Energy balance for closed systems, Equilibrium, The Phase rule, The reversible process, Heat capacity, Application of first law of thermodynamics to steady state flow process.		
2.	**VOLUMETRIC PROPERTIES OF PURE FLUIDS :** PVT behavior of pure substances, Ideal and non-ideal gases, Equation of states, Virial, Cubic, Vander Waals EOS, Redlich/Kwong (RK) EOS etc., Calculation of constants in terms of Pc, Tc, Vc. Generalized Correlations for gases and liquids.	8	18
3.	**HEAT EFFECTS:** Sensible heat effects, Temperature dependence of the heat capacity, Latent heats of pure substances, Approximate methods for the estimation of the latent heat of vaporization, Standard heat of reaction, Standard heat of formation, Standard heat of combustion, Temperature Dependence of $\Delta H0$, Heat effects of Industrial Reactions.	6	13
4.	**SECOND LAW OF THERMODYNAMICS:** Statements of second law of thermodynamics, Heat engines, Thermodynamic Temperature Scales, Concept of entropy, Entropy changes of an Ideal Gas, Third law of thermodynamics.	8	18
5.	**THERMODYNAMIC PROPERTIES OF FLUIDS:** The fundamental property relations for homogeneous phases, Maxwell's equations, Residual properties, Mathematical relations among thermodynamic properties, Two phase systems, Thermodynamic diagrams.	7	16
6.	**THERMODYNAMICS OF FLOW PROCESS:** Fundamental equations and relationships, flow in pipes, maximum velocity in pipe flow, nozzles, Single and Multistage compressors and ejectors.	4	9
7.	**REFRIGERATION AND LIQUEFACTION:** Carnot refrigerator, Vapor compression cycle, Absorption refrigeration, Choice of refrigerant, Heat pump, Liquefaction processes.	6	13

	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
15	**25**	**25**	**5**	**---**	**---**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

References/Suggested Learning Resources:

(a) Books:

1. "Introduction to Chemical Engineering Thermodynamics"; J. M. Smith, H. C. Vanness, M. M. Abbott, The McGraw-Hill Companies, Inc.
2. "Chemical, Biochemical and Engineering Thermodynamics"; S.I. Sandler, Wiley India Edition.
3. "A text book of Chemical Engineering Thermodynamics"; K. V. Narayanan, Prentice-Hall of India Pvt. Ltd.
4. "Chemical and Process Thermodynamics"; B.G. Kyle, Prentice-Hall Inc.
5. "Introduction to Thermodynamics"; Y.V.C. Rao, 2nd Edition, Wiley Eastern Limited

(b) Open source software and website:

1. Students can refer to video lectures available on the websites including NPTEL.
2. Students can refer to the CDs which are available with some reference books for the solution of problems using software. Students can develop their own programs for the solutions of problems.
3. XSEOS–Open Software for Chemical Engineering Thermodynamics

List of Tutorials: Numerical/problems based on topics of each theme of content.

Suggested Activities for Students: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the

faculty, Department and College on the first slide.

- **Activities suggested under self-learning:**

Sl. No.	Name of the activity	No. of hours	Evaluation Criteria
1.	Industry/Research laboratory visit	Visit = 5h, Report preparation = 5h Total = 10h	Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
2.	Technical Video based learning related to the subject	Duration of video = 5h Report preparation = 5h Total = 10h	Report /presentation based on the video learning outcomes.
3.	Assignment writing. Numericals based assignment is preferable.	5 assignments of 2h each. Total = 10h	Based on the assignment submitted.
4.	Problem solving/Coding using C, C++, Python, SCILAB, MATLAB, MS-EXCEL or any other relevant software	5 small coding based assignment of 2h each. Total = 10h	Based on the coding solution submitted.
5.	Self learning on-line course	Minimum duration of the course should be 10h.	Examination based assessment at the end of course. Based on the certificate produced.
6.	Complex problem solving	Maximum 2 problem. Study of the problem and solution finding, Total = 10h	Based on the depth of the solution submitted.
7	Videos on Industrial safety aspects based on subject	Duration of video = 5h Report preparation = 5h Total = 10h	Based on quiz/report submitted
9.	Poster/chart/power point preparation on technical topics	Duration = 6 h	Based on poster/chart preparation and presentation skills
11	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment/health/any other issue	Duration = 15 h for industrial exposure Problem identification and tentative solution = 10 h Total = 25 h	Based on evaluation of critical problems and solutions

12	Group Discussion on emerging/trending technical topics based on subject	Duration = 1 h each	Based on performance in group discussion, technical depth, knowledge etc.

Note:

- All records pertaining to the evaluation and assessment of self-learning activities must be properly maintained and preserved at the institute level. These records should be made available to the university upon request.
- Institutes are encouraged to utilize digital platforms, such as Microsoft Teams, for effective record-keeping and to ensure transparency in the evaluation and assessment of self-learning activities.

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Chemical Engineering
Subject Code : BE03005021
Subject Name : Chemical Process Technology

w. e. f. Academic Year:	2024-25
Semester:	3
Category of the Course:	Professional Core Courses

Prerequisite:	None
Rationale:	The primary goal of this subject is to teach the fundamentals of chemical processes that occur in chemical and allied industries like pharmaceuticals, cement, etc. The subject imparts knowledge about the basic concepts for manufacturing various chemical compounds.

Course Outcome:
After completion of the course, students will be able to:

No	Course Outcomes
01	understand the manufacturing of various inorganic and organic chemicals
02	understand the process flow diagram and various process parameters
03	identify and solve engineering problems during production
04	understand the practical methods of production in a chemical plant.
05	build a bridge between theoretical and practical concepts applied in industry

Teaching and Examination Scheme:

Teaching - Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	TW/ SL	TH		ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
45	0	30	45	120	04	70	30	20	30	50	200

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End-Semester Examination, PA = Progressive Assessment

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Chemical processing and the work of chemical engineering :** Basic chemical data, unit operation and unit process, batch and continuous processing, process flow sheet, environment aspects, safety aspects etc.	2	5
2.	**Sulphur, Sulphuric acid industry:** Mining and manufacturing of Sulphur, synthesis of Sulphur dioxide, Manufacture of Sulphuric acid and its applications, manufacturing technologies & associated engineering problems.	5	9
3.	**Fertilizer industry:** manufacturing processes of Ammonia, Urea, Nitric acid, Phosphoric acid, their uses and applications, manufacturing of phosphate fertilizers, major engineering problems, NPK fertilizer	5	10
4.	**Chlor-alkali and heavy inorganic industry:** Manufacturing of soda ash, Caustic Soda and Chlorine by membrane cell, mercury & diaphragm process.	4	9
5.	**Dye & its intermediates, paints and pigment industry:** Classification of dyes according to its constitution and application, Introduction to Disperse, Reactive, Azo dyes, H-acid, Koch acid, Vinyl sulphone, Vat dyes. Introduction to Paints classification & its constituents, PVC of Paints, different types of pigments such as white, blue, red, yellow, green, brown. Introduction to Varnishes, Solvent, Thinners & Industrial Coatings.	5	10
6.	**Soap and detergent industry:** Introduction to soap and detergent, soap manufacturing process, methods of detergent manufacture, manufacture of glycerine.	4	9
7.	**Drugs and pharmaceuticals industry:** Classification of various drugs and pharmaceuticals, Introduction of Antibiotics, Manufacturing of penicillin, Introduction of vitamins, Manufacturing processes of Aspirin, Vitamin-D, B-12, & C (Ascorbic acid)	4	10
8.	**Sugar & Fermentation Industry:** Manufacturing of Sugar. Fermentation process, Industrial Alcohol, Absolute Alcohol, Beers, Wines and Liquors, Manufacturing of Butyl Alcohol & Citric acid by fermentation.	4	10
9.	**Cement & ceramic industry:** Cement & Its types, Limestone benefication, manufacturing of Portland cement, lime manufacture. Introduction to Ceramic Industry, basic raw materials and ceramic chemistry, manufacturing of Refractory bricks.	4	10

10.	**Pulp and paper industry:** Pulp manufacturing by Kraft process, major engineering problems, chemical recovery, Manufacturing of Paper.	**4**	**9**
11.	**Industrial gases and carbon :** Importance of cryogenics in gas production**,** production of gases like carbon dioxide, oxygen, nitrogen, hydrogen, introduction to rare gases of atm. like helium and acetylene.	**4**	**9**
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	**25**	**25**	**10**	**---**	**---**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

References/Suggested Learning Resources:

(a) Books:

1. "Shreve's Chemical Process Industry", George T. Austin, McGraw Hill Publication, 5th edition
2. "DRYDENS outlines of chemical technology for the 21st century", M Gopalarao & Marshal Sitting, pub East- West Press, 3rd edition.
3. "Ulmanns Encyclopedia of Industrial Chemistry", Wiley
4."Encyclopedia of Chemical Technology", Kirk and Othmer, Wiley Interscience.
5. "Unit processes in Organic synthesis", Groggins, P.H., Tata McGraw Hill Education Pvt Ltd.

(b) Open source software and website:

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

LIST OF PRACTICALS: (Minimum 10 need to be performed)

Sr. No.	List of Experiments
1.	To prepare soap in the laboratory and carry out its cost analysis.
2.	To determine saponification value of oil sample
3.	To prepare detergent in the laboratory and to carry out its cost analysis.
4.	To determine the acid value of the given sample of oil.
5.	To prepare hydrated lime from the given calcium carbonate powder
6.	To prepare caustic soda by chemical method.

7.	To synthesis aspirin from salicylic acid.
8.	Preparation of phenyl azo – β – Naphthol from aniline.
9.	Preparation of disperse dye.
10.	To prepare mordant yellow dye.
11.	Preparation of fast green dye.
12.	Preparation of nitro benzene from benzene.
13.	To study Alcohol Fermentation by Saccharomyces cereviceae (Baker's Yeast).
14.	Fermentative production of citric acid using the fungi Aspergillus niger.

- **Self Learning Activities:**

Activity	No. of hours	Evaluation Criteria
Industry/Research laboratory visit	Visit = 5h, Report preparation = 5h Total = 10h	Based on the report submitted. Report should contain observations and calculations based on industry/ lab data.
Technical Video based learning related to the subject	Duration of video = 5h Report preparation = 5h Total = 10h	Report /presentation based on the video learning outcomes.
Assignment writing	5 assignments of 2h each. Total = 10h	Based on the assignment submitted.
Self learning on-line course	Minimum duration of the course should be 10h.	Examination based assessment at the end of course. Based on the certificate produced.
Working/non-working model on technical topics	Working = 12 h Non- working = 8 h	Based on inter department/external evaluation
Group Discussion on emerging/trending technical topics based on subject	Duration = 1 h each	Based on performance in group discussion, technical depth, knowledge etc.
Industrial exposure for 2-3 days to observe and provide tentative solutions on society/ environment/ health/ any other issue	Duration = 15 h for industrial exposure Problem identification and tentative solution = 10 h Total = 20 h	Based on evaluation of critical problems and solutions

Poster/chart/powerpoint preparation on technical topics	Duration = 6 h	Based on poster/chart preparation and presentation skills
Real world case studies-based learning	Duration of data collection/study = 5h Report preparation = 5h Total = 10h	Based on in-depth study, technical depth, data collected, fact finding, etc.

- Above activities are suggestive, faculty can choose any of these activities and cover up the rest of the credit hour.
- The number of hour is suggestive. Faculty can sub-divide the number of hours based on the activity. However, the total number of hours is fixed.
- All records pertaining to the evaluation and assessment of self-learning activities must be properly maintained and preserved at the institute level. These records should be made available to the university upon request.
- Institutes are encouraged to utilize digital platforms, such as Microsoft Teams, for effective record-keeping and to ensure transparency in the evaluation and assessment of self-learning activities.

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Chemical Engineering
Subject Code : BE03005031
Subject Name : Material and Energy Balance Computation

w. e. f. Academic Year:	2024-25
Semester:	3
Category of the Course:	Professional Core Courses

Prerequisite:	Basics of Mathematics and Chemistry
Rationale:	This subject's main objective is to teach the basic calculations required for the chemical processes that take place in the fertilizer, dye, petrochemical, speciality chemical industries. The subject imparts knowledge about the basic concepts required to prepare chemical process flow sheets.

Course Outcome:

After completion of the course, students will be able to:

No	Course Outcomes
01	Interpret different system of units with conversion and to develop fundamental concepts and basic chemical engineering principles
02	Apply the principles of material balance for chemical plant having different unit operations and unit processes
03	Evaluate the fundamentals of energy balance including thermal properties estimation for unit operations and unit processes of chemical industries.
04	Analyze quality of different types of fuel (Solid, Liquid and Gas)

Teaching and Examination Scheme:

Teaching - Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	TW/SL	TH		ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
60	15	0	45	120	04	70	30	20	30	00	150

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End-Semester Examination, PA = Progressive Assessment

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Units & Dimensions:** Dimensions & system of units, Fundamental and derived units, Unit conversion and its significance, Dimensional consistency, Dimensional Equations	4	5
2.	**Basic Chemical Calculations** Concepts of atomic weight, equivalent weight and mole. Composition of solids, liquids and solutions (weight percent, mole percent, molarity, normality etc.), other expressions for concentration, Average molecular weight and density, Gaseous mixtures, Ideal gas laws and its applications, Raoult's law, Henry's law, Amagat's Law & Dalton's law, Humidity and Saturation	10	10
3.	**Material Balance without Chemical Reactions:** Introduction, Process flow sheet such as process flow diagram, process block diagram, P&ID diagram, solving material balance problems without chemical reactions of unit operations, Material balance of unsteady state operations, Material balance with and without recycle; Bypass and Purge streams.	10	20
4.	**Material balances with Chemical reaction:** Concept of limiting and excess reactants, percentage conversion, selectivity and yield. Material balance involving reactions with special reference to fertilizers, petrochemicals, dyestuffs, electrochemical industries. Complex material balances	10	15
5.	**Energy balances:** Heat capacity of gases and gaseous mixtures, liquids & solids, Sensible heat change in liquid & gases, enthalpy changes during phase transformation, enthalpy changes accompanied by chemical reactions, standard heat of reaction, Hess's law, dissolutions of solids, Adiabatic reactions, heat of solution by partial molar quantities	10	20
6.	**Stoichiometry and Unit Operations:** Distillation, Absorption & Stripping, Extraction & Leaching, Crystallization, Psychrometric operations, Psychrometric chart for air–water system, Drying, Evaporation etc.	8	15
7.	**Fuel & Combustion** Types of fuels, calorific value of fuels, Problems on combustion of coal (NCV, GCV etc,) Dulong Formula, Calderwood Equation examples, liquid fuels, gaseous fuel etc. Proximate and ultimate analysis, combustion calculations, theoretical flame temperature, Air requirement and flue gases, Boiler material and energy balance calculations.	8	15
	Total	60	100

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
20	**15**	**25**	**15**	**25**	**---**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from the above table.

References/Suggested Learning Resources:

(a) Books:

1. Stoichiometry, B.I.Bhatt, Suchen Thakore & Dr Satish R Shah ,McGraw Hill Book Company, 6th Ed, 2021
2. Basic Principles & Calculations in Chemical Engineering, D.M.Himmelblau. 6th Ed., 2004
3. Chemical Process Principles, Vol.1, O. A.Hougen, K. M.Watson, R.A.Ragatz., Indian print, CBS Publishers, 2nd Ed., 1995
4. Stoichiometry & Process Calculations, Narayanan K.V., & Lakshmikutti B., Prentice Hall, 2006
5. Process Calculations, V Venkataramani and N Anantharaman, PHI Learning, 2004
6. Chemical Process Calculations Manual, David Carr Igbinoghene, McGraw Hill Professional, 2004

(b) Open source software and website:

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

- **Self-Learning Activities:**

Activity	No. of hours	Total hours claimed	Evaluation Criteria
Technical video demonstration based on subject content and learning related to the content	Duration of video 5h Report preparation 5h	10	Report /presentation based on the video learning outcomes.
Assignment writing. Numerical based assignment is preferable.	5 assignments of 2h each.	10	Based on the assignment submitted.

Problem solving/Coding using C, C++, Python, SCILAB, MATLAB, MS-EXCEL or any other relevant software	5 small coding-based assignments of 2 h each.	10	Based on the coding solution submitted.
Self-learning on-line course related to the subject	Minimum duration of the course should be 10h.	10	Examination based assessment at the end of course. Based on the certificate produced.
Complex problem solving of real industrial problem	Maximum 1problems. Study of the problem and solution finding, Problem related to industrial mass and energy balance of the plant.	10	Based on the depth of the solution submitted.
Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment/health/any other issue	Duration (15 h) for industrial exposure Problem identification and tentative solution (5 h)	20	Based on evaluation of critical problems and solutions
Poster/Chart/PowerPoint preparation on technical topics	Poster/Chart/Power point preparation and presentation	10	Based on poster/chart preparation and presentation skills
Real world case studies-based learning	Duration of data collection/study 5h Report preparation 5h	10	Based on in-depth study, technical depth, data collected, fact finding, etc.
Technical Video Preparation related to subject	Preparation of content 5 h Video Preparation and upload at department/college website 5h	10	Based on the quality of the video prepared by student

- Above activities are suggestive, faculty can choose any of these activities and cover up the rest of the Self Learning Hour.
- The number of hours is suggestive. Faculty can sub-divide the number of hours based on the activity. However, the total number of hours is fixed.
- All records pertaining to the evaluation and assessment of self-learning activities must be properly maintained and preserved at the institute level. These records should be made available to the university upon request.
- Institutes are encouraged to utilize digital platforms, such as Microsoft Teams, for effective record-keeping and to ensure transparency in the evaluation and assessment of self-learning activities.

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Chemical Engineering
Subject Code : BE03005041
Subject Name : Numerical Methods in Chemical Engineering

w. e. f. Academic Year:	2024-25
Semester:	3
Category of the Course:	Basic Science Course

Prerequisite:	Basics of Mathematics
Rationale:	The main objective of course is to introduce numerical methods and computational techniques to solve chemical engineering problems. This will provide a background for applying these methods to industrial problems.

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To demonstrate the concept of error, precision, significant digits and propagation of error in purview of numerical methods.	10
CO-2	To apply appropriate numerical method to solve chemical engineering problems.	10
CO-3	To apply the concept of numerical methods to solve linear and non-linear equation/s.	30
CO-4	To estimate parameters of linear and non-linear model equations using curve fitting and interpolation techniques	20
CO-5	To Solve problems related to integration, differentiation and ordinary differential equations using appropriate numerical method.	30

Teaching and Examination Scheme:

Teaching - Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	TW/ SL	TH		ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
45	0	15	60	120	04	70	30	20	30	0	150

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End-Semester Examination, PA = Progressive Assessment

Content:

Sr. No.	Content	Total Hrs
1	Approximations and Errors: Types of Errors, Significant figures, Accuracy of Numbers, Precision, Error Propagation, Applications in Chemical Engineering	03
2	Solution of Algebraic and Transcendental Equations: Basic Properties of Equations, Relations between Roots and Coefficients, Descartes Rule of Sign, Synthetic Division of a Polynomial by a Linear Expression, Bracketing Methods (Bisection, Secant, Method of False Position or Regula Falsi, etc.), Convergence of Iterative Methods, Newton-Raphson Method, Newton-Raphson Method for Non Linear	08
	Equations in Two Variables (Numericals based on application in chemical engineering)	
3	Solution of Linear Equations: Mathematical Background of Matrices and its operations, Matrix inversion, Gauss Elimination, Gauss-Jordan Method, Gauss-Seidel Iteration Method, Jacobi's Method, Gauss-Seidel Method, Eigen Value Problem (Numericals based on application in chemical engineering)	07
4	Curve Fitting: Method of Least Squares, Fitting a Straight Line and a Polynomial, Fitting a Non-linear Function, Fitting Geometric and Exponential Curves, Fitting a Hyperbola, a Trigonometric Function, etc (Numericals based on application in chemical engineering)	07
5	Finite Differences & Interpolation: Finite Differences: Forward, Backward and Divided Differences Table, Central Differences, Newton's Forward, Backward and Divided Differences Interpolation Formula, Interpolation Polynomials, Lagrange Interpolation Formula, Inverse Interpolation (Numericals based on application in chemical engineering)	06
6	Numerical Differentiation & Integration: Differentiation Formula based on Tabulator at Equal and Unequal Intervals, Newton-Cotes Integration Formulas, Trapezoidal Rule and Simpson's 1/3 and 3/8 Rule (Numericals based on application in chemical engineering)	06
7	Ordinary Differential Equations: Taylor's Series and Euler's Method, Modifications and Improvements in Euler's Method, Runge-Kutta 2nd Order & 4th Order Methods, Milne's Predictor-Corrector Methods, Boundary Value Problems (Numericals based on application in chemical engineering)	08

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**20**	**30**	**10**	**0**	**0**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Numerical Methods for Engineers by Steven C. Chapra and Raymond P. Canale, McGraw Hill Education India Private Limited, 7th Edition, 2016.
2. Introductory Methods of Numerical Analysis by S. S. Shastry, Prentice Hall India Learning Private Limited, 5th Edition, 2012.
3. Numerical Methods in Engineering & Science by B. S. Grewal, Khanna Publishers, 11th Edition, 2013.
4. Numerical Methods for Scientific and Engineering Computation by M. K. Jain, S. R. K. Iyengar, and R.K. Jain, New Age International Private Limited, 7th Edition, 2019.

List of Open Source Software/learning website:

- Reference to NPTEL lectures can be made for a better understanding regarding various numerical methods.

- **Self-Learning Activities**

Activity	No. of Hours	Total Hours Claimed	Evaluation Criteria
Assignments on Numerical Techniques (Methods like Newton-Raphson, Gauss-Seidel, Runge-Kutta, etc.)	Completing five assignments (3h each)	15	Evaluated based on assignment submission
Implementing Numerical methods in MS-Excel spreadsheet	Doing Two Spreadsheets based assignments (5h each)	10	Reviewed based on the implementation, results and presentation of results analysis

Activity	No. of Hours	Total Hours Claimed	Evaluation Criteria
Solving Problems & Coding using MATLAB, SCILAB or Python	Solving two coding-based assignments (5h each)	10	Reviewed based on Implementation, result accuracy and efficiency of coding solutions.
Technical Video Demonstration on concepts like error analysis, equation solving, interpolation, integration, differentiation, etc.	Watching video content and Preparing a report (5h)	05	Assessment based on understanding the content, report and presentation reflecting learning outcomes.
Literature Review and Concept Mapping: Review 3–5 research papers on numerical applications in chemical engineering; create a visual map of methodologies and findings	Literature reading: 5h Concept Map creation: 5h	10	Relevance of literature, clarity and technical quality of the concept map
Online Course (MOOC/NPTEL/SWAYAM/edX, etc.) on numerical methods or computational techniques in chemical engineering	Minimum course duration of 10 hours	10	Assessment through an examination at the end of the course. Certificate submission required
Experimental Data Analysis Using Numerical Methods (Processing real or simulated experimental data using numerical techniques)	Data collection and processing (5h) + Interpretation and report writing (5h)	10	Evaluated based on accuracy, technical depth, and insights derived from data analysis
Numerical Modelling and Simulation of Engineering Systems (Developing mathematical models and performing simulations for chemical processes)	Model formulation (5h) + Simulation and result analysis (5h)	10	Evaluated based on model accuracy, computational efficiency, and interpretation of results
Independent Course Project on Advanced Numerical Methods (Exploring Emerging Techniques) or **Applying Numerical Methods to Solve**	Literature review/Analysis/ Solution Development (15h) + Report writing	20	Evaluated based on originality, technical depth, research findings, solution and presentation

Activity	No. of Hours	Total Hours Claimed	Evaluation Criteria
Complex Industrial Problems	and preparation (5h)		
Producing Technical Videos related to the Subject Content	Content development (5h) + Video creation and uploading on the department/college website (5h)	10	Reviewed based on the quality and effectiveness of the video content
Develping Posters, Charts, or PowerPoint Presentations on Subject related Technical Topics	Designing and presenting visual content	10	Assessed based on creativity, clarity, and presentation skills

Guidelines for Faculty

- The activities listed above are **suggestive**, and faculty members have the flexibility to select and modify them as needed.
- The **total self-learning hours remain fixed at 60 hours**, ensuring comprehensive coverage of numerical methods in chemical engineering.
- Faculty can **adjust the distribution of hours** across different activities while maintaining a balanced learning approach.
- All records pertaining to the evaluation and assessment of self-learning activities must be properly maintained and preserved at the institute level. These records should be made available to the university upon request.
- Institutes are encouraged to utilize digital platforms, such as Microsoft Teams, for effective record-keeping and to ensure transparency in the evaluation and assessment of self-learning activities.

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TEACHING SCHEME / DETAIL SYLLABUS

Home

ME

30 - CHEMICAL ENGINEERING

1

2024-25

Select Elective / Non-Elective

Subject Code

Enter Subject Name

Search

*L=lectures,T=tutorial,P=Practical,E=TheoryExternal,M=TheoryInternal,I=Practical Internal,V=Practical External,On Job Training(OJT) is equivalent to Practical

							Hours			Credit	Max Marks					
Exp.	Subcode	Branch code	Eff_from	SubjectName	Category	Sem /Year	L.	T.	P.	PBL	Total	E	M	I	V	Total
	ME01000011	030	2024-25	Research Methodology and IPR	Mandatory Learning Course (Bridge Course)	1	1	0	2	NA	2	0	0	20	80	100
	ME01000021	030	2024-25	Technical Report Writing	Mandatory Non-Credit Courses – Audit Course	1	2	0	0	NA	0	50	0	0	0	50
	ME01000121	030	2024-25	Bio Process Engineering	Professional Elective - I	1	3	0	2	NA	4	70	30	20	30	150
	ME01030011	030	2024-25	Mathematical and Statistical Methods in Chemical Engineering	Professional Core Courses	1	3	0	2	NA	4	70	30	20	30	150
	ME01030021	030	2024-25	Advanced Chemical Engineering Thermodynamics	Professional Core Courses	1	3	0	2	NA	4	70	30	20	30	150
	ME01030031	030	2024-25	Advanced Petroleum Refining	Professional Elective - I	1	3	0	2	NA	4	70	30	20	30	150
	ME01030041	030	2024-25	Application of Nanotechnology in Chemical Engineering	Professional Elective - I	1	3	0	2	NA	4	70	30	20	30	150
	ME01030051	030	2024-25	Advanced Process Control	Professional Elective - II	1	3	0	2	NA	4	70	30	20	30	150
	ME01030061	030	2024-25	Process Plant Design and flow sheeting	Professional Elective - II	1	3	0	2	NA	4	70	30	20	30	150
	ME01030071	030	2024-25	Advanced Process Equipment Design	Professional Elective - II	1	3	0	2	NA	4	70	30	20	30	150

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Web Site Visit Count

00353260 5

GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: PG

Branch:ALL

Course / Subject Code : ME01000011

Course / Subject Name : Research Methodology and IPR

w. e. f. Academic Year:	2024-25
Semester:	1st Semester
Category of the Course:	MLC

Prerequisite:	Nil
Rationale:	The course is design to orient the students to the scientific methodology of research and presenting their thesis. Research constitutes primarily of literature review, giving critical comments on the literature reviewed and identifying the gap, problem formulation, modeling in either an analytical or experimental set up, validating the model and solving the problem set by the students for themselves. At the end, student should be able to present and defend the solution he/she has found, in a simple and easy manner.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT level
1	Explain various phases of the research and research ethics	Understand
2	Explain a quality literature review, research gap and objectives	Understand
3	Identify an original and relevant problem and identify methods to find its solution	Apply
4	Identify the model(s) developed for the research area	Apply
5	Relate IPR protection for further research and better products	Understand

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
1	0	2	2	-	-	20	80	100

GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: PG

Branch:ALL

Course / Subject Code : ME01000011

Course / Subject Name : Research Methodology and IPR

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Phases of Research:** What is expected of you? Identification of broad research area, literature review, identify research gap, formulate problem statement, validation, report writing, Research ethics	2	NA
2.	**Finding Good literature:** Sources of literature, finding information, identify main ideas in scholarly literature, write notes to organize your ideas, identification of research gap, identification of research objectives	4	NA
3.	**Basics of Research Design:** Qualitative, quantitative and mix methods, experimental research, uncertainty analysis	4	NA
4.	**Intellectual Properties:** Forms of IP, National IP policy 2016, International Scenario, patent rights, Information Technology and IPR	5	NA
	Total	**15**	

Suggested Specification Table with Marks (Theory):

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

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Research Methodology: Methods and Techniques by C. R. Kothari, Vishwa Prakashan
2. Research methodology: an introduction for science and Engineering students by Stuart Melville and Wayne Goddard
3. Research Methodology: A Step-by-Step Guide for beginners by Ranjit Kumar, SAGE Publications Pvt. Ltd
4. Research Design: Qualitative, Quantitative and Methods Approaches by John W. Creswell, SAGE Publications Pvt. Ltd
5. Intellectual Property Rights: Protection and Management by Nithyananda K V., Cengage Learning India Private Limited

(b) Open-source software and website:

1. https://onlinecourses.nptel.ac.in/noc22_hs59/
2. https://archive.nptel.ac.in/courses/110/105/110105139/
3. https://onlinecourses.swayam2.ac.in/cec20_hs18/preview
4. https://www.wipo.int/academy/en/courses/distance_learning/

Suggested Activities for Students: Students are required to download research papers from reputed international journals on the recent advancement in the area of their interest or as suggested by course teacher. They need to go through the same and prepare a review for the research papers. The review should have three parts: Summary, Critical Evaluation and Creative synthesize.

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: PG

Branch:ALL

Course / Subject Code : ME01000021

Course / Subject Name : Technical Report Writing

w. e. f. Academic Year:	2024-25
Semester:	1st Semester
Category of the Course:	MNC- AC

Prerequisite:	Interconnected Power System.
Rationale:	In technical education, academics and research go hand in hand. Effective clear and result- oriented writing plays a vital role in building successful career. This course provides comprehensive learning skills required for writing and presenting research proposals, dissertation reports and similar documents. The skills developed by individuals may be greatly Enhanced by quality of literature review, identification of research gaps, importantly, quality of research work done and the application of knowledge gained during the course.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	To understand various kinds of technical report writing.
02	To perform quality literature survey and avoid the plagiarism.
03	To develop basic skill of presenting and writing documents Like research proposal, research paper, dissertation and thesis out of the research work.
04	To prepare the digital copy of the document using latex.

Teaching and Examination Scheme:

Teaching Scheme(in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
2	0	0	0	50	0	0	0	50

GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: PG

Branch:ALL

Course / Subject Code : ME01000021

Course / Subject Name : Technical Report Writing

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Introduction:** Basic difference between technical writing and general writing, Types of technical reports, styles and content inclusion as per the types of documents, Prerequisites, English in technical report writing.	**4**	13.33%
2.	**Literature review and Plagiarism:** Introduction, sources for literature review, tools, Process, contents to be used in report writing with justification and ethics, Plagiarism, tools for detection of plagiarism, using evidences,	**6**	20%
3.	**Report writing:** Prerequisite, Introduction, review paper writing, research paper writing, main components of the paper, writing title, abstract, methodology, discussion, conclusion and references for the research paper. Comparison of research proposal with dissertation and research paper.	**10**	33.33%
4.	**Referencing and citations:** Introduction, tools used for referencing and citations.	**2**	6.66%
5.	**Introduction to LaTeX** Overview, Install LaTeX, Creat first LaTeX Document, Formatting Text ,Bullets and Numbering, Creating tables, Creating figures and subfigure, Creating equation, Cross Referencing Creating Bibliography,	**5**	16.66%
6.	**Presentation:** Introduction, technical work presentation basics, presentation of research work output using data, figures, graphs and tables. Creating LaTeX Presentation using Beamer, steps for editing and modifying the article for presentation.	**3**	10%
	Total	**30**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
20	25	25	15	15	10

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

/SuggestedLearningResources:

(a) Books:

1. A Short Introduction to LaTeX: A Book for beginners, Firuza karmali (Aibara)
2. More Maths Into LaTeX ,George Gratzer (2016), 5th edition, Springer
3. LaTeX beginners's Guide second edition, Stefan Kottwitz

(b) Open source software and website:

a. **https://onlinecourses.swayam2.ac.in/cec21_ge32**
b. **https://onlinecourses.nptel.ac.in/noc23_ge36/preview**
c. Getting Miktex **https://miktex.org/download**
d. Editor: TeXstudio - A LaTeX editor
e. Overleaf, Online Editor: https://www.overleaf.com/

Suggested Activities for Students:

- Write a review paper after doing literature survey and check the plagiarism
- Write a very small technical report on any topic of your interest
- Create an Article using LaTeX macros using paragraph, listing, figure, table and equation.
- Create a Report using LaTeX macros for minor/major project including bibliography or references.
- Create a Presentation using LaTeX for your subject/research work.

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GUJARATTECHNOLOGICALUNIVERSITY

Program Name: Master of Engineering
Level: Post Graduate Degree
Branch: Chemical Engineering
Course/Subject Code: ME01000121
Course/Subject Name: Bio Process Engineering

w.e.f. Academic Year:	A.Y. 2024-25
Semester:	1st Semester
Category of the Course:	PEC

Prerequisite:	Basic Concepts of Transport Phenomena, Mass transfer and Reaction kinetics
Rationale:	This subject is an integration of chemical engineering with biological systems. It deals with kinetics of biological reactions, mass and heat transfer concepts and transport phenomena occurring within biological reactors.

Course Outcome:

After Completion of the Course, Student will be able to:

No	Course Outcomes
01	Understand the different cells and their use in biochemical processes
02	Understand the role of enzymes in kinetic analysis of biochemical reaction
03	Analyze bioreactors, upstream and downstream processes in production of bio products
04	Apply the concepts of various unit operations in downstream processes of biological products

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+(PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial/ Practical		
L	T	PR	C	ESE (E)	PA/ CA (M)	PA/CA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	%of Weightage
1.	**Kinetics of Enzyme Catalyzed Reaction** The Enzyme Substrate Complex and Enzyme Action, Simple Enzyme kinetics with one and two substrates, Determination of Elementary Step Rate Constants, Other patterns of substrate concentration dependence, Modulation and	**9**	**19**

	Regulation of Enzymatic Activity, Other Influences on enzyme activity, Enzyme deactivation, Enzyme reactions in Heterogeneous systems		
2.	Kinetics of Substrate Utilization, Product Formation, Biomass Production in Cell Cultures Ideal Reactors for kinetics measurements, Stoichiometry and kinetics of Balanced Growth, Transient growth kinetics, structured kinetic models, product formation kinetics, Segregated kinetic models of Growth and Product Formation, Thermal Death kinetics of Cells and Spores.	**9**	**19**
3.	**Transport Phenomena in Bioprocess Systems** Gas Liquid Mass transfer in cellular systems, determination of oxygen transfer rates, mass transfer for freely rising or falling bodies,forced convection mass transfer, overall K_La estimates and power requirements for sparged and agitated vessels, Mass transfer across free surfaces, other factors affecting Kla, Scaling of Mass transfer equipment, Heat Transfer, Sterilization of Gases and liquids	**9**	**19**
4.	**Design and Analysis of Biological Reactors:** Ideal reactors, reactor dynamics, reactors with non-ideal mixing, sterilization reactors, immobilized biocatalysts, multiple bioreactors, Fermentation Technology, animal and plant cell reactor technology.	**8**	**19**
5.	**Product Recovery Operations** Recovery of particulates – cells and solid particles by Filtration, Centrifugation, Flocculation, Cell Disruption, Production isolation by Liquid Liquid extraction, Precipitation, Chromatography and Fixed Bed Adsorption, Dialysis, Membrane Separation, Electrophoresis, Crystallization and Drying	**10**	**25**
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
7	28	28	7	0	0

Where R:Remember; U:Understanding; A:Application, N:Analyze and E:Evaluate C:Create(as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:
(a) Books:

1) Shuler, M. L., Kargi, F., Kargı, F. (2002). Bioprocess Engineering: Basic Concepts. India: Prentice Hall.
2) Doran P.M (1995) Bioprocess Engineering Principles, Elsevier Science and Technology Publishers
3) Bailey, J. E., Ollis, D. F. (1986). Biochemical engineering fundamentals. Singapore: McGraw-Hill.
4) Stanbury, P. F., Whitaker, A., Hall, S. J. (2013). Principles of Fermentation Technology. United Kingdom: Elsevier Science.

(b) Open source software and website:

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

Suggested Course Practical List: List of lab experiments:

1 Estimation of Iodine Value of Fats and Oils
2 Estimation of Saponification Value of Fats/Oils
3 Bioreactor- Basics
4 Estimation of growth kinetic parameters in batch fermentation
5 Determination of Volumetric Mass Transfer Co-efficient (Dynamic method)
6 Determination of Volumetric Mass Transfer Co-efficient (Oxygen balance method)
7 Batch Microbial Cultivation
8 Fed-Batch Microbial Cultivation
9 Continuous Microbial Cultivation
10 Study of Enzyme Kinetics
11 Immobilization of whole cells

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: M.E. in Chemical Engineering
Level: Post Graduate Degree
Branch: Chemical Engineering
Course / Subject Code: ME01030011
Course / Subject Name: Mathematical and Statistical Methods in Chemical Engineering

w. e. f. Academic Year:	2024-25
Semester:	1st Semester
Category of the Course:	PCC

Prerequisite:	Engineering Mathematics
Rationale:	The increasing importance of numerical methods in various branches of science and engineering have led to enhanced demand for courses dealing with the techniques of numerical analysis as numerical methods give the solution of applied problems when ordinary analytical methods fail. It is therefore clean training in engineering would be incomplete without an adequate understanding of numerical methods. Statistics deals with the collection, presentation, analysis and use of data to make decisions, solve problems and design products and processes.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Solve system of linear algebraic equations
02	Fit relationship between two data sets using linear, non-linear regression.
03	Calculate maxima/minima and functions
04	Design, simulate and optimise chemical engineering operations and processes.

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Equation Forms in Process Modeling:** Introduction and motivation, linear and nonlinear algebraic equation, optimization based formulations, Ordinary Differential Equations	**5**	**12**

	(ODE) - Initial Value Problems (IVPs) and Differential Algebraic Equations (DAEs), ODE - Initial Value Problems (IVPs) and Partial Differential Equations (PDEs), abstract model forms, fundamentals of vector spaces, generalized concepts of vector space, sub-space, linear dependence, concept of basis, dimension, norms defined on general vector spaces, norms defined on different vector spaces, Cauchy sequence and convergence, Cauchy-Schwartz inequality and orthogonal sets, Gram-Schmidt process and generation of orthogonal basis, orthogonal basis matrix norms, classification of problems in numerical analysis, polynomial approximations, Taylor series approximation, Necessary and sufficient conditions for unconstrained multivariate optimization, transformations and unified view of problems through the concept of transformations		
2.	**Interpolation & Curve Fitting:** Least square approximations, Formulation and derivation of weighted linear least square estimation, Geormtraic interpretation of least squares Projections and least square solution, Function approximations and normal equation in any inner product space, Model Parameter Estimation using linear least squares method, Generic equation forms in transformed problems. Linear and Polynomial Regression, Introduction to polynomial interpolation, Polynomial and function interpolations, Lagrange Interpolating Polynomials, Spline Interpolation, Cubic Spline	**7**	**12**
3.	**Linear Algebraic Equations:** System of linear algebraic equations, conditions for existence of solution - geometric interpretations (row picture and column picture), review of concepts of rank and fundamental theorem of linear algebra, Classification of solution approaches as direct and iterative, review of Gaussian elimination, Introduction to methods for solving sparse linear systems: Thomas algorithm for tri-diagonal and block tri-diagonal matrices, Block-diagonal, triangular and block-triangular systems, solution by matrix decomposition, Iterative methods: Derivation of Jacobi, Gauss-Siedel and successive over-relaxation methods, Convergence of iterative solution schemes: analysis of asymptotic behavior of linear difference equations using Eigen values, convergence of iterative solution schemes, Optimization based solution of linear algebraic equations, matrix conditioning, examples of well conditioned and ill-conditioned linear systems.	**8**	**13**
4.	**Nonlinear Algebraic Equations:**	**5**	**12**

	Method of successive substitutions, derivative free iterative solution approaches, Secant method, Regulafalsi method and Wegsteine iterations, Modified Newton's method and Qausi-Newton method with Broyden's update, Optimization based formulations and Leverberg-Marquardt method, contraction mapping principle and introduction to convergence analysis		
5.	**Ordinary Differential Equations - Initial Value Problems (ODE-IVPs):** Introduction, Analytical Solutions of Linear ODE-IVPs, basic concepts in Numerical solutions of ODE-IVP: step size and marching, concept of implicit and explicit methods, Taylor series based and Runge-Kutta methods, Multi-step (predictor-corrector) approaches, Stability of ODEIVP solvers, choice of step size and stability envelopes, stiffness and variable step size implementation, Introduction to solution methods for differential algebraic equations (DAEs)	**10**	**15**
6.	**Ordinary Differential Equations – Boundary Value Problems (ODE-BVPs):** Method of least squares for solving ODE-BVP, Gelarkin's method and generic equation forms arising in problem discretization, Errors in Discretization, Discretization using approximation theory, finite difference method for solving ODE-BVPs with examples, finite difference method for solving PDEs with examples, , Orthogonal Collocations method for solving ODE-BVPs with examples, Orthogonal Collocations method for solving PDEs with examples, Single shooting method for solving ODE-BVPs	**10**	**12**
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
7	12	35	10	6	0

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. S C Chapra and R P Canale, Numerical Methods for Engineers, McGraw Hill International Edition.
2. M K Jain, S R K Iyengar and R K Jain, Numerical Methods for Scientific and Engineering Computation, Wiley Eastern.
3. S S Shastry, Introductory Methods of Numerical Analysis, Prentice Hall of India.
4. B. S. Grewal, Numerical Methods in Engineering & Science, Khanna Publishers.
5. W.J. DeCoursey, Statistics and Probability for Engineering Applications With Microsoft Excel , Newnes.
6. Montgomery, D.C. and Runger, G.C. Applied Statistics and Probability for Engineers, John Wiley & Sons, 2011.

(b) Open source software and website:

1. Students can refer to video lectures available on the websites including NPTEL lecture series.
2. Students can refer to the CDs available with some reference books for the solution of problems using software/spreadsheets. Students can develop their own programs/spreadsheets for the solution of problems.

Suggested Course Practical List:

1. Introduction to computation platform to be used for laboratory (C/C++/ MATLAB /SCILAB)
2. Applications of data Analysis tools and Plotting
3. Fitting experimental data to model
4. Solution of Linear Algebraic Equations using inbuilt solvers.
5. Implementation of algorithm for solution of Linear Algebraic Equations
6. Solution of non-Linear Algebraic Equations using inbuilt solvers.
7. Implementation of algorithm for solution of non-Linear Algebraic Equations
8. Application to solution of multi-component distillation
9. Solution of ODE with inbuilt solvers for chemical engineering application
10. . Solution of PDE with inbuilt solvers for chemical engineering application.

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: M.E. in Chemical Engineering
Level: Post Graduate Degree
Branch: Chemical Engineering
Course / Subject Code: ME01030021
Course / Subject Name: Advanced Chemical Engineering Thermodynamics

w.e.f. Academic Year:	A.Y. 2024-25
Semester:	1st Semester
Category of the Course:	PCC

Prerequisite:	**Introductory Chemical Engineering Thermodynamics (CET-I and CET-II)**
Rationale:	Efficient separation operations and many other chemical processes depend on a thorough understanding of the properties of gaseous and liquid mixtures. This course is advanced, building upon prior courses in thermodynamics covered at graduate level. The goal of this course is to interpret, correlate, and predict thermodynamic properties used in mixture related phase-equilibrium and reaction equilibrium calculations. Solving phase equilibria problems involves general computational techniques that have widespread applications in chemical engineering.

Course Outcome:

After Completion of the Course, Student will be able to:

No	Course Outcomes
01	Apply chemical engineering thermodynamics to a variety of systems and problems, including phase and reaction equilibrium.
02	Use theoretical concepts to describe and interpret solution properties.
03	Know how to qualitatively calculate the equilibrium properties of real liquid mixtures.
04	Solve phase equilibria problems; this includes the ability to determine which of a variety of models best describes a given set of data, and to calculate the model parameters.

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+(PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial/ Practical		
L	T	PR	C	ESE (E)	PA/ CA (M)	PA/CA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	%of Weightage
1.	**Review of Chemical Engineering Thermodynamics** Introduction to Molecular Thermodynamics of Fluid Phase Equilibria, Basic Differences among Classical, Statistical and Molecular Thermodynamics, Fundamental Concepts of Statistical Thermodynamics, Classical Thermodynamics of Phase Equilibrium, Gibbs-Duhem Equation, Chemical Potential, Fugacity and Activity, **Fundamental of Statistical thermodynamics** Combinatorial Analysis of statistical thermodynamics, Distinguishable and indistinguishable particles, ensemble method, microstates and macrostates, most probable macrostate, Postulates of statistical thermodynamics, Maxwell-Boltzmann Statistics, Bose-Einstein statistics, Fermi Dirac statistics, Most probable particle distribution.	**9**	**19**
2.	**Thermodynamics Properties from Volumetric Data** Fugacity of a Component in a Mixture at Moderate Pressures, Fugacity of a Pure Liquid or Solid, Thermodynamics Properties with Independent Variables V and T, Fugacity of a Component in a Mixture according to Van der Waals' Equation, Recent advancements in the above topic.	**5**	**10**
3.	**Fugacities in Gas Mixtures** The Virial Equation of State, Extension to Mixtures, Fugacities from the Virial Equation, Calculation of Second and Third Virial Coefficients, Recent advancements in the above topic.	**5**	**10**
4.	**Fugacities in Liquid Mixtures: Excess Functions** The Ideal Solution, Fundamental Relations of Excess Functions, Temperature and Pressure dependency of Activity Coefficients, Activity Coefficients from Excess Functions in Binary Mixtures, Testing Equilibrium Data for the Thermodynamic Consistency, Wohl's Expansion for the Gibbs Energy, Wilson NRTL and UNIQUAC Equations, Excess Functions and Partial Miscibility, Upper and Lower Consolute Temperatures, Excess Functions for Multicomponent Mixtures, Wilson, NRTL, and UNIQUAC Equations for Multicomponent Mixtures, Recent advancements in the above topic.	**11**	**25**
5.	**Solubility of Gases in liquids** The ideal solubility of gas, Henry's Law and its significance, Effect of Pressure and Temperature on gas solubility, Gas solubility in mixed solvents, Chemical effects on Gas solubility, Recent advancements in the above topic.	**5**	**10**

6.	**Chemical reaction Equilibria** Review of Reaction Equilibrium Principle, Equilibrium Conversion, Calculation and Construction of Equilibrium Conversion Charts, Algorithmic Calculation of Equilibrium Conversion, Homogeneous and Heterogeneous reaction Systems, Phase Rule for Reacting Systems, Chemical Reaction Equilibria for Complex and Multiple Reactions, Lagrange's Undetermined Multiplier's Methods, Various Methods for Computation of Equilibrium Composition of Complex Multiphase Systems, Recent advancements in the above topic.	**10**	**25**
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
7	28	28	7	0	0

Where R:Remember; U:Understanding; A:Application, N:Analyze and E:Evaluate C:Create(as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. J. M. Prausnitz, R. N. Litchtenthaler, E. G. de Azevedo, "Molecular Thermodynamics of Fluid PhaseEquilibria" 3rd Edition, Prentice Hall.
2. S. M. Walas, "Phase Equilibria in Chemical Engineering", Butterworth-Heinemann .
3. J. M. Smith, H. C. Van Ness, M. M. Abbott, "Introduction to Chemical Engineering Thermodynamics", 7th Edition, McGraw-Hill Education.
4. Poling, Bruce E., John M. Prausnitz, and John P. O'Connell. 2001. "Properties of Gases and Liquids". 5th Edition, New York: McGraw-Hill Education.
5. Laurendeau, N. M. (2005). Statistical Thermodynamics: Fundamentals and Applications. United Kingdom: Cambridge University Press.

(b) Open source software and website:

1. Students can refer to video lectures available on the websites including NPTEL lecture series.
2. Students can refer to the CDs available with some reference books for the solution of problems

using software's /spreadsheets. Students can develop their own programs/spreadsheets for the solution of problems.

Suggested Course Practical List: List of Virtual lab experiments:

- Binary Vapour Liquid Equilibrium
- Ebulliometric Determination of Vapour Pressure
- Adsorption Isotherm
- Vib-rotational Spectroscopy of Carbon dioxide
- Simultaneous estimation method for multicomponent samples: Principle of additivity of absorbance
- Study of Phase Change
- Sample Preparation for TEM analysis (Bulk metal, Powder sample, Brittle material)

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GUJARATTECHNOLOGICALUNIVERSITY

Program Name: Master of Engineering
Level: Post Graduate Degree
Branch: Chemical Engineering

Course/Subject Code: **ME01030041**

Course/Subject Name: Application of Nanotechnology in Chemical Engineering

w.e.f. Academic Year:	2024-25
Semester:	1st Semester
Category of the Course:	PEC

Prerequisite:	None
Rationale:	This course is designed to introduce students to the ideas of nanoscience and nanotechnology in the design and construction of devices and systems that take advantage of the unique features of nanoscale materials to develop whole new functionality and capabilities. It would also focus on underlying scientific, technological, and engineering difficulties for advancing nanotechnology in the controlled synthesis of nanostructured materials, notably for industrially important, energy, and environmentally relevant technologies. The curriculum was designed to meet the educational needs of this emerging engineering discipline.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	To understand and classify nanomaterials and impact of nano size on nanomaterials property.
02	To gain the knowledge of nanomaterial synthesis by different methods and its approach.
03	To understand the characterization of nanomaterials by various techniques.
04	To study the scope and applications of nanotechnology in chemical industry as well as its environmental impact.

Teaching and Examination Scheme:

Teaching Scheme(in Hours)			Total Credits L+T+(PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial/Practical		
L	T	PR	C	ESE (E)	PA/ CA (M)	PA/CA(I)	ESE(V)	
3	0	2	4	70	30	20	30	150

CourseContent:

Unit No.	Content	No.of Hours	% of Weightage
1.	**Introduction:** Definition of nanomaterial, nanoscience, nanotechnology; History and scope of nanomaterials; Emergence of nanotechnology and Moore's law; Classification of nanomaterials; Nano dimension impact on (i) elastic properties, (ii) melting point, (iii) diffusivity, (iv) Grain growth characteristics, (v) solid solubility, (vi) Magnetic, (vii) electrical, (viii) optical, (ix) mechanical and, (x) thermal properties. Physical chemistry concept of nanomaterials: (i) surface energy, (ii) Chemical potential, (iii) Electrostatic Stabilization, and (iv) Steric Stabilization.	7	16
2.	**Nanomaterial synthesis using Top-down approach:** Mechanical alloying, Equal channel angular pressing, High-pressure torsion, Accumulative roll bonding, Nanolithography	5	12
3.	**Nanomaterial synthesis using Bottom-up approach:** Physical vapour deposition, Chemical vapour deposition, Magnetron sputtering,molecular beam epitaxy,Colloidal methods,Spray conversion processing, Sol–gel process, Electrodeposition, Hydrothermal and solvothermal method, Wet chemical synthesis, Self-assembly.	5	12
4.	**Synthesis of nanoparticles:** Homogeneous nucleation, Heterogeneous nucleation, Factor affecting size of nanoparticles, Conventional methods, Novel methods such as sonochemical and microwave. Synthesis methods of 1D, 2D nanomaterials, Nanostructure fabrication by physical techniques.	5	12
5.	**Characterization of nanomaterials**: X-Ray Diffraction (XRD), Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy, UV/Visible Spectroscopy, Scanning Tunnelling Microscopy, Filed Ion Microscopy, Three dimensional atom probe, Nano indentation.	6	14
6.	**Synthesis route of Nanostructured Materials with High Application Potential:** (i) Quantum dot, (ii) carbon nanotube, (iii) GaN nanowires, (iv) Nano-crystalline ZnO, (v) Nano-crystalline TiO_2, (vi) Titania nanotubes, (vii)	7	14

	M50 steel, (viii) Silicon based nanostructure, (ix) Fullerene, and (x) micro and mesoporous materials.		
7.	**Applications of nanomaterials:** (i) Cosmetics and Consumer Goods, (ii) Nano Sensor, (iii) Nano catalysts, (iv) Water Treatment and the Environment, (v) Paints, (vi) Food and Agriculture Industry, (vii) energy storage, (ix) Nano-medical Applications, and (x) Textiles	5	10
8.	**Scope, Concerns and Challenges of nanotechnology:** Scalability, Environmental, ecological and health hazards of nanoparticles, Nano-toxicology and its effect	5	10
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

DistributionofTheoryMarks					
RLevel	**ULevel**	**ALevel**	**NLevel**	**ELevel**	**CLevel**
12	35	07	09	07	00

WhereR:Remember;U:Understanding;A:Application,N:AnalyzeandE:EvaluateC:Create(asperRevisedBloom'sTaxonomy)

References/SuggestedLearningResources:

(a) Books:

1. Textbook of Nanoscience and Nanotechnology, B.S. Muty, P. Shankar, Baldev Raj, B.B Rath and James Murday, University Press, IIM (ISBN-978 81 7371 738 3).
2. Nanostructures and Nanomaterials: Synthesis, Properties and Applications by G. Cao, Imperial College Press, 2004.
3. The Chemistry of Nanomaterials: Synthesis, Properties and Applications by C. N. R. Rao, A. Muller, A. K. Cheetham, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, ISBN: 3-527-30686-2.
4. Nanomaterials: Synthesis, Properties & Applications, by Edelstein, A. S & R C Cammarata (Eds.), Taylor & Francis, New York, 1996.
5. Introduction to Nanotechnology, C.P. Poole Jr. and F.J.Owens, Wiley, 2003.
6. Hand book of Nanostructured Materials and Nanotechnology, H. Nalwa, Vol. 1 to 5, Academic Press, 1999.
7. Hand book of Nanotechnology, B. Bhusan, Springer, 2004.

(b) Opensourcesoftwareandwebsite:

1. NPTEL https://nptel.ac.in/courses/118104008
2. NPTEL https://onlinecourses.nptel.ac.in/noc19_mm21/preview
3. MIT: https://mitnano.mit.edu/opportunities/fall-2021-course-6s059-nanotechnology-design-atoms-everything

SuggestedCoursePractical List:If any

ListofLaboratory/Learning ResourcesRequired:

SuggestedProject List:

1. Preparation of catalyst by wet impregnation method.
2. Preparation of catalyst by precipitation method.
3. Preparation of catalyst by co-precipitation method.
4. Preparation of catalyst by hydrothermal method.
5. To synthesize a heterogeneous catalyst by sol-gel method.
6. To synthesize graphene oxide nanomaterials.
7. Synthesis of nanoparticles.
8. Effect of process conditions of size and shape of nanoparticles.
9. To identify the functional group and analyze the sample using FTIR.
10. To analyze the sample using UV-vis spectroscopy.
11. VLAB experiment on XRD
12. VLAB experiment on electron microscopy.

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GUJARATTECHNOLOGICALUNIVERSITY

Program Name: M.E. in Chemical Engineering
Level: Post Graduate Degree
Branch: Chemical Engineering
Course/Subject Code: ME01030061
Course/Subject Name: Process Plant Design and flow sheeting

w.e.f.Academic Year:	2024-25
Semester:	1st Semester
Category of the Course:	PEC

Prerequisite:	The student should have basic understanding of Chemical Engineering Economics and Plant design.
Rationale:	Process Plant design and flow sheeting is concern with designing and project development of chemical plant. It also involves the development of plant layout, flow diagrams and various design consideration during the development of project. This subject also deals with the advanced understanding of various process auxiliaries and utilities used in chemical plant.

Course Outcome:

After Completion of the Course, Student will able to:

No	CourseOutcomes
01	Design and develop a chemical process and perform a complete economic analysis of the plant.
02	Evaluate the profitability of process for chemical plant.
03	Use commercial flowsheeting software to simulate plant
04	Analyze optimal condition for plant with process auxiliaries and utilities

TeachingandExamination Scheme:

Teaching Scheme(in Hours)			Total Credits L+T+(PR/2)	AssessmentPattern andMarks				Total Marks
				Theory		Tutorial/Practical		
L	T	PR	C	ESE (E)	PA/ CA (M)	PA/CA(I)	ESE(V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No.of Hours	% of Weightage
1.	Introduction: Basic concepts, General Design Considerations, Process design development, layout of plant items, Economic aspects and optimum design, Practical considerations in design and engineering ethics, Network analysis, PERT/CPM	8	21
2.	Analysis of cost estimation, Factors affecting investment and production costs, Estimation of capital Investment and total product cost, Interests, Time value of money, Taxes and Fixed Charges, Salvage value, Depreciation calculation	6	14
3.	Flow-sheeting: Synthesis of flow sheet: Propositional logic and semantic equations, Deduction theorem, Algorithmic flow sheet generation using P-graph theory, Sequencing of operating units, Feasibility and optimization of flow sheet using various algorithms viz, Solution Structure Generation (SSG), Maximal Structure Generation (MSG), Simplex, Branch-and-bound etc.	10	21
4.	Optimum Design and Design Strategy: Break-even analysis, Optimum production rates in plant operation, Optimum batch cycle time applied to evaporator and filter press, Economic pipe diameter, Optimum insulation thickness, Optimum cooling water flow rate and optimum distillation reflux ratio.	9	19
5.	Process Auxiliaries: Basic considerations and flow diagrams in chemical engineering plant design. Piping design: Selection of material, pipe sizes, working pressure, Basic principles of piping design, piping drawings, pipe installations, overhead installations, Process steam piping, selection and determination of steam – pipe size, Piping insulation, application of piping insulation, weather proof and fire resisting pipe insulation jackets, piping fittings, pipe joints. Valves: Types of valves, selection criteria of valves for various systems. Pumps: Types of pumps	12	25
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

DistributionofTheoryMarks					
RLevel	**ULevel**	**ALevel**	**NLevel**	**ELevel**	**CLevel**
7	21	28	7	7	0

WhereR:Remember;U:Understanding;A:Application,N:AnalyzeandE:EvaluateC:Create(asperRevisedBloom'sTaxonomy)

References/SuggestedLearningResources:

(a) Books:

1. M.S. Peters and Timmerhaus, Plant design and Economics for Chemical Engineers, McGraw Hill 4th Edition.
2. F.C. Vibrandt and C.E. Dryden, Chemical Engineering Plant Design, McGraw Hill, 5th Edition.
3. Anil Kumar, Chemical Process Synthesis and Engineering Design, Tata McGRaw Hill (1982)
4. Roger Hunt and Ed Bausbacher, Process Plant layout and Piping Design, PTR Prentice-Hall Inc.
5. Jack Broughton; Process utility systems; Institution of Chem. Engineers, U.K.

(b) Opensourcesoftwareandwebsite:

1. NPTEL lecture series
2.DWSIM(open-source CAPE-OPEN compliant chemical process simulator)

SuggestedCoursePractical List:

1. Flowsheeting tutorials in DWSIM (open-source CAPE-OPEN compliant chemical process simulator)
2. Capital cost estimate in DWSIM (estimate capital and operating cost for a chemical plant based on data from the flowsheet)

ListofLaboratory/Learning ResourcesRequired:

SuggestedProject List:

Suggested Activities for Students:

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

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GUJARATTECHNOLOGICALUNIVERSITY

Program Name: Engineering
Level: Post Graduate Degree
Branch: Chemical Engineering
Course/Subject Code: ME01030071
Course/Subject Name: Advanced Process Equipment Design

w.e.f.Academic Year:	2024-25
Semester:	1st Semester
Category of the Course:	PEC -02

Prerequisite:	Study of Process Equipment Design at Undergraduate Level
Rationale:	Chemical industries deal with various types of Heat exchangers, Distillation columns, absorbers, extractors, etc., hence, the knowledge of the process design of these equipments is very much important.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Create understanding of equipment design with mechanical concept.
02	Build a bridge between theoretical and practical concepts used for designing the equipment in any process industry.
03	Design process equipment and modify the design of existing equipment to new process conditions or new required capacity
04	Review the importance of design concepts in process industry.

Teaching and Examination Scheme:

Teaching Scheme(in Hours)			Total Credits L+T+(PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial/Practical		
L	T	PR	C	ESE (E)	PA/ CA (M)	PA/CA(I)	ESE(V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No.of Hours	% of Weightage
1.	**Process Design of Shell & Tube Heat exchangers:** Process Design of Without phase Change by using Delaware Method, Multicomponent Condensers, Condensers involving subcooling and de-superheating, Condensation along with cooling of non-condensable.	8	

2.	**Process Design of Air cooled heat exchangers, air Heaters and Plate heat exchangers:** Air side or Fin side Heat Transfer Coefficient and pressure drop. Advantages and Disadvantages of Plate Heat Exchangers over Shell and Tube Heat Exchangers. Calculation of heat transfer coefficient and pressure drop of plate type heat exchanger.	7	
3.	**Process Design of Reboilers and Vaporizers:** Process design of Kettle-type Reboiler and Vertical Thermosyphon Reboiler, Criteria of selection between Kettle-type Reboiler and Thermosyphon Reboiler.	8	
4.	**Process design of Distillation Column:** Selection of equipment for distillation, Design of binary and multicomponent Distillation, Determination of nos. of theoretical stages for binary distillation by McCabe Thiele method, Determination of nos. of theoretical stages for multicomponent distillation by FenskeyUnderwood-Gilliland's method, Lewis Matheson and Thiele Geddes method, Selection of trays, Calculations for tower diameter & pressure drop of sieve tray tower, Checking of conditions for weeping, downcomer flooding, liquid entrainment, tray efficiency, etc., Process design of binary and multicomponent Batch distillation with rectification.	8	
5.	**Process design of Absorbers:** Introduction, Criteria for selection among different types of absorption equipment, Process Design of packed tower type absorber, Process design of Spraytower type absorber, Venturi Scrubber, Process design of falling film absorber, Process design of absorption column involving chemical reaction.	7	
6.	**Process design of Extractor:** Industrial applications of liquid-liquid extraction, choice of solvent, Process design of counter current multistage extractor, Selection criteria among different types of Extractor, Process design of mixer-settler type extractor & packed tower type extractor.	7	
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
RLevel	**ULevel**	**ALevel**	**NLevel**	**ELevel**	**CLevel**
5	25	15	10	10	5

WhereR:Remember;U:Understanding;A:Application,N:AnalyzeandE:EvaluateC:Create(asperRevisedBloom'sTaxonomy)

References/Suggested Learning Resources:

(a) Books:

- Introduction to Process Engineering and Design by S B Thakore and B I Bhatt, Tata McGraw Hill, 2nd Edition.
- Chemical Engineering, Coulson and Richardson and Sinnot, Vol.6, Asian Pub.
- Brownell and Young, Process Vessel Design, Wiley Eastern, 1977.
- TEMA Standards.
-

(b) Open source software and website:

- HTRI
- Aspan
- Chemsep

Suggested Course Practical List:

- Delaware method for design of shell & tube heat exchanger
- Process design of condenser with non-condensables
- Process design of Air cooler
- Process design of Plate heat exchanger
- Process design of Kettle type Reboiler
- Process Design of Distillation Column
- Process Design of packed tower absorber
- Process Design of Venturi Scrubber

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TEACHING SCHEME / DETAIL SYLLABUS

Home

ME

30 - CHEMICAL ENGINEERING

2

2024-25

Select Elective / Non-Elective

Subject Code

Enter Subject Name

Search

*L=lectures,T=tutorial,P=Practical,E=TheoryExternal,M=TheoryInternal,I=Practical Internal,V=Practical External,On Job Training(OJT) is equivalent to Practical

							Hours			Credit	Max Marks					
Exp.	Subcode	Branch code	Eff_from	SubjectName	Category	Sem /Year	L.	T.	P.	PBL	Total	E	M	I	V	Total
	ME02000011	030	2024-25	Disaster Management	Mandatory Non-Credit Courses – Audit Course	2	2	0	0	NA	0	50	0	0	0	50
	ME02000141	030	2024-25	Mini Project with Seminar	Core Courses	2	0	0	4	NA	2	0	0	100	0	100
	ME02030011	030	2024-25	Advanced Reaction Engineering	Professional Core Courses	2	3	0	2	NA	4	70	30	20	30	150
	ME02030021	030	2024-25	Advanced Transport Phenomena in Chemical Engineering	Professional Core Courses	2	3	0	2	NA	4	70	30	20	30	150
	ME02030031	030	2024-25	Waste Water Treatment and Design	Professional Elective - III	2	3	0	2	NA	4	70	30	20	30	150
	ME02030041	030	2024-25	Air Pollution Control System and Design	Professional Elective - III	2	3	0	2	NA	4	70	30	20	30	150
	ME02030051	030	2024-25	Hazardous Waste Management	Professional Elective - III	2	3	0	2	NA	4	70	30	20	30	150
	ME02030061	030	2024-25	Process Design Synthesis	Professional Elective - IV	2	3	0	2	NA	4	70	30	20	30	150
	ME02030071	030	2024-25	Computational Fluid Dynamics	Professional Elective - IV	2	3	0	2	NA	4	70	30	20	30	150
	ME02030081	030	2024-25	Advanced Optimization Techniques in Chemical Engineering	Professional Elective - IV	2	3	0	2	NA	4	70	30	20	30	150
	ME02030091	030	2024-25	Advanced Separation Techniques	Professional Elective - V	2	3	0	2	NA	4	70	30	20	30	150
	ME02030101	030	2024-25	Membrane Separation Processes	Professional Elective - V	2	3	0	2	NA	4	70	30	20	30	150
	ME02030111	030	2024-25	Advanced Analytical Techniques	Professional Elective - V	2	3	0	2	NA	4	70	30	20	30	150

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Web Site Visit Count

00353263 1

GUJARAT TECHNOLOGICAL UNIVERSITY

Programme Name: Master of Engineering

Level: PG

Subject Code : ME02000011

Subject Name : Disaster Management

WEF Academic Year :	2024-25
Semester :	2
Category of the Course :	MNC – AU - 02

Prerequisite :	NIL
Rationale :	This subject is conceptual applications of principles of management and application of science & technology to mitigate various types of natural as well as manmade disasters.

Course Outcome :

After Completion of the Course, Student will able to :

No	Course Outcomes
01	Apply critical understanding of key concepts in disaster risk reduction and humanitarian response
02	Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
03	Develop actions of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations
04	Identify the strengths and weaknesses of disaster management approaches and carry out planning and programming in different countries, particularly their home country or the countries they work in

Teaching and Examination Scheme :

Teaching Scheme			Total Credits	Assessment Pattern and Marks				Total Marks
				Theory		Practical		
L	T	PR	C	ESE (E)	PA(M)	ESE (V)	PA (I)	
2	0	0	0	50	0	0	0	50

Course Content :

Sr. No.	Course Content	No. of Hours	% of Weightage
1	**Introduction:** Understanding Disasters Understanding the Concepts and definitions of Disaster, Hazard, Vulnerability, Risk, Capacity – Disaster and Development, and disaster management	2	8
2	**Disasters And Hazards**: Types, Trends, Causes, Consequences and Control of Disasters Geological Disasters (earthquakes, landslides, tsunami, mining); Hydro-Meteorological Disasters (floods, cyclones, lightning, thunder-storms, hail storms, avalanches, droughts, cold and heat waves); Biological Disasters (epidemics, pest attacks, forest fire); Technological Disasters (chemical, industrial, radiological, nuclear) and Manmade Disasters (building collapse, rural and urban fire, road and rail accidents, nuclear, radiological, chemicals and biological disasters); Global Disaster Trends – Emerging Risks of Disasters – Climate Change and Urban Disasters, Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem	4	17
3	**Disaster Prone Areas In India** Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics	2	8
4	**Disaster Management** Disaster Management Cycle and Framework Disaster Management Cycle – Paradigm Shift in Disaster Management Pre-Disaster – Risk Assessment and Analysis, Risk Mapping, zonation and Micro zonation, Prevention and Mitigation of Disasters, Early Warning System; Preparedness, Capacity Development; Awareness During Disaster – Evacuation – Disaster Communication – Search and Rescue – Emergency Operation Centre – Incident Command System – Relief and Rehabilitation – Post-disaster – Damage and Needs Assessment, Restoration of Critical Infrastructure – Early Recovery – Reconstruction and Redevelopment	12	50
5	**Applications of Science and Technology for Disaster Management & Mitigation**	4	17

	Geo-informatics in Disaster Management (RS, GIS, GPS and RS) Disaster Communication System (Early Warning and Its Dissemination) Disaster Safe Designs and Constructions, Structural and Non-Structural Mitigation of Disasters S&T Institutions for Disaster Management in India		
	Total	**24**	**100**

Reference Books:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company
2. Sahni, PardeepEt.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.
3. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.
4. Disaster Management Act 2005, Publisher by Govt. of India
5. National Disaster Management Policy, 2009, GoI

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GUJARAT TECHNOLOGICAL UNIVERSITY

Programme Name: Master of Engineering

Level: PG

Subject Code : ME02000141

Subject Name : Mini Project with Seminar

WEF Academic Year :	2024-25
Semester :	2
Category of the Course :	Core

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Identify engineering problems reviewing available literature.
02	Study different techniques used to analyze complex systems.
03	Solve a live problem using software/analytical/computational tools and present solution by using his/her technique applying engineering principles.
04	Learn to write technical reports and develop skills to present and defend their work in front of technically qualified audience.

Teaching and Examination Scheme:

Teaching Scheme			Total Credits	Assessment Pattern and Marks				Total Marks
				Theory		Practical		
L	T	PR	C	ESE (E)	PA(M)	ESE (V)	PA (I)	
0	0	4	2	0	0	0	100	100

Course Content :

A mini project requires comparatively less time than major projects. They are comparatively simpler and have shorter duration. Mini Project helps students to explore and strengthen the understanding of fundamentals through practical application of theoretical concepts. Mini Project can help them to boost their skills and widen their horizon of thinking. It will act like a beginners guide to undertake the major project/dissertation during the final year and will ensure preparedness of students to undertake major projects/dissertation. Students will be required to select the topic relevant to their specialization and that has value addition. Students will get an opportunity to work in actual industrial environment if they opt

for internship. Based on the selected topic student will also prepare seminar report based on the literature survey

Mini Project will have mid semester presentation and end semester presentation. Mid semester presentation will include identification of the problem based on the literature review on the topic referring to latest literature available. End semester presentation should be done along with the report on identification of topic for the work and the methodology adopted involving scientific research, collection and analysis of data, determining solutions highlighting individuals' contribution. Continuous assessment of Mini Project at Mid Sem and End Sem will be monitored by the departmental committee.

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Chemical Engineering

Subject Code: ME02030011

Subject Name : Advanced Reaction Engineering

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Core Courses

Prerequisite:	Knowledge of Reaction engineering at Undergraduate Level
Rationale:	This subject deals with the heterogeneous reactions and non-ideal flow systems including performance of various types of reactors. The non-isothermal systems are introduced with its application. The catalyst systems are also be covered in this.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Evaluate heterogeneous reactions and reactor performance
02	Apply computational and optimization techniques to reactor design and scale-up.
03	Estimate the performance of multiphase reactors under non-isothermal conditions
04	Understand non-ideal flow and reactor models

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Introduction:** Overview of Reaction Engineering & challenges, Reactor Design Equations for ideal Reactors, Advantage Disadvantage and selection criteria of ideal reactors, Non-ideal Flow reactors.	5	10

2.	**Plug Flow Reactors:** Plug Flow Recycle Reactors design equation, Advantages of plug flow recycle reactor, Effect of Pressure Drop on performance of Plug Flow vessels, Effect of Condensing gas on Reactor design, Design of fixed bed catalytic reactor.	7	16
3.	**CSTR:** Multiple Reactions, finding number of independent reactions and independent set, Polymerization reaction in a CSTR, Energy Balance for stirred vessels, Stability of Steady States in CSTR, Plotting Liapunov Contours, Understanding Multiple steady states in a CSTR.	8	18
4.	**Semi Batch Reactors:** Semi batch reactor operation, Heat Effects in reversible exothermic reactions, Need for Multi-staging, Optimal Design of Reactors for Reversible exothermic reactions.	7	16
5.	**Advanced Reaction Kinetics:** Complex reaction mechanisms (parallel, series, autocatalytic). Non-elementary reactions and enzyme kinetics. Chain reactions and polymerization kinetics. Reaction kinetics for multiphase systems. Adsorption isotherms (Langmuir, BET models). High-Temperature Kinetics (e.g. Combustion, Pyrolysis and Gasification reaction kinetics), Kinetic of photocatalytic reactions.	9	20
6.	**Design of Industrial Reactors:** Bubble column rectors, Loop reactors, Agitated vessel type batch reactor, Gas- liquid reactors involving Gas induction type agitator with spiral baffle jacket, Sulfonation reactor by using SO_3 as a sulfonating agent, Trickel bed reactor.	9	20
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
5	25	15	10	10	5

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:
(a) Books:

- K.G. Denbigh: Chemical Reactor Theory, Cambridge University Press, Second Edition, 1971
- J.M. Smith: Chemical Engineering Kinetics, Mcgraw Hill, Third Edition, 1981
- Keith J. Laidler and John H. Meiser: Reaction Kinetics: Principles and Applications in Organic and Biological Chemistry", Pearson, Third Edition, 1987
- Levenspiel O., Chemical Reaction Engineering, Wiley, 1998
- Foggler,H.S., Elements of Chemical Reaction Engineering, Prentice Hall of India, 2008
- Fromment G.F. and Bischoff K.B., Chemical Reactor Analysis and Design, John Wiley, 2010

(b) Open source software and website:

- DWSIM (Industrial reaction modeling, Thermodynamic property estimation, Process optimization.)
- OpenFOAM (Reactor modeling, multiphase systems, Industrial chemical processes)
- CHEMKIN (Computational tools for reaction mechanism analysis)
- Kinetics Database Resources (NIST Chemical Kinetics Database)
- ASCEND (Dynamic and steady-state reactor modeling)

Suggested Course Practical List:

- To study RTD in PFR, CSTR and CSTR in series.
- To compare conversion in CSTR and PFR.
- To compare catalytic and non-catalytic reaction conversion.
- To study the performance of quench bed reactor.
- To determine kinetic data and rate equation for esterification reaction.
- To determine kinetic data and rate of reaction for fermentation reaction.
- To verify performance of the Plug flow reactor.
- Design of quench bed reactor for synthesis of ammonia.
- Design of reactor of DCDA (Double Contact Double Absorption) process of sulfuric acid.
- Design of Ammonia oxidation reactor of Nitric Acid plant.

List of Laboratory/Learning Resources Required:

- Fluidized Bed Reactor
- Fixed Bed Reactor
- Microwave Reactor
- Autoclave Reactor
- Gas Chromatography Mass Spectrometry (GC/MS)
- High-Performance Liquid Chromatography (HPLC)
- Fourier Transform Infrared Spectroscopy (FTIR)
- UV-Vis Spectrophotometer for reaction kinetics in photochemical studies
- Flow calorimeters for studying reaction heat
- Thermogravimetric Analyzer and Derivative Thermogravimetric Analyzer (TGA/DTG)

Suggested Activities for Students:

- Design a scale-up strategy for a lab-scale reaction to an industrial pilot plant.
- Work on real-world reaction engineering projects.
- Synthesize and characterize a catalyst

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Chemical Engineering

Subject Code:

Subject Name: Advanced Transport Phenomena in Chemical Engineering

W.E.F. Academic Year:	A.Y. 2024-25
Semester:	2
Category of the Course:	PCC-04

Prerequisite:	Students should have a foundational understanding of the basics of Fluid Mechanics, Heat Transfer and Mass Transfer Operations
Rationale:	This course enables students to understand Momentum, Heat and Mass Transfer in chemical engineering. It is essential to understand mathematical modelling and analogical aspects of chemical process systems where these transport processes occur simultaneously. This course focuses on such typical situations and thereby its complete understanding on axial as well as radial profiles

Course Outcome:

Upon successful completion of this course, students will be able to:

No	Course Outcomes
01	Understand the mechanism of momentum, heat and mass transport for steady and unsteady flow.
02	Perform momentum, energy and mass balances for a given system at macroscopic and microscopic scales.
03	Solve the governing equations to obtain velocity, temperature and concentration profiles.
04	Model the momentum, heat and mass transport under turbulent conditions.
05	Develop analogies among momentum, energy and mass transport.

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+(PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial/ Practical		
L	T	PR	C	ESE (E)	PA/ CA (M)	PA/CA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	%of Weightage
1.	**Analogies in Momentum, Heat and Mass Transfer:** Introduction, Reynolds analogy, Prandtl Taylor analogy, Van Karman analogy	**3**	**7**
2.	**Principles of Momentum Transport:** Molecular and convective momentum transport, Molecular theory of viscosity in gases and liquids. **Shell Momentum Balances and Velocity Distributions in Laminar Flow**: Shell momentum balances and boundary conditions, Flow of a falling film, Flow through a circular tube, Flow through an annulus, Flow of two adjacent immiscible fluids, Creeping flow around a sphere, **The Equations of Change for Isothermal Systems and its application to solve flow problems** **Velocity Distributions with More Than One Independent Variable:**Time-dependent flow of Newtonian fluids**:** Unsteady Laminar Flow between two parallel plates. Flow near a Wall suddenly set in motion, Unsteady Laminar Flow near an Oscillating Plate. Solving flow problems using a stream function **Turbulent flow:** Reynolds stress, Time-Smoothed Equations of Change for Incompressible Fluids and Velocity distributions, Boundary layer flow.	**14**	31
3.	**Principles of Energy Transport:** Molecular and convective energy transport, Theory of thermal conductivity in solids, gases and liquids, Shell energy balances, Heat conduction with various heat sources, Equation of changes in non-isothermal systems and its applications to solve steady-state forced and free convection and viscous heat generation problem, Unsteady state heat conduction, transient conduction, temperature distributions in laminar tube flow and laminar forced convection near the heated flat plate. Temperature distributions in turbulent flow: time smoothened equation of changes and time smoothened temperature profile near wall. Temperature distribution in boundary layer.	**14**	31
4.	**Principles of Mass Transport:** Molecular and convective mass transport, Theory of binary and multicomponent diffusion in gases and liquids, Shell mass balances and concentration distribution in laminar flow, Diffusion in a homogeneous and heterogeneous chemical reaction, diffusion in falling liquid film, diffusion and chemical reaction inside porous catalyst,	**14**	31

	diffusion in three component gas system, equation of changes for multicomponent systems, Use of the Equations of Changes to solve Simultaneous heat and mass transport and concentration profile in a tubular reactor principles of unsteady state diffusion.		
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
07	17	18	14	14	00

References/Suggested Learning Resources:

(a) Books:

1. Bird R.B., Stewart W.E., Lightfoot E.N., Transport Phenomena, 2nd Edition, John Wiley & Sons, 2002
2. James Welty, Charles E. Wicks and Wilson, Gregory L Rorrer, "Fundamentals of Momentum, Heat and Mass transfer", 5th Edition, 2008.
3. Frank P.U., David P.D., Theodore L. B. "Fundamentals of heat and mass transfer",6th edition, John Wiley & Sons, 2005.
4. Geankoplis C.J., Transport Processes and Separation Process Principles,4th Edition
5. Slattery J.C., Advanced Transport Phenomena, Cambridge University Press.

(b) Open-source software and website:

To enhance learning, students can use the following open-source software tools and websites for modelling and simulation in transport phenomena.

Open-Source Software

- Scilab: Numerical computation for the transport process.
- OpenFOAM:For computational fluid dynamics involving heat, momentum and mass transport.
- FIAT: Finite Element Analysis Tool for solving partial differential equations in diffusion, heat conduction, and fluid dynamics problems.

- SU2 :Stanford University Unstructured for turbulence and structural mechanics.
- MFiX:Multiphase Flow with Interphase eXchanges for multi-phase transport problems.
- Elmer FEM: For heat and mass transfer.

Websites and Resources

- NPTEL https://archive.nptel.ac.in/courses/103/106/103106068/
- NPTEL https://nptel.ac.in/courses/103108123
- MIT https://ocw.mit.edu/courses/10-302-transport-processes-fall-2004/pages/syllabus/
- MIT https://mitxonline.mit.edu/programs/program-v1:MITxT+10.50x/

Suggested Course Practical List:

1. Determination of kinematic viscosity of mixture using different viscometers.
2. Determination of Efflux time for various fluids.
3. Efflux time for a given fluid in different systems.
4. Experiments with flow through concentric pipe and modelling for shear stress and velocity distribution.
5. Experiments with flow through slit and modelling for shear stress and velocity distribution.
6. Experiments with flow through inclined plane and modelling for shear stress and velocity distribution.
7. Determination of thermal conductivity of metal rods and modelling heat flux and temperature distribution.
8. Experiment and modelling on Free and forced convection heat transfer.
9. Determination of diffusion from the stagnant fluid at room and at elevated temperature,
10. Determination of mass transfer coefficient with and without chemical reaction.
11. Experiment on the performance of the cooling tower.
12. Experiments on unsteady state heat conduction.

Equipments: Redwood Visco meter, capillary U tube viscometer, Efflux time system such as cylindrical and conical system with and without extended pipe, Slit and concentric pipe, inclined plane system. Thermal conductivity apparatus, Free convection apparatus, forced convection apparatus, diffusion cell, autoclave, cooling tower setup etc.

List of Laboratory/ Learning Resources Required:

Laboratory Facilities

1. Chemical Storage Cabinets
2. Personal Protective Equipment (PPE)

Suggested Project List:

- Computational Fluid Dynamics (CFD) of Pipe Flow.
- Drag Reduction in Flow over a Flat Plate
- Flow through Porous Media
- Diffusion in a Solid Matrix
- Diffusion in a mesoporous catalytic system.
- Unsteady state flow for parallel pates
- Heat and mass transfer in turbulence.
- Unsteady laminar flow between parallel plates.
- Unsteady laminar flow near an oscillating plates.
- Unsteady state heat conduction in solid.
- Concentration profile in a tubular reactor.
- Catalytic oxidation of carbon monoxide.
- Unsteady state evaporation of liquid.

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Chemical Engineering

Subject Code: ME02030031

Subject Name: Wastewater Treatment and Design

w.e.f. Academic Year:	A.Y. 2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite:	A foundational knowledge of environmental engineering, chemical process engineering, and microbiology is essential to understand the principles of wastewater treatment and the associated processes.
Rationale:	This course equips students with the skills to design, evaluate, and optimize wastewater treatment systems, ensuring compliance with environmental standards. By integrating theory with practical applications, it prepares students to address real-world challenges in water management, contributing to sustainable practices and environmental protection.

Course Outcome:

After Completion of the Course, Student will be able to:

No	Course Outcomes
01	Explain the Characteristics and Regulatory Frameworks for Wastewater Management
02	Analyze and Apply Principles of Wastewater Treatment Processes
03	Design Key Wastewater Treatment Units
04	Evaluate Advanced and Specialized Wastewater Treatment Solutions

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+(PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial/ Practical		
L	T	PR	C	ESE (E)	PA/ CA (M)	PA/CA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	%of Weightage
1.	**Introduction to Wastewater Treatment:** Sources and Types of Wastewater: Domestic, industrial, and combined wastewater, Characteristics of Wastewater: Physical, chemical, and biological	**4**	**9**

	parameters, Regulatory Frameworks: National and international wastewater discharge standards.		
2	**Principles of Wastewater Treatment:** Overview of Treatment Processes: Preliminary, primary, secondary, and tertiary treatment, Biological Treatment: Aerobic and anaerobic processes, microbial degradation pathways, Chemical Treatment: Coagulation, flocculation, and oxidation processes etc, Selection of Treatment System, Function of treatment Plant Units	**6**	**14**
3	**Design of Preliminary and Primary Treatment Units:** Essential Prerequisites, Design of Sump and Pump Wells of pumping station, Design of Approach channel, Design of Screen chamber, Design of Grit chambers, Aerated grit chambers, Oil and Grease Trap Design of Primary settling tank, Design of Flotation systems	**10**	**22**
4	**Design of Secondary Treatment Systems:** Activated Sludge Process: Design of aeration tanks and secondary clarifiers, Trickling Filters and Rotating Biological Contactors: Working principles and design, Sequencing Batch Reactors (SBRs) and Membrane Bioreactors (MBRs): Applications and design aspects, Anaerobic Treatment Systems: Upflow anaerobic sludge blanket (UASB) reactors, digesters.	**10**	**22**
5	**Advanced Wastewater Treatment and Tertiary Processes**: Nutrient Removal: Phosphorus and nitrogen removal processes, Membrane Filtration: Ultrafiltration, nanofiltration, and reverse osmosis, Disinfection Methods: Chlorination, UV treatment, and ozonation, Multi Effect Evaporator (MEP), Sludge Management: Dewatering, stabilization, and disposal methods.	**8**	**18**
6	**Wastewater Treatment for Industrial Applications:** Specialized Treatment Systems: Treatment of effluents from industries like textiles, pharmaceuticals, and chemicals, Emerging Contaminants: Removal of microplastics, heavy metals, and endocrine disruptors.	**3**	**6**
7	**Design and Case Studies:** Factors affecting plant layout and operation, Economic Analysis: Cost estimation and comparison of treatment options, Case Studies: Success stories in wastewater treatment plant implementation.	**4**	**9**
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	15	15	15	10	5

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy

References/Suggested Learning Resources:

(a) Books:

1. Water and Wastewater Engineering by M. L. Davis. 2017. 7th Ed. McGraw-Hill, ISBN: 978-1259064838
2. Waste water Treatment Concept and Design Approach by G L Karia, R A Christian, 2 nd edition, PHI Learning Pvt. Ltd.
3. Wastewater Engineering: Treatment and Resource Recovery by Metcalf & Eddy, 2013., 5th Ed, McGraw-Hill. ISBN13: 978-0073401188
4. Principles of Water and Waste Water Treatment Processes by Stuetz R and T Stephenson. 2009.. IWA Publishing, Alliance House, UK. 214p.
5. Wastewater Treatment for Pollution Control and Reuse by Arceivala S.J. and Asolekar S.R., 3rd Ed., Tata McGraw Hill, 2007.
6. Biological Wastewater Treatment: Principles, Modelling and Design by Henze M., van-Loosdrecht M.C.M., Ekama G.A. and Brdjanovic D., , IWA publishing, 2008.
7. Advanced Biological Processes for Wastewater Treatment: Emerging, Consolidated Technologies and Introduction to Molecular Techniques by Márcia Dezotti, Geraldo Lippel, João Paulo Bassin, , Springer Nature, 2018.
8. Biological wastewater treatment processes: mass and heat balances by Davide Dionisi.. CRC Press, 2017.
9. Basic Principles of Wastewater Treatment by Marcos von Sperling,. IWA Publishing, 2007.
10. Biological Wastewater Treatment by C. P. Leslie Grady, Glen T. Daigger, Nancy G. Love, Carlos D. M. Filipe.. Co-published by IWA Publishing & CRC Press, 2011.

(b) Open source software and website:

1. Students can refer to video lectures available on the websites including NPTEL lecture series.
2. Students can refer to the CDs available with some reference books for the solution of problems using software's /spreadsheets. Students can develop their own programs/spreadsheets for the solution of

problems.

Suggested Course Practical List:

1. Determination of physical (e.g., turbidity, color), chemical (e.g., BOD, COD), and biological (e.g., MPN) parameters of wastewater.
2. Jar test experiments to determine the optimal coagulant dose and pH for wastewater treatment.
3. Study the sedimentation process in a model tank and calculate settling velocities for different particle sizes.
4. Practical demonstration of grit removal and estimation of efficiency in a laboratory-scale grit chamber.
5. Experiment on oil and grease trap systems to determine efficiency and factors affecting separation.
6. Simulation of the activated sludge process in a lab setup to measure microbial activity and efficiency in organic matter removal.
7. Study the production of biogas in a laboratory anaerobic digester and analyze its composition.
8. Demonstration of ultrafiltration or reverse osmosis for wastewater treatment, including efficiency evaluation.
9. Practical study of phosphorus and nitrogen removal using chemical or biological methods.
10. Study of sludge dewatering and stabilization processes (e.g., centrifuge or drying beds) and measurement of moisture content reduction.

Major Equipments Turbidity Meter, pH Meter, Spectrophotometer, BOD Incubator, Jar Test Apparatus, Sedimentation Tank Setup, Oil and Grease Trap Setup, Activated Sludge Process (ASP) Unit, Anaerobic Digester, Membrane Filtration Unit, Nutrient Removal System, Sludge Dewatering Equipment

Laboratory Facilities

1. Waste water Sample Collection kit
2. Chemical Storage Cabinets
3. Fume Hoods and Waste Disposal Unit
4. Personal Protective Equipment (PPE)

Suggested Project List:

- Optimizing Activated Sludge Process
- Anaerobic Digestion plant design for Biogas Production
- Development of Adsorbent Materials for Waste Treatment
- Development of Low-cost Membrane Filtration Systems

- Electrocoagulation for Industrial Wastewater Treatment
- Magnetic Nanoparticles for Pollutant Removal
- Wastewater Reuse for Agriculture
- Nutrient Recovery from Wastewater
- Recovery of Energy from Wastewater
- Zero-Liquid Discharge (ZLD) Systems
- Production of Bio-plastics from Sludge
- Development of Eco-friendly Coagulants

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Chemical Engineering

Subject Code: ME02030041

Course/ Subject Name: Air Pollution Control System and Design

w.e.f. Academic Year:	A.Y. 2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite:	Basic knowledge of environmental engineering, thermodynamics, fluid mechanics, and heat transfer principles. Familiarity with chemical reaction engineering and pollution control concepts is recommended.
Rationale:	Air pollution control is crucial for mitigating environmental and health impacts. This course equips students with the knowledge and skills required to design, evaluate, and optimize systems for controlling particulate and gaseous pollutants. It prepares postgraduate students to address current and emerging air quality challenges in industrial and urban settings. Understanding control technologies, regulatory frameworks, and monitoring techniques will enable students to develop efficient and sustainable solutions in the field of environmental engineering.

Course Outcome:

After Completion of the Course, Student will be able to:

No	Course Outcomes
01	Analyze air pollution sources, effects, and regulatory standards.
02	Design and evaluate control technologies for particulate and gaseous pollutants.
03	Conduct sampling and analysis of air pollutants.
04	Assess and optimize air pollution control systems for multi-pollutant removal

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+(PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial/ Practical		
L	T	PR	C	ESE (E)	PA/ CA (M)	PA/CA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	%of Weightage
1	**Introduction to Air Pollution and its Effects:** Air pollution in India and the world, sources and classification of air pollutants, Air Quality Standards and Regulations, Health and Environmental Effects of Air Pollution,	04	9
2	**Meteorological Aspects of Air Pollution:** Temperature lapse rates and stability, meteorological factors influencing air pollution, plume behavior, dispersion of air pollutants and estimation of plume rise.	04	9
3	**Control Technologies for Particulate Matter:** Mechanical Collectors: Cyclones, settling chambers, and scrubbers, Electrostatic Precipitators (ESP): Design, operation, and Efficiency, Bag Filters: Types of filters, performance, and applications, Wet Scrubbers for Particulate Removal: Design considerations and selection criteria.	08	18
4	**Control Technologies for Gaseous Pollutants** Absorption Systems: Scrubbers, packed columns, and design considerations, Adsorption Systems: Activated carbon, design parameters, and efficiency, Catalytic and Thermal Oxidation: Principles of incineration, catalytic oxidation, and thermal oxidizers, Biofiltration and Bioreactors: Biological treatment of air pollutants.	08	18
5	**Sampling and Measurement of Air Pollution:** Types of pollutant sampling and measurement, ambient air sampling, stack sampling, analysis of air pollutants.	06	13
6	**Air Pollution Control Principles and System Design:** Basic Principles: Source control vs. end-of-pipe control, Flow Properties: Dispersion, deposition, and diffusion of gaseous pollutants. Pollutant Collection: Particle collection principles (size distribution, velocity, etc.)., Thermodynamics: Adsorption, absorption, condensation processes, Design Parameters: Flow rate, temperature, pressure, and pollutant concentration, Control System Design: Wet Scrubbers: Absorber size and liquid-to-gas ratio .Electrostatic Precipitators and Bag Filters: Sizing and performance. Adsorption and Absorption Units: Material selection, bed size, pressure drop, and mass transfer.	10	22

7	**Case Studies and Applications:** Industrial Applications: Air pollution control in chemical plants, refineries, and power plants etc., Emerging Technologies: Nanotechnology, membrane filtration, and catalytic materials, Recent Advances: Innovative air pollution control approaches and energy recovery, Maintenance and Troubleshooting: Common issues and solutions in air pollution control systems	05	11
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
11	18	21	14	3	3

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Air Pollution Control Engineering by Noel de Nevers, McGraw-Hill Education.
2. Introduction to Air Pollution by P. Aarne Vesilind and William A. W. Stokes, Prentice Hall.
3. Air Pollution Control: A Design Approach by C. David Cooper and F. C. Alley, Waveland Press.
4. Air Pollution Control: A Practical Guide by Sanjay K. Gupta, Butterworth-Heinemann.
5. Fundamentals of Air Pollution by Richard W. Boubel, Donald L. Fox, D. Bruce Turner, and Arthur C. Stern, Academic Press.
6. Air Pollution Control Equipment Calculations by Theodore L., John Wiley & Sons Inc., New Jersey.
7. Air Pollution Meteorology and Dispersion by S. P. Arya, Oxford University Press.
8. Air Pollution by H.C. Perkins, McGraw-Hill Kogakusha, Tokyo.
9. Fundamentals of Air Pollution" by Richard C. Flagan and John H. Seinfeld.
10. Air Pollutionby M.N. Rao, H.V.N. Rao, Tata McGraw Hill.

Open source software

OpenFOAM: OpenFOAM is an open-source software used for computational fluid dynamics (CFD) simulations, ideal for modeling air pollution dispersion and airflow patterns. It helps simulate pollutant behavior and plume dispersion under various atmospheric conditions.

SimScale: SimScale is a cloud-based simulation software offering tools for simulating environmental processes such as air pollution dispersion, thermal flow, and air quality monitoring

Website:

- United States Environmental Protection Agency (EPA)
- World Health Organization (WHO)
- Air Pollution Control Association (APCA)

Suggested Course Practical List: NA

1. To measure ambient air pollutants such as particulate matter (PM), sulfur dioxide (SO_2), nitrogen oxides (NO_x), and carbon monoxide (CO) using air quality monitoring instruments
2. To calculate and visualize the dispersion of air pollutants and estimate plume rise using meteorological data.
3. To evaluate the performance of an Electrostatic Precipitator (ESP) for particulate removal by measuring the efficiency of particle collection.
4. To design and test a cyclone separator for the removal of coarse particulates from an airstream.
5. To evaluate the collection efficiency of different types of bag filters for particulate removal from air streams.
6. To study the absorption of gaseous pollutants (e.g., CO_2 or SO_2) in a packed column scrubber.
7. To investigate the adsorption capacity of activated carbon for removing volatile organic compounds (VOCs) from air.
8. To design and optimize a wet scrubber for the removal of particulate and gaseous pollutants from air streams, considering parameters like liquid-to-gas ratio and absorber size.
9. To measure the concentration of pollutants such as CO_2, NO_x, and SO_2 in stack gases from industrial sources.
10. To conduct a case study on an industrial plant (e.g., chemical plant or power plant) for air pollution control systems, including identifying control technologies and assessing their performance.

List of Laboratory/ Learning Resources Required:

Air Quality Monitoring Instruments: Particulate Matter (PM_{10}, $PM_{2.5}$) analyzers, Sulfur Dioxide (SO_2) analyzers, Nitrogen Oxides (NO_x) analyzers, Carbon Monoxide (CO) analyzers, Ozone (O_3) analyzers, Gas

sampling pumps and collection bags, Electrostatic Precipitator (ESP) Setup, Cyclone Separator System, Bag Filter System, Packed Column Scrubber Setup, Packed Column Scrubber Setup, Wet Scrubber Setup, Stack Sampling and Measurement Equipment: Stack sampling probes, Gas analyzers (CO_2, NO_x, SO_2), Data logging devices, Condensing apparatus for moisture removal

Suggested Project List:

- Design and Performance Evaluation of a Cyclone Separator
- Development of a Wet Scrubber for Industrial Emissions
- Study of Adsorption Efficiency Using Activated Carbon for VOCs
- Modeling and Simulation of Air Pollution Dispersion Using AERMOD
- Design and Optimization of an Electrostatic Precipitator (ESP)
- Air Quality Monitoring in Industrial Zones: A Case Study
- Performance Evaluation of a Bag Filter System for Dust Removal
- Analysis of Catalytic Oxidation for Gaseous Pollutant Removal
- Design of a Packed Column Scrubber for Acid Gas Removal
- Investigation of Emerging Air Pollution Control Technologies

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Chemical Engineering

Subject Code: ME02030051

Subject Name: Hazardous Waste Management

W.E.F. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite:	Students should have a foundational understanding of environmental science, chemical process industries, material and energy balances, reaction engineering, and industrial safety to comprehend waste generation, treatment, and regulatory aspects effectively.
Rationale:	This course enables students to address hazardous waste challenges by equipping them with technical expertise, regulatory knowledge, and sustainability principles, preparing them to design efficient management systems and mitigate environmental risks.

Course Outcome:

Upon successful completion of this course, students will be able to:

No	Course Outcomes
01	Analyze hazardous wastes and suggest appropriate management strategies
02	Apply regulatory requirements to ensure compliance
03	Recommend sustainable solutions for waste minimization and recovery
04	Design and evaluate treatment, storage, and disposal systems

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+(PR /2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial/ Practical		
L	T	PR	C	ESE (E)	PA/ CA (M)	PA/CA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	%of Weightage
1.	**Introduction to Hazardous Waste Management:** Definitions and Types of Hazardous Wastes, Sources and Characteristics of Hazardous Wastes, Global and National Perspectives: Magnitude and Challenges, Environmental and Human Health Impacts of Hazardous Wastes	**5**	11
2.	**Regulatory Frameworks and Policies:** Overview of National and International Regulations, Basel Convention, Hazardous Waste (Management and Transboundary Movement) Rules, 2016 (India), Compliance and Enforcement: Role of Authorities, Case Studies on Non-Compliance and Regulatory Failures	**6**	14
3.	**Waste Characterization and Risk Assessment:** Sampling and Analysis of Hazardous Wastes, Risk Assessment Framework: Hazard Identification, Exposure Assessment, and Risk Characterization, Use of Modeling Tools for Risk Assessment	**6**	14
4.	**Hazardous Waste Treatment Technologies:** Physico-Chemical Treatment: Neutralization, Precipitation, Adsorption, Ion Exchange; Thermal Treatment: Incineration, Pyrolysis, Plasma Arc; Biological Treatment: Bioremediation, Phytoremediation, and Enzyme-based Treatment, Stabilization and Solidification Techniques	**12**	27
5.	**Storage, Transport, and Disposal:** Design of Secure Landfills and Underground Storage, Transport Regulations and Packaging of Hazardous Wastes, Long-Term Monitoring and Maintenance of Disposal Sites, Emergency Response and Spill Management	**8**	18
6	**Waste Minimization and Resource Recovery:** Process Optimization for Waste Reduction, Recycling and Reuse of Hazardous Wastes, Recovery of Valuable Resources from Wastes	**4**	8
7	**Emerging Trends and Case Studies:** Advances in Hazardous Waste Management Technologies, Integrated Waste Management Strategies, Case Studies of Successful and Failed	**4**	8

	Waste Management Projects		
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
11	19	17	13	8	2

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Hazardous Waste Management by Michael D. LaGrega, Phillip L. Buckingham, Jeffrey C. Evans, Waveland Press Inc
2. Handbook of Hazardous Waste Management for Small Quantity Generators by Russell W. Phifer, William R Mctigui, Jr., Lewis Publisher
3. Integrated Solid Waste Management-Engineering Principles and Management Issues by George Tchobanoglous, Hilary Theisen and Samual A. Vigil, McGraw Hill Publishers
4. Hazardous Wastes - Sources, Pathways, Receptors by Richard J. Watts, John Wiley and Sons
5. Standard Handbook of Hazardous Waste Treatment and Disposal by Freeman H. M., McGraw-Hill

(b) Open-source software and website:

To enhance learning, students can use the following open-source software tools and websites for simulations, data analysis, and regulatory information related to hazardous waste management:

Open-Source Software

- EPA Waste Reduction Model (WARM): Calculates GHG emissions, energy savings, and costs of waste management strategies.
- QGIS: GIS tool for spatial analysis, mapping, and waste tracking.
- Scilab: Numerical computation for process optimization and treatment modeling.
- OpenLCA: Life cycle assessment tool for environmental impact analysis.

Websites and Resources

- UNEP: Reports and resources on global hazardous waste practices.
- Basel Convention: Information on international hazardous waste movement.
- MoEF&CC (India): Hazardous waste rules, guidelines, and updates.
- WHO: Insights into health and environmental impacts of hazardous waste.
- HazWasteOnline: Platform for hazardous waste classification and regulations.
- NEERI: Research papers and project reports on hazardous waste management.

Suggested Course Practical List:

1. Analyze physical and chemical properties (pH, moisture, volatile solids) of hazardous waste samples.
2. Determine the concentration of heavy metals (e.g., lead, cadmium, chromium) using atomic absorption spectroscopy (AAS).
3. Assess the leachability of hazardous constituents from waste samples.
4. Evaluate adsorption of contaminants (e.g., dyes, metals) using activated carbon or other adsorbents.
5. Study thermal degradation of hazardous waste and analyze ash residue properties.
6. Perform Solidification/Stabilization of Hazardous Waste using cement or other binding materials and test the structural integrity.
7. Study microbial degradation of hazardous organic compounds in waste samples.
8. Simulate landfill conditions and analyze generated leachate for contaminants.
9. Use software tools to model risk scenarios for hazardous waste exposure.
10. Demonstrate the recovery of valuable metals using chemical or electrochemical techniques.
11. Simulate hazardous waste spill and test containment and clean-up strategies.

Major Equipments Atomic Absorption Spectrometer (AAS), Gas Chromatography-Mass Spectrometry (GC-MS), TCLP Extraction Apparatus, High-Temperature Furnace/Incinerator, Spectrophotometer (UV-Vis), Adsorption Column Setup Solidification/Stabilization Molds and Tools, Bioreactor Setup, Leachate Collection and Analysis Setup, Electrochemical Cell Setup etc.

List of Laboratory/ Learning Resources Required:

Laboratory Facilities

1. Hazardous Waste Sample Collection Area
2. Chemical Storage Cabinets
3. Fume Hoods and Waste Disposal Unit
4. Personal Protective Equipment (PPE)

Suggested Project List:

- Design of a Hazardous Waste Treatment Facility
- Risk Assessment for a Hazardous Waste Landfill
- Development of Adsorbent Materials for Waste Treatment
- Case Study Analysis: Successful and Failed Hazardous Waste Management Projects
- Assessment of Leachate Contamination from Landfills
- Bioremediation of Hazardous Wastes
- Life Cycle Assessment of Hazardous Waste Disposal Methods
- Development of a Waste Minimization and Resource Recovery Plan
- Modeling Air Emissions from Hazardous Waste Incineration
- Integration of IoT for Hazardous Waste Tracking
- Advances in Stabilization and Solidification of Hazardous Wastes

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering
Level: PG
Branch: Chemical Engineering
Subject Code: ME02030061
Subject Name: Process Design Synthesis

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite:	Basics of heat transfer, mass transfer and reaction engineering
Rationale:	For sustainable industrial activity, processes should use raw materials as efficiently as is economic and practicable, both to prevent the production of waste that can be environmentally harmful and to preserve the reserves of raw materials as much as possible. Processes should use as little energy as economic and practicable. Water must also be consumed in sustainable quantities. Chemical Process Synthesis requires the selection of a series of processing steps and their integration. Extensive applications of computer softwares, simulators and optimization tools in the process industries have made it mandatory to understand computer aided design tools.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Analyze alternative processes and equipment
02	Synthesize a chemical process flow sheet that would approximate the real process
03	Design best process flow sheet for a given product
04	Perform economic analysis related to process design and evaluate project profitability

Teaching and Examination Scheme:

Teaching Scheme(in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Introduction:** Introduction to fundamental concepts and principles of process synthesis and design and use of flow sheet simulators to assist process design. Process Flow sheet models: An Introduction to Design, Chemical process synthesis, analysis and optimization. Introduction to commercial process design software such as HYSYS, Aspen plus etc., Chemical Process (reactor, heat exchanger, distillation etc) analysis using commercial software	**4**	**9**
2.	**Product design and developments:** Process engineering economics and project evaluation Life Cycle Assessments of process: From design to product development, Engineering Economic Analysis of Chemical Processes, Project costing and performance analysis, Environmental concerns, Green engineering, Engineering ethics, Health and safety	**6**	**13**
3.	**Reactor Networks:** Geometry of mixing and basic reactor types, The Attainable Region (AR) approach, AR in higher dimensions & for other processes, Reactive Separation processes, Fundamental behavior and problems, Separation through reactions. Reactive Residue Curve Maps	**6**	**13**
4.	**Synthesis of Separation Trains:** Criteria for selection of separation methods, select ion of equipment: Absorption, Liquid-liquid extraction Membrane separation, adsorption, leaching, drying, crystallization, Ideal distillation – Column and sequence fundamentals, Sharp splits & sequencing Phase diagrams for 2, 3 and 4 components, Feasibility and vapor flow rates for single columns, Residue curve basics, Non-ideal Distillation – Azeotropic systems; detecting binary azeotropes, Residue curve maps for azeotropic systems, Topological analysis, Feasibility for single azeotropic columns, Binary VLLE and pressure swing separation, Non-ideal distillation synthesis. Equipment sequencing: VLE + VLLE, Detailed Residue Curve Maps, Residue curve maps: Interior structure	**12**	**27**
5.	**Heat Exchanger Network Synthesis:** Minimum heating and cooling requirements, Minimum Energy Heat Exchanger Network, Loops and Paths, Reducing Number of Exchangers, HENS basics & graphics, The pinch point approach, Stream Splitting, Performance targets, trade-off & utilities, Heat & power integration, HENS as mathematical programming	**11**	**25**
6.	**Mass Integration:** Introduction, Minimum Mass Separating Agent	**6**	**13**

	(MSA), Mass Exchanger Networks Minimum External MSA, Minimum Number of Mass Exchangers		
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
7	12	35	10	6	0

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Conceptual Design of Chemical Processes by Douglas, J., New York, NY: McGraw-Hill Science/ Engineering / Math, 1988. ISBN: 0070177627.
2. Product and Process Design Principles: Synthesis, Analysis, and Evaluation by Seider, W. D., J. D. Seader, and D. R. Lewin, 2nd ed. New York, NY: Wiley, 2004. ISBN: 0471216631.
3. Systematic Methods of Chemical Process Design by Biegler L.T., Grossmann I.E. and Westerberg A.W., Prentice Hall, 1997

(b) Open source software and website:

1. Students can refer to video lectures available on the websites including NPTEL lecture series.
2. Students can refer to the CDs available with some reference books for the solution of problems using softwares/spreadsheets.

Suggested Course Practical List:

1. Determine minimum utility requirements for the given process stream information.
2. Calculate pinch point and utility requirements for given process data.
3. Solution of linear programming model for determination of pinch point using tools like GAMS / MATLAB / SCILAB / Excel.
4. Solution of MILP model for determination of pinch point using tools like GAMS / MATLAB / SCILAB / Excel.

5. Analyze optimum approach temperature and parameters influencing it for the heat exchanger network synthesis using given stream information.
6. Estimate the area and cost of heat exchangers required for the given process plant data.
7. Optimize utilities, number of heat exchangers and average area of heat exchangers in a heat exchange network design assignment using sequential optimization.
8. Optimize utilities, number of heat exchangers and average area of heat exchangers in a heat exchange network design assignment using simultaneous optimization.
9. Plotting of Attainable Region for reactor networks.
10. Pinch point and utility requirement calculation for mass exchanger network synthesis.
11. Determine the best sequence of distillation column for multi-component system.
12. Course project by each student with analysis of HENS for industrial case study.

Major Softwares: MS Excel, HINT, GAMS, MATLAB, SCILAB

List of Laboratory/Learning Resources Required:

- Computer Lab

Suggested Project List:

- Design a sustainable cracking process with a heat recovery system.
- Synthesis gas production for renewable energy applications.
- Hybrid systems combining thermal and reverse osmosis processes.

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering
Level: PG
Branch: Chemical Engineering
Subject Code: ME02030071
Subject Name: Computational Fluid Dynamics

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite:	Numerical Methods
Rationale:	To be able to model and simulate all the mass, momentum, and energy transport processes in chemical engineering using the generalized conservation equations. Students will understand the governing equations of fluid dynamics and their derivation from laws of conservation. To develop a good understanding in computational skills, including discretisation, accuracy and stability. To acquaint the students with a process of developing a mathematical and geometrical model of flow, applying appropriate boundary conditions and solving system of equations.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Develop governing equations for a given fluid flow system
02	Apply finite difference method for fluid flow and heat transfer problems
03	Solve computational fluid flow problems using finite volume techniques
04	Get familiarized to modern CFD software used for the analysis of complex fluidflow systems

Teaching and Examination Scheme:

Teaching Scheme(in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Introduction to Fluid Dynamics:** Concepts of Fluid Flow, Pressure distribution in fluids, Reynolds transport theorem, Integral form of conservation equations, Differential form of conservation equations, Different Types of Flows, Euler and Navier Stokes equations, Properties of supersonic and subsonic flows, Flow characteristics over various bodies. Philosophy of CFD, Governing equations of fluid dynamics and their physical meaning, Mathematical behavior of governing equations and the impact on CFD simulations, Simple CFD techniques and CFL condition. Numerical Methods in CFD: Finite Difference, Finite Volume, and Finite Element, Upwind and downwind schemes, Simple and Simpler schemes, Higher order methods, Implicit and explicit methods, Study and transient solutions	**10**	**22**
2.	**Grid Generation:** Basic theory of structured grid generation, Surface grid generation, Mono block, multi block, hierarchical multi block, Moving and sliding multi-block, Grid clustering and grid enhancement. Basic theory of unstructured grid generation, advancing front, Delaunay triangulation and various point insertion methods, Unstructured quad and hex generation, grid based methods, various elements in unstructured grids, Surface mesh generation, Surface mesh repair, Volume grid generation, Volume mesh improvement, mesh smoothing algorithms, grid clustering and quality checks for volume mesh. Adaptive, Moving and Hybrid Grids, Need for adaptive and, moving grids, Tet, pyramid, prism, and hex grids, using various elements in combination	**10**	**22**
3.	**Turbulence and its Modeling:** Transition from laminar to turbulent flow, Effect of turbulence on time averaged Navier-Stokes equations, Characteristics of simple turbulent flows, Free turbulent flows, Flat plate boundary layer and pipe flow, Turbulence models, Mixing length model, the k-e model, Reynolds stress equation models, Algebraic stress equation models	**10**	**22**
4.	**Chemical Fluid Mixing Simulation:** Stirred tank modeling using the actual impeller geometry, Rotating frame model, The MRF Model Sliding mesh model, Snapshot model, Evaluating Mixing from Flow Field Results, Industrial Examples	**8**	**18**
5.	**Post-Processing of CFD results:** Contour plots, vector plots, and scatter plots, Shaded and transparent surfaces, Particle trajectories and path line trajectories, Animations and movies, Exploration and	**7**	**16**

	analysis of data.		
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
7	12	35	10	6	0

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as perRevised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Computational Fluid Dynamics: The Basics with Applications by Anderson John D., McGraw Hill, 1995
2. Computational Flow Modeling for Chemical Reactor Engineering by Ranade V.V., Process Engineering Science, Volume 5, 2001
3. Fundamentals of Grid Generation by Knupp Patrick and Steinberg Stanly, CRC Press, 1994.
4. Turbulence Modelling for CFD by Wilcox D.C., 1993
5. An Introduction to Multigrid Methods by Wesseling Pieter, John Wiley & Sons, 1992
6. Numerical Grid Generation: Foundations and Applications by Thompson J.F., Warsi Z.U.A. and Mastin C.W., North Holland, 1985
7. Numerical Heat Transfer and Fluid Flow by Patankar S.V., McGraw-Hill,1981
8. Simulation and Modelling of Turbulent Flows by Gatski Thomas B., Hussaini M. Yousuff and Lumley John L., Oxford University Press, 1996
9. Computational Gas Dynamics by Laney, C. B., Cambridge Uni. Press, 1998.

(b) Open source software and website:

1. OpenFOAM (https://www.openfoam.com/)
2. ANSYS/Fluent (https://www.ansys.com/en-in/products/fluids/ansys-fluent)
3. Star-CD (https://mdx.plm.automation.siemens.com/star-cd)
4. Star-CCM+ (https://mdx.plm.automation.siemens.com/star-ccm-plus)
5. COMSOL Multiphysics
6. CFDTool (https://www.cfdtool.com/)
7. MATLAB
8. C/C++/Python based tutorials

Suggested Course Practical List:

1. Evaluation of matrix format of conservation equation
2. Grid generation for Ideal CSTR and PFR reactors
3. Grid generation technique for fluidized bed
4. Application of grid refinement on PID of chemical plant
5. Simplification of momentum balance to derive bernoulli's equation
6. Comparison of solution methods for various CFD softwares
7. Evaluation of heat loss using CFD software
8. Evaluation of fluid dynamics in water hammer effect using Open FOAM
9. Setting up the modeling equation for simultaneous heat, mass and momentum transfer application.

List of Laboratory/Learning Resources Required:

- Computer lab

Suggested Project List:

- Study Pressure drop and heat transfer in packed bad for exothermic reaction.
- Simulate fluid flow and optimize impeller design for improved mixing.
- Investigate gas liquid interactions and bubble dynamics.
- Study solid liquid interactions and pressure drops.
- Study mass transfer enhancement due to microbubbles.

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Chemical Engineering

Subject Code: ME02030081

Subject Name: Advanced Optimization Techniques in Chemical Engineering

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite:	Concepts of Optimization of undergraduate level
Rationale:	Process Optimization is intended to teach students how to use optimization algorithms to improve the design and operation of chemical processes. This course emphasizes problem formulation; i.e., how one develops mathematical statements for the objective function (usually economic model) to be minimized or maximized and the equality and inequality constraints (the process model) and selection of optimization technique which is best suited to the problem characteristics.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Understand optimization techniques to solve linear programming and nonlinear programming problems
02	Use optimization as a tool in process design and operation
03	Proficiency in the applications of optimization in chemical plants
04	Nontraditional optimization techniques application in other areas

Teaching and Examination Scheme:

Teaching Scheme(in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**The Nature and Organization of Optimization Problems:** Scope and Hierarchy of Optimization, Examples of applications of Optimization, The Essential Features of Optimization Problems, General Procedure for Solving Optimization Problems, Obstacles to Optimization	**3**	**7**
2.	**Developing Models for Optimization:** Classification of Models, How to Build a Model, Selecting Functions to Fit Empirical Data, Factorial Experimental Designs, Degrees of Freedom, Examples of Inequality and Equality Constrains in Models, Formulation of the Objective Function Economic Objective Functions, The Time Value of Money in Objective Functions, Measures of Profitability	**6**	**13**
3.	**Basic Concepts of Optimization:** Continuity of Function, NLP Problem Statement, Convexity and Its Applications, Interpretation of the Objective Function in Terms of its Quadratic Approximation, Necessary and Sufficient Conditions for an Extremum of an Unconstrained Function	**6**	**13**
4.	**Optimization of Unconstrained Functions:** One-Dimensional Search Numerical Methods for Optimizing a Function of One Variable, Scanning and Bracketing Procedures, Newton and Quasi-Newton Methods of Uni-dimensional Search, Polynomial Approximation Methods, How One-Dimensional Search is Applied in a Multidimensional Problem, Evaluation of Uni-dimensional Search method	**6**	**13**
5.	**Unconstrained Multivariable Optimization:** Methods Using Function Values Only, Methods That Use First Derivatives, Newton's Method, Quasi-Newton Methods	**5**	**12**
6.	**Linear Programming (LP) and Applications:** Geometry of Linear Programs, Basic Linear Programming Definitions and Results, Simplex Algorithm, Barrier Methods, Sensitivity Analysis, Linear Mixed Integer Programs, LP Software, A Transportation Problem Using the EXCEL Solver Spreadsheet Formulation, Network Flow and Assignment Problems	**7**	**16**
7.	**Non linear and mixed integer programming:** Examples of Optimization in Chemical Processes like optimizing recovery of waste heat, Optimal Shell and Tube Heat Exchanger Design, Optimal Design and Operation of binary Distillation Column, Optimal pipe diameter etc.	**6**	**13**

8.	**Chemical reactor Design and operation:** Optimization of a Thermal Cracker Via Linear Programming, Optimal Design of an Ammonia Reactor Solution of an Alkylation Process by Sequential Quadratic Programming, Predicting Protein Folding, Optimization of Low-Pressure Chemical Vapor Deposition, Reactor for the Deposition of Thin Films Reaction Synthesis	**6**	**13**
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
7	12	35	10	6	0

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Optimization of Chemical Processes by Edger, Himmelblau, Lasdon, McGraw-Hill International Edition.
2. Optimization: Theory and Practice by Gordon S. G. Beveridge and Rober S. Schechter, McGraw-Hill Book Company.
3. Optimization for Engineering Design by K. Deb, Prentice-Hall.
4. Optimization: Theory and Practice by MC Joshi and K M Moudgalya, Narosa Publishing.
5. Numerical Optimization by J Nocedal and S J Wright, Springer Verlag.
6. Introduction to Linear Optimization by Dimitris Bertsimas, John N. Tsitsiklis, John Tsitsiklis, Athena Scientific Series in Optimization and Neural Computation.

(b) Open source software and website:

1. Students can refer to video lectures available on the websites including NPTEL lecture series.
2. MS Excel, MATLAB, SCILAB, DWSIM

Suggested Course Practical List:

1. Familiarization to tools used for laboratory like Excel Spreadsheet, COCO/DWSIM (open source simulator and MATLAB/SCILAB (computation platform)
2. Solve single and multi-variable optimization problems in Excel Spreadsheet using solver
3. Solve Linear Programming problems in Excel Spreadsheet using solver

4. Estimate kinetic parameters of the reaction using batch reactor data
5. Plot ideal and non-ideal vapour liquid equilibrium (VLE) plots computing data using (i) ideal mixture assumption and (ii) using Van-Laar activity coefficient model
6. Simulate continuous binary distillation column developing material and enthalpy balance in the column. Compute ideal number of places using optimal reflux ratio.
7. Simulate multicomponent distillation with reboiler and condenser.
8. Develop material and energy balance for adiabatic combustion of methane and simulate the effect of excess air on performance of combustion
9. Develop simulation of shell and tube heat exchange and evaluate Rating / Design
10. Develop design and optimization of single and multiple effect evaporator

List of Laboratory/Learning Resources Required:

- Computer Lab

Suggested Project List:

- Minimize energy consumption while maximizing product purity using NLP or MILP.
- Use multi objective optimization for integrating solar wind or biomass energy.
- Apply genetic algorithms to identify optimal solvents for extraction process.
- Maximize yield and control particle size distribution using advanced techniques.
- Optimize the operating schedule for catalyst regeneration to minimize downtime.
- Apply dynamic optimization techniques to control temperature and concentration profiles.

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Chemical Engineering

Subject Code: ME02030091

Subject Name: Advanced Separation Techniques

W.E.F. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite:	Fundamentals of Mass Transfer Operations.
Rationale:	The aim of this subject is to impart comprehensive understanding to the students regarding various novel and advanced separation techniques and its advancement which have profound significance in Industrial and Research arenas.

Course Outcome:

Upon successful completion of this course, students will be able to:

No	Course Outcomes
01	Familiarize various advanced aspects of separation processes and the selection of separation processes
02	Understand principles and advanced techniques in distillation, adsorption, absorption and membrane separation
03	Introduce new trends used in the separation technologies
04	Apply advanced separation techniques to identify and study environmental as well as Chemical industries problems

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+(PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial/ Practical		
L	T	PR	C	ESE (E)	PA/ CA (M)	PA/CA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	%of Weightage
1	**Advances in Distillation:** Introduction to Advances in Separation by Distillation, Introduction to Multi Component Distillation, Selection of	14	28

	Operating Pressure, Equilibrium for Multi component System, Methods for Multi Component Distillation, Design of Batch Distillation for Multi component with Rectification, with constant reflux and constant over head component, Continuous distillation of multi component system, Energy Conservation in Distillation column, Advanced topics in distillation, Short path distillation.		
2	**Membrane Separation Processes:** Membrane types, materials, Different membrane modules; Working principle, and Industrial Applications for individual Membrane Processes such as Reverse osmosis, Forward Osmosis, Ultrafiltration and Pervaporation.	7	16
3	**Advances in Absorption**: Criteria for selection of Packed tower, Tray tower, Spray chamber, Venturi Scrubber etc. Design of Falling Film Absorber, Design of Spray Chamber, Design of Venturi Scrubber, Important Design Aspects and Advantage of Falling Film Absorber.	8	16
4	**Separation By Adsorption Techniques:** Mechanism, Types and Selection of Adsorbents, Normal Adsorption Techniques, Types of equipment and commercial processes, Recent Advances and Case Studies on Adsorption.	8	16
5	**Recent Developments in Separation Techniques**: Separations involving Lyophilisation, Zone Melting, Freeze Crystallization, Adductive Crystallization, Supercritical Fluid Extraction, Case Studies of Advanced Separation Techniques.	8	24
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
7	24	28	07	04	00

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Equilibrium-stage separation operation in chemical engineering by Ernest J. Henley and J.D. Seader, Second edition Wiley India Pvt. Ltd.
2. Perry's Chemical Engineer's Handbook, by R.H.Perry & Green D. Ninth Edition, McGraw Hill, New York, 2018.
3. Mass Transfer Operation by Robert Treybal, Third Edition, McGraw Hill, New York, 2017.
4. Industrial Processing with Membranes by Lacey, R.E. and S.Loaeb - Wiley -Inter Science, New York, 1972.
5. New Chemical Engineering Separation Techniques by Schoew, H.M. - Interscience Publishers, 1972.
6. Ronald W.Roussel - "Handbook of Separation Process Technology ", John Wiley, New York, 1987.
7. Introduction to process Engineering & Design" by S.B. Thakore & B.I Bhatt,Tata McGraw-Hill Ltd.,2007.

(b) Open-source software and website:

- Students can refer to video lectures available on the websites including NPTEL lecture series.
- Students can refer to the CDs available with some reference books for the solution of problems using Softwares/spreadsheets.
- Students can develop their own programs/spreadsheets for the solution of problems excel, Chemcad and other
simulation softwares.

Suggested Course Practical List:

1. To determination of percentage efficiency of separation of butyl acetate by reactive distillation
2. To determine the characteristics of adsorption of moisture on Silica gel
3. To Plot Frendlich Adsorption Isotherm for a System of oxalic Acid & Activated Charcoal.
4. To recover water/salt from salt solution via freeze crystallization.
5. To perform experiment on removal of organic acid from effluent via freeze crystallization.
6. To reduce COD of waste water using freeze crystallization.
7. Study of membrane modules and their parts for pressure activated Membrane separation process such as

Reverse Osmosis, Ultra Filtration, Pervaporation.

Major Equipments Distillation Column, Cascade refrigerator, COD Apparatus, Refractometer, Membrane Modules

List of Laboratory/ Learning Resources Required:

Laboratory Facilities

1. Water supply and drainage in Lab Area
2. Weighing balance, Vacuum pump
3. Chemical Storage Cabinets
4. Personal Protective Equipment (PPE)

Suggested Project List:

- Solve design problems for multi component distillation
- Separation of given components using short path distillation unit
- Application of nanofiltration in separation of solute from waste water of food processing units
- Design of a Pervaporation Unit
- Design of falling film absorber
- Study of green solvent based absorption processes
- Optimization of separation by Freeze Crystallization
- Applications of Freeze Crystallization in removal of pollutants from waste water
- Recovery of valuable materials using melt crystallization

Suggested Activities for Students:

- Explore emerging areas in advance separation techniques
- Understand design and scale-up of equipments required for advanced separation techniques
- Apply advance separation techniques effectively for real world separation problems

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Chemical Engineering

Subject Code: ME02030101

Course/ Subject Name: Membrane Separation Processes

W.E.F. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite:	Students should have a fundamental understanding of mass transfer operations, chemical process industries, material and energy balances, reaction engineering, and industrial safety to comprehend waste generation, treatment, and regulatory aspects effectively.
Rationale:	Membranes are applied in a range of processes from selective separation to solvent and material recovery. This course will enable students to understand membrane-based separation problems by acquiring in-depth knowledge in the area of membrane separation mechanisms, transport models, membrane materials and modules etc. and also provide an insight to the membrane based separation processes that are an integral part of the down-stream processing of various industries.

Course Outcome:

Upon successful completion of this course, students will be able to:

No	Course Outcomes
01	Define and select the appropriate membrane properties, configurations, materials, and operating circumstances
02	Evaluate the effectiveness of membrane separation processes and analyze the properties of membrane separation
03	Select a membrane process and design components to carry out a specific separation process
04	Utilize the cutting-edge membrane technology to address issues in the chemical and environmental sectors

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+(PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial/ Practical		
L	T	PR	C	ESE (E)	PA/ CA (M)	PA/CA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	%of Weightage
1	**Introduction to Membrane Separation Processes:** Definition and Types of Membranes, Historical Development, Classification of Membrane Separation Processes, Advantages, Limitations and Applications of Membrane Separation Processes.	4	08
2	**Rate Governed and Equilibrium Governed Membrane Separation Processes:** Different Methods for Synthesis of Membrane, Various Types of Membranes Modules, Flow Patterns and Membrane materials, Membrane Characterization.	4	10
3	**Reverse Osmosis (RO) and Nanofiltration (NF):** Working Principle, Applications, Benefits and Drawbacks of RO and NF. Design and operating parameters, Various Transport Models, Kedem-katchalsky Model, Spiegler-Kedem Model, Solution-Diffusion Model, Concentration Polarization and Flux Decline, Design of an RO module, Forward Osmosis, NF membrane Transport Mechanism and Parameters affecting the Performance, NF membrane mass transfer and Fouling Model.	7	16
4	**Microfiltration(MF) and Ultrafiltration(UF):**Working Principle, Applications, Benefits and Drawbacks of MF and UF Processes, Transport mechanism and Factors affecting Performance of MF and UF, Fouling in MF membranes, Types of devices for UF, Flux equation, Resistance Model and Gel Polarization Model in UF, Fouling and flux Decline in UF, Micellar-Enhanced UF, Affinity UF.	6	14
5	**Membrane Gas Separation and Pervaporation (PV):** Key Aspects of Gas Separation Membranes, Fundamental Mechanism of Gas Transport, Knudsen Diffusion, Molecular Sieving, Solution-Diffusion, Dual Sorption model, Factors affecting Gas Permeation, Applications of Gas Separation. Principle of PV, Mass Transfer and Thermodynamics aspects of PV, Temperature Drop at membrane interface, Design of a PV Module. Applications of PV.	7	16
6	**Dialysis and Electrodialysis(ED):**Principle of Dialysis, Dialysis Systems, Mass transfer in Dialysis, Modeling of Solute Transport in Hem Dialyzer, Advantages and Applications of Diffusion dialysis, Working and Mechanism of ED, Applications of ED, Important Aspects of Membranes for ED.	5	12

7	**Liquid Membrane and Facilitated Transport:** Merits of Liquid Membrane, Bulk, Emulsion, Thin sheet supported and Hollow fiber supported liquid membrane, Recent Advances and Case Studies on Liquid Membrane. Important Aspects and Mechanism of Facilitated Transport, Coupled Transport, Carrier Agents, Competitive Facilitated Transport with Two permeates active and passive transport, Some potential applications of facilitated transport.	7	12
8	**Membrane Distillation (MD) and Electrophoresis (EP):** Introduction to Membrane Distillation and Electrophoresis, Principle of MD and EP. Principle of Electrophoresis, Factors affecting Electrophoresis, Different Typesof Electrophoresis, Applications of MD and EP.	5	12
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
20	28	22	18	10	02

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Transport Processes and Separation Process principles, Christie J Geankoplis Prentice-Hall of India Private Ltd, New Delhi, 4th Edition 2006.
2. Membrane Separation Processes, Second Edition, by Kaushik Nath, PHI Learning Pvt. Ltd, New Delhi, 2017.
3. Membrane Handbook Eds. By W. S. W. Ho and K. K. Sirkar Springer New York, NY, 1992.
4. Membrane technology and applications, Baker, R.W., 2nd ed., John Wiley 2004
5. Synthetic membranes: Science, Engineering and Applications, Eds. By P. B. Bunge, H. K. Lonsdale and M. N. Depinho, Springer Dordrecht, 1996.
6. Basic Principles of Membrane Separation, Mudler J, (2nd Edition), Springer Dordrecht 1996.
7. Ultrafiltration and Microfiltration Handbook, (2nd Edition), Munir Cheryan, CRC Press.

8. Equilibrium-stage separation operation in chemical engineering by Ernest J. Henley and J.D. Seader, Second edition Wiley India Pvt. Ltd.

(b) Open-source software and website:

1. Video lectures available on the NPTEL website.
2. MIT open course lecture on equipment design.
3. Use of subject relevant software for the problems solving and analyzing the separation processes.

Suggested Course Practical List:

1. Preparation and characterization of polymeric membrane.
2. Swelling characteristics of membrane in aqueous-organic mixture.
3. Determination of Membrane Permeability for different membrane materials.
4. Experimental determination of permeate flux, permeate rejection and permeate characteristics in MF and UF.
5. Experimental determination of permeate flux, permeate rejection and permeate characteristics in NF and RO.
6. The above experiment no. 4 and 5 should be repeated with different membranes and fluxes may be compared.
7. Determination of various mass transfer resistances during pressure driven membrane process.
8. Determination of rate of mass transfer of gases through dense polymeric membrane.
9. Experiment on emulsion liquid membrane using oil-water emulsion or in separation of phenol/ heavy metals etc.
10. Separation efficiency determination using Electrophoresis separation.
11. Numerical / Design problems based on the selected topics of content.
12. Term paper submission on any specific membrane separation processes application in industrial operations.

Major Equipments Laboratory scale membrane film applicator unit, bench-scale cross/tangential flow membrane test cells, pilot plant for nanofiltration, (Flat sheet & Spiral Wound Module) where various flat sheet membranes can be tested with respect to various feed solutions for the operating parameters, lab scale set up for micro and ultrafiltration unit, pervaporation pilot plant with flat sheet membrane, a laboratory-scale filtration unit that is designed to evaluate a variety of Osmotically Driven Membrane Processes (ODMP), including Forward Osmosis (FO) and Pressure Retarded Osmosis (PRO).Setup.

List of Laboratory/ Learning Resources Required:

Laboratory Facilities

1. Water supply facility and facility for proper drainage of water in Lab Area
2. Weighing balance, Vacuum pump
3. Chemical Storage Cabinets
4. Personal Protective Equipment (PPE)

Suggested Project List:

- Fabrication and Characterization of TFC membrane
- Fabrication and Characterization of TFC membrane
- Microfiltration application in separation of solute from waste water of food processing units
- Design of a Pervaporation Unit
- Separation of a selective material from water using Nano-RO Hybrid Systems
- Synthesis and applications of grapheme-based NF membrane
- Modified processes for ultrafiltration for separation of specific solute from waste water
- Correlation of pressure driven membrane separation with zero liquid discharge
- Energy efficient membrane separation processes
- Draw Solute recovery using forward osmosis
- Development of stable emulsion systems for ELM
- Recovery of organic acids using ELM
- Green-Solvent based ELM
- Optimization of performance of different gas separation membrane
- Efffectiveness of membrane separation for radioactive waste treatment

Suggested Activities for Students:

- Explore emerging areas in membrane separation processes
- Learn membrane preparation, modification and characterization
- Apply membrane separation processes effectively for real world separation problems

GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Chemical Engineering

Subject Code: ME02030111

Course/ Subject Name: Advanced Analytical Techniques

W.E.F. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite:	Students should have a foundational understanding of physical, inorganic and organic chemistry.
Rationale:	This course is intended to familiarize students with various traditional and modern physicochemical methods of analysis and the development of the students' ability to the interpretation of the results obtained by various techniques.

Course Outcome:

Upon successful completion of this course, students will be able to:

No	Course Outcomes
01	Recognize fundamentals as well as recent developments in instrumental methods of analysis
02	Understand the working of instruments as well as for the development of new technologies.
03	Select the best method of sample preparation required for a particular analytical technique.
04	Spectroscopy and microscopy to identify molecular structures from their spectra and micrograms.

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+(PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial/ Practical		
L	T	PR	C	ESE (E)	PA/ CA (M)	PA/CA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	%of Weightage
1.	**Theory of errors:** Sources and classification of errors.True value, Precision, accuracy, error, mean and median, spread, deviation, standard deviation, coefficient of variation, variance Statistical treatment of analytical data & presentation of result. Sampling of solids, liquids and gases. Evaluation and validation of analytical methods. Good laboratory practices.	**6**	13
2.	**Chromatographic methods**: Introduction & classification of chromatography. Theory, instrumentation & applications of the following chromatographic techniques: (i) Column chromatography (ii) TLC (iii) Paper chromatography (iv) GC (v) HPLC.	**6**	13
3.	**UV-Visible Spectroscopy**: Introduction, Theory of UV-Visible Spectroscopy & colourimetry, Beer-Lambert law, Deviation from Beer-Lambert law. **Infrared Spectroscopy**: Introduction, Infrared radiation & its interaction with organic molecules, vibrational mode of bonds, instrumentation & applications, interpretation of IR spectra. **Mass spectrometry**: Basic principles & brief outline of instrumentation. Ion formation, molecular ion, metastable ion, fragmentation process in relation to molecular structure & functional groups.	**8**	18
4.	**Thermo-gravimetric analysis:** principles and applications. **Differential scanning calorimetry**: principles and applications.	**8**	18
5.	**Analytical Techniques:** Potentiometry, ion selective electrodes. Voltametric methods, Conductometry and conductometric titration, and Coulometric methods applied to industrial analysis and air pollution observation.	**8**	18
6	**X-ray Diffraction studies**: Principles and applications **Microscopic analysis**: SEM, TEM and AFM. Working principles, applications and sample preparations	**9**	20
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	18	22	20	00	00

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Chemical Analysis, Modern Instrumentation Methods and Techniques, F. Rouessac, A. Rouessac, Jon Wiley & Sons Ltd, 2007.
2. Analytical Chemistry, Theoretical and Metrological Fundamentals, K. Danser, Springer, 2007.
3. Instrumental Methods of Analysis, B. K. Sharma, Goel Publishing house.
4. Elementary Organic Spectroscopy, Y.R. Sharma, S.Chand& company Ltd. New Delhi 2008
5. Spectroscopic identification of organic compounds, R.M. Silverstein, F.X. Webster, D.J. Kiemle,John Wiley & Sons Ltd, 2005

(b) Open-source software and website:

To enhance learning, students can use the following open-source software tools and websites for simulations, data analysis, and regulatory information related to hazardous waste management:

Open-Source Software

- FullProf Suite: For sample analysis using X-ray and neutron diffraction data
- VESTA: Open-source 3D visualization software
- OpenSEM: SEM image processing and automated feature detection.
- ImageJ / FIJI: SEM image processing.
- Thermoanalysis (TA): Processing and analyzing thermogravimetric data
- Spectrographer: Processing UV-Vis, IR, and other types of spectroscopic data

Websites and Resources

- NPTEL https://archive.nptel.ac.in/courses/102/107/102107028/
- NPTEL https://nptel.ac.in/courses/104104066
- NPTEL https://onlinecourses.swayam2.ac.in/ugc19_bt16/preview
- MIThttps://ocw.mit.edu/courses/18-305-advanced-analytic-methods-in-science-and-engineering-fall-2004/

Suggested Course Practical List:

1. Isolation of compound using TLC techniques.
2. Isolation of compound using paper chromatography.
3. Isolation of compound using Column Chromatography techniques.
4. Identification of functional group using FTIR.
5. Analysis of mixture using GC.
6. Analysis of the given sample using UV-Vis spectroscopy.
7. Analysis of the given sample using IR spectroscopy.
8. Determination of crystalline characteristics from the data of XRD.
9. Analysis of image from the scanning electron microscopy.
10. Analyzing the given data from TGA.
11. Sample analysis using AFM.

Major equipment: Scanning electron microscopy, Transmission electron microscopy, X-Ray diffraction**,** Gas Chromatography-Mass Spectrometry (GC-MS), TCLP Extraction Apparatus, Column chromatography apparatus, TGA apparatus, Spectrophotometer (UV-Vis) etc.,

List of Laboratory/ Learning Resources Required:

Laboratory Facilities

1. Chemical Storage Cabinets
2. Personal Protective Equipment (PPE)

Suggested Project List:

- Evaluation of Photodegradation of Pollutants Using UV-Vis Spectroscopy.
- Identification and Quantification of Natural Antioxidants in Food Using UV-Vis Spectroscopy.
- Spectroscopic Characterization of Vitamin A and Its Derivatives.
- Characterization of Semiconductor Materials for Photovoltaic Devices
- Determination of Lattice Strain and Crystallite Size in Materials
- Analysis of Nanomaterials Using XRD.

- Surface Morphology and Particle Size Analysis of Nanoparticles.
- Characterization of Cell Morphology for Drug Delivery Systems.
- Investigation of Surface Functionalization in Catalysts.
- Analysis of Pharmaceuticals and Active Pharmaceutical Ingredients (APIs) using HPLC.
- Detection of Contaminants in Food and Beverages using HPLC.
- Impact of Additives on Thermal Degradation of Rubber using TGA.
- Thermal Stability of Food Additives and Ingredients using TGA,
- Application of Potentiometry in Blood Gas Analysis
- Study of Redox Reactions Using Potentiometry

****

TEACHING SCHEME / DETAIL SYLLABUS

Home

ME

30 - CHEMICAL ENGINEERING

3

2024-25

Select Elective / Non-Elective

Subject Code

Enter Subject Name

Search

*L=lectures,T=tutorial,P=Practical,E=TheoryExternal,M=TheoryInternal,I=Practical Internal,V=Practical External,On Job Training(OJT) is equivalent to Practical

							Hours				Credit	Max Marks				
Exp.	Subcode	Branch code	Eff_from	SubjectName	Category	Sem /Year	L.	T.	P.	PBL	Total	E	M	I	V	Total
	ME03000011	030	2025-26	Internal Review Phase-I	Internal Review/Dissertation Work	3	0	0	8	NA	4	0	0	50	0	50
	ME03000021	030	2025-26	Dissertation Phase-I	Internal Review/Dissertation Work	3	0	0	30	NA	15	0	0	0	150	150
	ME03030011	030	2025-26	Energy Conversion and BioRefinery	Multidisciplinary Open Professional Electives Courses	3	3	0	0	NA	3	70	30	0	0	100
	ME03030021	030	2025-26	Renewable Energy Engineering: Solar, Wind And Biomass Energy Systems	Multidisciplinary Open Professional Electives Courses	3	3	0	0	NA	3	70	30	0	0	100
	ME03030031	030	2025-26	Chemical Process Utilities	Multidisciplinary Open Professional Electives Courses	3	3	0	0	NA	3	70	30	0	0	100
	noc25-ch09	30	Jan-2025	Biomass Conversion and Biorefinery	MOPEC-01(MOOC)	3	3	0	0	NA	3	100	0	0	0	100
	noc25-ch16	30	Jan-2025	Chemical Process Utilities	MOPEC-01(MOOC)	3	3	0	0	NA	3	100	0	0	0	100
	noc25-ch40	30	Jan-2025	Renewable Energy Engineering: Solar, Wind And Biomass Energy Systems	MOPEC-01(MOOC)	3	3	0	0	NA	3	100	0	0	0	100

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GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering

Subject Code : ME03000011

Subject Name : Internal Review Phase-I

WEF Academic Year:	2024-2025
Semester:	3
Category of the Course:	Core

Course Scheme:

Teaching Scheme			Total Credits	Assessment Pattern and Marks				Total Marks
				Theory		Practical		
L	T	PR	C	ESE (E)	PA(M)	ESE (V)	PA (I)	
0	0	8	4	0	0	0	50	50

The objective of the Internal Review - I

Dissertation is an essential component where student identify a topic of concern to their field and read, understand, and incorporate the relevant literature into a new research problem to be investigated. The dissertation process allows students to design and implement a study that illuminates the research question, followed by analyzing the data, discussing the results, and identifying the implications. During the 3rd semester, students will carry out the partial work of the dissertation on identified research issues. Students will be recommended for the university-level dissertation phase-I upon completing the internal review.

Course Outcome:

Following are the expected outcome at the end of the 3rd semester. Students will be able to,

No	Course Outcomes	RBT Level*
01	Understand the chosen research topic and its relevant challenges.	UN
02	Systematically identify relevant theoretical concepts and appropriate quality literature from reputed recent journal publications to validate the problem statement.	UN
03	Do a comparative analysis of the existing solutions for the chosen researchproblem and identify the further scope of work.	AN

04	Evaluate the comparative analysis with relevant quantitative and qualitative performance parameters using problem-specific datasets.	EL
05	Design a hypothesis with significant technicality using the appropriate algorithm/methodology to solve the chosen research problem.	CR

*RM: Remember, UN: Understand, AP: Apply, AN: Analyze, EL: Evaluate, CR: Create

* * * * * * *

GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering

Subject Code : ME03000021

Subject Name : Dissertation Phase - I

WEF Academic Year:	2024-2025
Semester:	3
Category of the Course:	Core

Course Scheme:

Teaching Scheme			Total Credits	Assessment Pattern and Marks				Total Marks
				Theory		Practical		
L	T	PR	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
00	00	30	15	NA	NA	150	NA	150

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Chemical Engineering

Subject Code: ME03030011

Subject Name: Energy Conversion and BioRefinery

w. e. f. Academic Year:	2024-25
Semester:	3
Category of the Course:	MOPEC-01

Prerequisite:	Basic knowledge of chemical engineering principles, reaction engineering and thermodynamics.
Rationale:	This course will enable students to become skilled professionals in sustainable technology. It gives them the knowledge to create new solutions in renewable energy and green chemistry. The students will be ready to tackle environmental problems and support the growth of the bioeconomy.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Understand the environmental, economic, and social impacts of biomass utilization and compare it with fossil fuel-based systems.
02	Explore various technologies for biomass conversion to fuels, chemicals, and materials.
03	Evaluate the principles and process flows of biorefineries for the production of biofuels, bioenergy, and value-added chemicals.
04	Develop practical skills to analyze biomass composition, conversion efficiencies, and product characterization.

Teaching and Examination Scheme:

Teaching Scheme(in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	0	3	70	30	0	0	100

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Introduction:** World energy and environmental scenario, Fossil fuel depletion and associated environmental challenges, Global policies promoting bioenergy and bioproducts, Historical development of biorefineries, Overview of successful biorefinery projects.	8	18
2.	**Biomass:** Definition and scope of biomass. Biomass significance as an energy resource. Types and availability of waste biomass (municipal, industrial, agricultural, and forestry). Biomass production, selection, and abundance. Oil crops and their potential for biorefineries. Enhancing biomass properties for biofuel applications. Conversion pathways for biomass utilization. Challenges in biomass utilization and scaling up technologies. Emerging trends and innovations in biomass usage.	10	22
3.	**Thermal and Chemical Conversion:** **Thermal Conversion:** Choice of thermal process based on biomass type and product requirement (combustion, gasification, torrefaction, pyrolysis), Pyrolysis: Types, products (oil, gas, charcoal), and applications, Hydrothermal liquefaction and hydro-pyrolysis, Fischer-Tropsch synthesis and transesterification, Equilibrium and kinetic considerations for thermal processes. **Chemical Conversion:** Hydrolysis & hydrogenation, Solvent extraction of hydrocarbons, Solvolysis of wood, Production of Biocrude and biodiesel and other chemicals from biomass.	10	22
4.	**Biological Conversion:** Biodegradability of substrates and microbial processes, Microalgae as feedstock for biofuels and biochemicals, Biochemistry and process parameters of biomethanation, Biogas digester types, Digester design and biogas utilization, Biogas plant design, utilization, and economic aspects, Bioconversion processes for alcohols, organic acids, solvents, amino acids, and antibiotics.	9	20
5.	**Sustainability and Environmental Aspects of Biorefinery**: Techno-economic analysis (TEA) and life cycle assessment (LCA) of biorefineries, Greenhouse gas mitigation and carbon footprint reduction, Waste valorization and its role in the circular economy, Environmental and social impacts of biorefinery operations, Role of government incentives and subsidies in promoting biorefineries.	8	18
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
5	25	15	10	10	5

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

- Biomass as a Sustainable Energy Source for the Future: Fundamentals of Conversion Processes Wiebren de Jong, J. Ruud van Ommen, AIChE/Wiley, ISBN: 978-1-118-30491-4. (2015)
- Biorefineries: Design and Analysis" by Paul R. Stuart and Mahmoud M. El-Halwagi, CRC Press, 2012.
- Biorenewable Resources: Engineering New Products from Agriculture, Robert C. Brown, Wiley-Blackwell Publishing (2014)
- Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983 3.
- Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991 4.
- Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996
- Biogas Systems: Principles and Applications, Mital K.M
- Handbook of Bioenergy Crops: A Complete Reference to Species, Development, and Applications. London: Earthscan, El Bassam, Nasir, 2010.

Suggested Activities for Students:

- Analyze biomass properties (e.g., calorific value, moisture content, and lignocellulosic composition).
- Visit power plants, renewable energy facilities, and research labs to observe energy conversion technologies in action.
- Study and compare advancements in biomass conversion technologies, including catalytic, thermal, and biological processes.
- Analyze case studies of successful biorefineries and their economic viability.
- Examine trends in biomass availability, cost, and biofuel production in different regions.
- Create a conceptual design for a biorefinery processing municipal waste or agricultural residues into biofuels and chemicals.

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Chemical Engineering

Course / Subject Code: ME03030021

Subject Name: Renewable Energy Engineering: Solar, Wind And Biomass Energy Systems

w. e. f. Academic Year:	2024-25
Semester:	3
Category of the Course:	MOPEC

Prerequisite:	Students should have a basic knowledge of renewable energy systems.
Rationale:	This course standardises material on non-conventional energy sources like solar, wind, and biomass, emphasising their importance in clean energy. It focuses on engineering and design aspects, highlighting advancements in these technologies. Students will learn about biomass types, classifications, selective utilization, bio-digester, wind machine, and thermo-digester design.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Understand the fundamental principles of solar energy, including solar radiation components, Earth-Sun geometry, and methods for solar radiation measurement and estimation.
02	Analyze the performance and design parameters of solar collectors, including flat plate and parabolic collectors, to assess their efficiency and the impact of various factors on their functionality.
03	Demonstrate knowledge of wind energy systems, including wind power estimation, turbine dynamics, energy storage, and environmental impact, with a focus on system integration and hybrid setups.
04	Explore biomass energy conversion technologies, including biochemical and thermochemical methods, with emphasis on process mechanisms, parameters, and product properties for sustainable energy solutions.

Teaching and Examination Scheme:

Teaching Scheme(in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	0	3	70	30	0	0	100

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Solar Energy:** An overview of thermal applications. **Solar radiation**: Extraterrestrial solar radiation, Components of radiation, Geometry of the Earth and Sun, Geometry of collector and the solar beam, Effects of the Earth's atmosphere, Measurements and estimation of solar radiation, Practice problems of solar energy.	4	9
2.	**Solar collector:** classification of solar collector, Performance Indices, **Non-concentrating solar collectors:** Liquid flat plate collector, Material Selection, Flat plate air heating collector, Evacuated Tube Collector, performance analysis, transmissivity of the cover system, overall loss coefficient and heat transfer correlation. Collector efficiency factor, collector heat removal factor, Effect of Various Parameters on Performance.	4	9
3.	**Parabolic solar collectors:** Modified Flat Plate Collector, Compound Parabolic Concentrator, Cylindrical Parabolic Concentrator, Fixed Mirror Solar Concentrator, Linear Fresnel Lens Collector, Paraboloidal Dish Collector, Hemispherical Bowl Mirror Concentrator, Circular Fresnel Lens Concentrator, Central Tower Receiver, geometry, performance analysis, and loss calculation.	4	9
4.	**Thermal energy storage systems:** Introduction, sensible heat storage, latent heat storage, Thermochemical storage, Photovoltaic generation, Solar energy utilization methods, problem-based on thermal energy storage.	4	9
5.	**Wind power:** Introduction, Factors Affecting the Distribution of Wind Energy on the Surface of Earth, Estimation of Wind Energy at a Site, Turbine types and terms, Linear momentum and basic theory, Dynamic matching, Blade element theory, Characteristics of the wind, Power	4	9

	extraction by a turbine, Electricity generation, Mechanical power, Application of wind power, Examples based on wind power.		
6.	**Wind energy conversion**: Wind energy conversion system, Wind diesel hybrid system, system integration, wind energy storage, Environmental impact, Characteristics and Power Generation from Wind Energy, Practice problems	4	9
7.	**Biomass Energy**: Classification of energy resources, Photosynthesis process, Usable forms of biomass, their composition and fuel properties, Broad classification and compositional analysis, Characteristics of biomass, Physical and thermodynamic properties of biomass, Properties and structural components of biomass, biomass composition expression.	4	9
8.	**Biomass conversion:** Biomass residues and energy conversion routes: Utilisation of biomass through biochemical and thermo-chemical routes, Motivation for biomass conversion	4	9
9.	**Biogas:** Conversion mechanism of biomass to biogas and its properties, Classification of biogas plants, Practice problems **Bioconversion:** Bioconversion of substrates into alcohol	4	9
10.	**Thermo-chemical conversion:** Thermo-chemical methods such as torrefaction, combustion and pyrolysis, process stages, mechanism, process parameter impact and properties of product and technology involved. Design consideration of torrefaction, combustion and pyrolysis.	5	9
11.	**Gasification:** Theory, process steps and types, gasification process in reactor, kinetics of gasification. Models of gasification, practice problems.	4	10
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
5	25	15	10	10	5

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

- Sukhatme S. P., Nayak J. K., Solar Energy: Principles of thermal Collection and Storage, 3 rd Ed., Tata McGraw-Hill Education Pvt. Ltd 2008.
- Twidell, J. and Tony W., Renewable Energy Resources, 2 nd Edition, Taylor & Francis 2006.
- Khan B. H., Non-Conventional Energy Resources, 2 nd Edition, Tata McGraw-Hill Education Pvt. Ltd. 2009.
- Prabir Basu, Biomass Gasification, Pyrolysis and Torrefaction, Academic Press, Elsevier, 2013.

(b) Open-source software and website:

To enhance learning, students can use the following open-source software tools and websites for modelling and simulation in renewable energy system.

- Open-Source Software
- OpenFOAM: For chemical kinetics, thermodynamics, and transport processes.
- Reaction Mechanism Generator: Generates detailed kinetic mechanisms for thermochemical processes.
- BioRT: Biomass reaction modelling tool that supports pyrolysis kinetics.
- PVWatts: Tool for estimating the energy production of grid-connected solar PV.
- OpenModelica: Modeling and simulation environment for renewable energy.
- PVLib: A Python library for modeling solar photovoltaic systems.

Websites and Resources

- NPTEL MOOC course: https://onlinecourses.nptel.ac.in/noc25_ch40/preview

Suggested Activities for Students:

- Energy Storage Solutions for Solar Power
- Building Integrated Photovoltaics (BIPV)
- Solar-Powered Desalination Plant
- Solar Thermal Energy for Industrial Applications
- Advanced Solar Panel Design
- Solar-Powered Microgrid
- Floating Wind Turbines
- Grid Integration of Wind Energy
- Vertical Axis Wind Turbine (VAWT) Development
- Wind Energy Forecasting Using Machine Learning
- Advanced Wind Turbine Materials

- Optimization of Wind Turbine Blade Design
- Kinetic Modeling of Biomass Combustion
- Design of a Small-Scale Biomass Gasifier
- Comparative Study of Biomass Feedstocks for Thermochemical Conversion
- Development of Biochar-Based Catalysts
- Torrefaction of Biomass for Improved Gasification
- Techno-Economic Analysis of Biomass-to-Fuel Pathways
- Modeling and Simulation of Biomass Conversion Systems
- Bio-Synthetic Natural Gas (Bio-SNG) Production
- Catalytic Upgrading of Pyrolysis Bio-Oil

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GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering
Level: PG
Branch: Chemical Engineering
Subject Code: ME03030031
Subject Name: Chemical Process Utilities

W.E.F. Academic Year:	A.Y. 2024-25
Semester:	3
Category of the Course:	MOPEC

Prerequisite:	Students should have a basic knowledge of unit process in chemical industries.
Rationale:	This course of Chemical Process Utilities encompasses the knowledge needed to design process plants and formulate plant layout designs. It encompasses the fundamental principles of chemical engineering, including the creation of flow diagrams, the significance of various design considerations, the diverse utility systems involved, and the critical selection criteria when developing and designing any process. This course aims to provide students with a comprehensive understanding, ranging from the basics to more advanced concepts, regarding the various process auxiliaries and utilities employed in chemical plants. It emphasizes how these components integrate with the overall process facilities and contribute to the efficient operation of the plant.

Course Outcome: Upon successful completion of this course, students will be able to:

No	Course Outcomes	RBT Level*
01	To understand the importance of process auxiliaries and utilities in a chemical industry.	20
02	To acquire an overview of key selection considerations of plant utilities	35
03	To understand how the utilities could be integrated with the process facilities and overall operation	20
04	To understand basic calculation involved in the steam generation, psychometric operation, and refrigeration	25

Course Scheme:

Teaching Scheme			Total Credits	Assessment Pattern and Marks				Total Marks
				Theory		Practical		
L	T	P	C	ESE (E)	PA(M)	ESE (V)	PA(I)	
3	0	0	3	70	30	0	0	100

GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering
Level: PG
Branch: Chemical Engineering
Subject Code: ME03030031
Subject Name: Chemical Process Utilities

Course Content:

Sr. No.	Course Content	No. of Hours	% of Weightage
1	**Introduction to Process Utilities** Utilities in process industries, primary & secondary and their importance, Introduction to Chemical Process Utilities, Energy Perspective to the Utilities, Criteria of selection. Cost of Utilities	4	8
2	**Steam Generation & Utilization:** Types of Industrial Steam Boiler, Modern boilers, Calculation of efficiency of boiler, Steam traps-classification and characteristics, Condensate recycle system, Efficient steam heating systems, Safety in boiler systems, Use of superheated steam in power plant, Combined heat, and power system.	12	27
3	**Thermal fluid heating system:** Hot oil, Dowtherm A, Dowtherm E, Molten salt and sodium-potassium alloys, Flow sheet of hot oil cycle and Dowtherm A cycle – Principle, construction and working, Hot air system, Furnace. Hot Insulation system.	4	9
4	**Process Water:** Sources of water, hard and soft water, Requisites of industrial water and its uses, Methods of water treatment – DM water plant and water softening plant, Reverse Osmosis plant.	7	15
5	**Cooling Water:** Different types of cooling towers and their selection criteria, Mass and Energy balance for cooling tower, Cooling water circuit.	3	7
6	**Refrigeration and Chilling systems:** Chilling water plant and brine plant, Vapour compression refrigeration plant and vapour absorption refrigeration plant, working, flow sheet and selection criteria. R134a vapour compression cycle and its mass, energy, and COP calculation, LiBr water vapour absorption cycle and its mass, energy and COP calculation, Use of economizer, Cold insulation system.	12	27
7	**Air :** Use of air in process in industries for conveying, drying and instrumentation; design of air receivers.	3	7
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
05	**20**	**15**	**15**	**10**	**05**

Where R: Remember; U: Understanding; A: Application; N: Analyze and E: Evaluate; C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

a. Books:

1. Plant design and Economics for Chemical Engineers, Max S Peters, Klaus D Timmerhaus, Ronald E West. Mc Graw Hill 5th Edition
2. Steam generators and waste heat boilers for process and plant engineers, V Ganapathy, CRC Press, Taylor & Francis Group.
3. Process Utility Systems: Introduction to Design, Operation, and Maintenance, Jack Broughton, I Chem E, UK
4. Water Treatment for Industrial and other uses, Nordell and Kskel, Reinhold Publishing Corporation, New York
5. Perry's Chemical Engineers' Handbook, 8th Edition, Robert H. Perry, Don W. Green, Mc Graw Hill Education.

b. Open-source software and website:

Open-source Software

DWSIM: Open-source software for chemical process simulation.

Websites and Resources:

NPTEL MOOC Course: https://onlinecourses.nptel.ac.in/noc24_ch10/preview

Suggested Project List:

- Design of Cooling Tower
- Design of Vapour absorption refrigeration plant
- Design of Vapour compression refrigeration plant
- Cold and Hot Insulation system
- Efficient Steam Heating System

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TEACHING SCHEME / DETAIL SYLLABUS

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ME

30 - CHEMICAL ENGINEERING

4

2024-25

Select Elective / Non-Elective

Subject Code

Enter Subject Name

Search

*L=lectures,T=tutorial,P=Practical,E=TheoryExternal,M=TheoryInternal,I=Practical Internal,V=Practical External,On Job Training(OJT) is equivalent to Practical

							Hours			Credit	Max Marks					
Exp.	Subcode	Branch code	Eff_from	SubjectName	Category	Sem /Year	L.	T.	P.	PBL	Total	E	M	I	V	Total
	ME04000011	030	2025-26	Internal Review Phase-II	Internal Review/Dissertation Work	4	0	0	8	NA	4	0	0	50	0	50
	ME04000021	030	2025-26	Dissertation Phase-II	Internal Review/Dissertation Work	4	0	0	32	NA	16	0	0	0	150	150

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Vishwakarma Government Engineering College

Chemical Engineering Department

SYLLABUS

[FROM JULY 2018 TO JUNE 2024]

GUJARAT TECHNOLOGICAL UNIVERSITY
Bachelor of Engineering
Subject Code: 3110001
CHEMISTRY
1ST YEAR

Type of course: Basic Science**.**

Prerequisite: Zeal to learn the subject.

Rationale: Chemistry is considered as Basic Science subject.

Teaching and Examination Scheme:

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

Contents:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	**General Chemistry:** Introduction to Chemical Sciences, Basics includes: Periodic properties, Effective nuclear charge, penetration of orbitals, variations of s, p, d and f orbital energies of atoms in the periodic table, electronic configurations, atomic and ionic sizes, ionization energies, electron affinity and electronegativity, polarizability, oxidation states, coordination numbers and geometries, hard soft acids and bases, molecular geometries Structure of an Atom, Formation of molecules – Kossel – Lewis approach to Chemical Bonding, Lewis Representations of Simple Molecules and Ions, Types of Bonds.	5	40%
2	**Water Technology:** Introduction, Sources of water, Impurities in water, Hardness of Water, Boiler Problems, Softening of water (External & Internal treatments), Domestic water treatments, Waste water treatments, Desalination of Brackish water.	5	
3	**Metals, Alloys and Corrosion:** Introduction, Physical properties of Metals, Definition and purpose of alloy, Classification of alloys. Alloys: Steel, Cu, Al, Pb and its industrial applications. Introduction to Corrosion, Theories of corrosion, Protective measurements against corrosion – organic and inorganic materials, Inhibitors, Cathodic protection.	6	
4	**Polymers and Fibers** Introduction, Classification based on Source, Structure, Molecular forces. Polymerization and its mechanism. Definition of Rubber, Types of Rubber, Vulcanization of rubber. Application of Rubber. Biodegradable Polymers, Commercially important polymers- PE, PP, PS, PVC, ABS, PMMA, Glyptal and their uses. Types of fibers – Natural, semi synthetic, synthetic fibers. Physical properties of fibers and uses of Cellulose acetate, Viscose Rayon, Nylon, Polyesters acrylic, Glass fibers and Liquid Crystals.	7	40%

5	**Nano material:** Introduction, Sources, Properties and application of fullerenes, fullerols, Metal based nanoparticles, Carbon nanotubes and nanowires. Synthesis: Top down and Bottom up approaches, Nanoelectronics. Applications of nanomaterial in catalysis, textile and medicine.	5	
6	**Fuel and Combustion:** Definition, Types of fuel and their applications. Calorific Value, Characteristics of good fuel. Analysis of coal – ultimate and proximate analysis, LPG, Natural gas, Biogas, Refining of Petroleum by Fractional distillation, Octane and Cetane Number, Unleaded Petrol and Diesel.	5	
7	**Chemical aspect of Biotechnology:** Introduction, Scope, importance and application, Benefits through biotechnology – Agriculture, Food quality, Medicines, Fermentation processes: Preparation of Ethanol and Acetic acid, Enzymes and its application in industries, Importance of Biofuels, Bio fertilizers, Bio surfactants and Bioreactors.	5	20%
8	**Analytical Techniques:** Measurement and understanding of pH, Conductance, and Potential, Spectroscopic techniques: Principles of Spectroscopy and Selection rules. UV-Visible Spectroscopy and its Application, Vibrational and Rotational spectroscopy (IR) of diatomic molecules and its application.	4	

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**50**	**10**	**30**	**0**	**0**

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

Reference Books:

1. Engineering Chemistry by Jain and Jain, Dhanpat Rai Publishing Co.
2. Engineering Chemistry Willey India Publisher
3. Engineering Chemistry by Marry Jane & Shultz, Cencage Learning Publisher
4. Engineering Chemistry by N. Krishnamurthy, P. Vallinaygam and D. Madhavan,
1. Prentice Hall of India Pvt. Ltd.
5. Engineering Chemistry by K. Sesha Maheswaramma and Mridula Chugh, Pearson India Education Pvt Ltd.
6. Engineering Chemistry by B K. Sharma, Krishna Prakashan Media (P) Ltd.
7. A textbook of Engineering Chemistry by Shashi Chawla, Dhanpatrai Publishing Co. Ltd.
8. Fundamentals of Biotechnology by B D Singh, Kalyani Publisher. New Delhi.
9. Essential of Physical Chemistry by Bahl and Tuli., S Chand & Co. Ltd, New Delhi.
10. Introduction to Nano Science by N N. Lindsay, Oxford University Press.
11. NANO: The Essentials by T Pradeep Tata McGraw-Hill Publishing Company, New Delhi.

Course Outcome:

Sr. No.	CO statement	Marks % weightage
CO-1	Relate periodic properties such as ionization potential, oxidation states and electro negativity.	15
CO-2	Analyze microscopic chemistry in terms of atomic and molecular orbital's and inter molecular forces.	10

CO-3	Describe the importance and relevance of chemistry in our everyday life	10
CO-4	Select the appropriate chemical material and utilization of it.	50
CO-5	Interpret the methods of science as a logical means of problem solving	10
CO-6	Distinguish the ranges of the electromagnetic spectrum used for exciting different molecular energy levels in various spectroscopic techniques.	5

LIST OF PRACTICALS: (Minimum 8 to be performed.)

1. Analysis of Steel Sample.
2. Analysis of Pyrolusite Ore.
3. Analysis of Brass Alloy.
4. Estimation of Hardness.
5. Gravimetric Analysis of decomposition of Na_2CO_3 & $NaHCO_3$.
6. Determination of Concentration of Unknown Solution Spectrophotometrically.
7. To study Wet Corrosion loss of Steel by weight loss method using electrochemical theory.
8. Stress Corrosion Cracking of Brass in NH_3 Solution.
9. To determine Alkalinity of a given Water Sample.
10. Determination of Saponification Value of Oil.
11. Determination of chloride content of water
12. Study of decomposition reaction of $ZnCO_3$ by Gravimetric analysis.
13. To determine the moisture content in coal.

Reference Books:

1. Laboratory Manual of Engineering Chemistry, by S K. Bhasin & Sudha Rani. Publisher: Dhanpat Rai Publishing Company Ltd.
2. Engineering Chemistry with Laboratory Experiments, by M S. Kaurav. Publisher: PHI Learning Pvt. Ltd. New Delhi.
3. Vogel's textbook of Quantitative Chemical Analysis, by Arthur I Vogel, Revised by Jeffery et al, Publisher: Addison Wesley, Longman Ltd, England
4. Engineering Chemistry with Laboratory Experiments, by R. P. Mani & Mishra, Publisher: Cen cage Publisher.

Major Equipment:

1. Spectrophotometer.
2. Laboratory Oven.
3. Melting Point Instrument.
4. Electronic Balance

List of Open Source Software/learning website:

NPTEL, World Wide Web, etc.

GUJARAT TECHNOLOGICAL UNIVERSITY
Bachelor of Engineering
Subject Code: 3110002

ENGLISH
B.E. 1ST YEAR

Type of course: Language and Communication

Prerequisite: Zeal to learn the subject

Rationale: The rationale of the curriculum is to help students refresh their knowledge of English language. It also targets the understanding of grammar, focusing on comprehension, and reading, speaking and writing skills. This would be developed through balanced and integrated tasks.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Topics	Teaching Hours	Module Weightage
1	Vocabulary building: Introduction to Word Formation Types of word formation processes: compounding, clipping, blending, derivation, creative respelling, coining and borrowing Acquaintance with prefixes and suffixes Synonyms, antonyms, and standard abbreviations.	06	20%
2	Phonetics: IPA Transcription Introduction to different accents	04	10%
3	Identifying Common Errors in Writing: Tenses Subject-verb agreement Noun-pronoun agreement Misplaced modifiers Articles Prepositions Modal Auxiliaries Redundancies	06	20%
4	Basic Writing Skills: Sentence Structures Use of phrases and clauses in sentences Importance of proper punctuation Creating coherence Organizing principles of paragraphs in documents	04	10%

5	Nature and Style of Writing: Describing Defining Classifying Writing introduction and conclusion	06	20%
6	Writing Practices: Comprehension Précis Writing Letter Writing Email etiquettes Abstract Memo writing	06	20%

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**10**	**20**	**20**	**20**	**20**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

(i) Technical English, Dr. M. Hemamalini, Wiley. 2014
(ii) Practical English Usage, Michael Swan, OUP. 1995
(iii) Remedial English Grammar, F.T. Wood, Macmillan. 2007
(iv) Oxford Language Reference, (Indian Edition) OUP
(v) On Writing Well, William Zinsser, Harper Resource Book. 2001
(vi) Study Writing, Liz Hamp-Lyons and Ben Heasly, Cambridge University Press. 2006
(vii) Communication Skills, Sanjay Kumar and Pushp Lata, Oxford University Press. 2011
(viii) Exercises in Spoken English, Parts. I-III. CIEFL, Hyderabad. Oxford University Press
(ix) The Study of Language, George Yule, CUP, 4th Edition. 2010
(x) A Course in English Phonetics, T R Kansakar, Orient Longman. 1998
(xi) Spoken English, R K Bansal and J B Harrison, Orient Longman. 2013

Course Outcome: At the end of the course students will be able to –

Sr. No	Course Outcomes	Weightage
CO1	Use various forms of vocabulary in varied situations in oral and written communication.	10%
CO2	Understand the phonetics and the transcription pattern to learn correct pronunciation.	10%
CO3	Comprehend the dynamics of various rules of grammar and check its validation while they speak and write language correctly.	20%

CO4	Use grammar effectively to make themselves competent Listener, Speaker, Reader and Writer by exposing to various set of situations.	20%
CO5	Write various formal and informal documents of day to day life and professional set up.	20%
CO6	Demonstrate the qualities of writing in diverse situation by using the nuances such as conciseness, clarity, accuracy, organization, and coherence.	20%

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List of Experiments:

Sr.No.	Activity type	Duration in hrs	Preferably to be conducted in:
1	Word Formation-1	2	Lab/classroom
2	Word Formation-2	2	Lab/classroom
3	Listening Comprehension	2	Lab/classroom
4	Transcription and dictionary usage	2	Lab/classroom
5	Common Everyday Situations: Conversations and Dialogues	4	Classroom/Hall
6	Communication at Workplace	4	Classroom/Hall
7	Common errors in writing	4	Classroom/Hall
8	Reading Comprehension	2	Classroom/Hall
9	Letter Writing, Precis Writing	4	Classroom/Hall
10	Email Writing: Formal and Informal	2	Lab/classroom
11	Practical assessment	4	Lab/classroom

GUJARAT TECHNOLOGICAL UNIVERSITY
Bachelor of Engineering
Subject Code: 3110003
PROGRAMMING FOR PROBLEM SOLVING
1ST YEAR

Type of course: Engineering Science

Prerequisite: Zeal to learn the subject

Rationale: Understanding of basic principles of Mechanical Engineering is required in various field of engineering.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Topics	Teaching Hours	Module Weightage
1	**Introduction to computer and programming:** Introduction, Basic block diagram and functions of various components of computer, Concepts of Hardware and software, Types of software, Compiler and interpreter, Concepts of Machine level, Assembly level and high level programming, Flowcharts and Algorithms	5	11
2	**Fundamentals of C:** Features of C language, structure of C Program, comments, header files, data types, constants and variables, operators, expressions, evaluation of expressions, type conversion, precedence and associativity, I/O functions	4	9
3	**Control structure in C:** Simple statements, Decision making statements, Looping statements, Nesting of control structures, break and continue, goto statement	5	11
4	**Array & String:** Concepts of array, one and two dimensional arrays, declaration and initialization of arrays, string, string storage, Built-in-string functions	6	13
5	**Functions:** Concepts of user defined functions, prototypes, definition of function, parameters, parameter passing, calling a function, recursive function, Macros, Pre-processing	5	11
6	**Recursion:** Recursion, as a different way of solving problems. Example programs, such as Finding Factorial, Fibonacci series, Ackerman function etc. Quick sort or Merge sort.	4	9
7	**Pointers:** Basics of pointers, pointer to pointer, pointer and array, pointer to array, array to pointer, function returning pointer	4	9
8	**Structure:** Basics of structure, structure members, accessing structure members, nested structures, array of structures, structure and functions, structures and pointers	4	9
9	**Dynamic memory allocation:** Introduction to Dynamic memory allocation, malloc, calloc	4	9
10	**File management:** Introduction to file management and its functions	4	9

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**30**	**30**	**20**	**0**	**0**

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

Reference Books:

1. Programming in ANCI C, Seventh edition, by Balagarusamy E, Tata McGraw-Hill Publishing Company Limited
2. Programming with C, Second edition, by Gottfried, Tata McGraw-Hill Publishing Company Limited
3. Star C Programming, Pub: STAR Certification
4. C Programming language, Second edition, by Kernighan B W and Ritchie D M Prentice Hall,
5. Let us C, Fifth edition, by Kanetkar Y. P., BPB Publication
6. Fundamentals of Computing and Programming in C, First Edition, Oxford University Press, 2009 by Pradip Dey, Manas Ghosh,
7. "Computer programming", Pearson Education, 2007 by Ashok N. Kamthane.
8. "How to Solve it by Computer", Pearson Education, Fourth Reprint, 2007 by R.G. Dromey.
9. Programming in C, Reema Theraja, Oxford.

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Formulate algorithm/flowchart for given arithmetic and logical problem	**10**
CO-2	Translate algorithm/flowchart into C program using correct syntax and execute it	**10**
CO-3	Write programs using conditional, branching, iteration, and recursion	**40**
CO-4	Decompose a problem into function	**20**
CO-5	Develop an application using the concepts of array, pointer, structure, and file management to solve engineering and/or scientific problems	**20**

List of Experiments:

1. Write a program to that performs as calculator (addition, multiplication, division, subtraction).
2. Write a program to find area of triangle(a=h*b*.5)
   a = area
   h = height
   b = base
3. Write a program to calculate simple interest (i = (p*r*n)/100)
   i = Simple interest
   p = Principal amount
   r = Rate of interest
   n = Number of years
4. Write a C program to interchange two numbers.
5. Write a C program to enter a distance in to kilometre and convert it in to meter, feet, inches and centimetre

6. Write a program to compute Fahrenheit from centigrade (f=1.8*c +32)
7. Write a C program to find out distance travelled by the equation d = ut + at^2
8. Write a C program to find that the accepted number is Negative, or Positive or Zero.
9. Write a program to read marks of a student from keyboard whether the student is pass or fail(using if else)
10. Write a program to read three numbers from keyboard and find out maximum out of these three. (nested if else)
11. Write a C program to check whether the entered character is capital, small letter, digit or any special character.
12. Write a program to read marks from keyboard and your program should display equivalent grade according to following table(if else ladder)

Marks	Grade
100 - 80	Distinction
79 - 60	First Class
59 - 40	Second Class
< 40	Fail

13. Write a c program to prepare pay slip using following data.
    Da = 10% of basic, Hra = 7.50% of basic, Ma = 300,
    Pf = 12.50% of basic, Gross = basic + Da + Hra + Ma, Nt = Gross – Pf.
14. Write a C program to read no 1 to 7 and print relatively day Sunday to Saturday.
15. Write a C program to find out the Maximum and Minimum number from given 10 numbers
16. Write a C program to input an integer number and check the last digit of number is even or odd.
17. Write a C program to find factorial of a given number.
18. Write a program to reverse a number.
19. Write a program to generate first *n* number of Fibonacci series
20. Write a program to find out sum of first and last digit of a given number.
21. Write a C program to find the sum and average of different numbers which are accepted by user as many as user wants
22. Write a program to calculate average and total of 5 students for 3 subjects (use nested *for* loops)
23. Read five persons height and weight and count the number of person having height greater than 170 and weight less than 50,
24. Write a program to check whether the given number is prime or not.
25. Write a program to evaluate the series 1^2+2^2+3^2+……+n^2
26. Write a C program to find 1+1/2+1/3+1/4+....+1/n.
27. Write a C program to find 1+1/2!+1/3!+1/4!+.....+1/n!.
28. Write a program to evaluate the series sum=1-x+x^2/2!-x^3/3!+x^4/4!.....-x^9/9!
29. Write a program to print following patterns :

```
i      *              ii       *              iii      *****
       * *                    *  *                     ****
       * * *       *  *  *                    ***
       * * * *           *  *   *  *          **
       * * * * *        *  *   *   *  *              *
```

30. Write a program to print following patterns :

```
i      1          ii      12345        iii      55555        iv      1
       12         1234                 4444                 22
       123                123                   333                  333
       1234               12                    22                   4444
       12345              1                     1                    55555
```

31. Write a program to print following patterns:

i	AAAAA	ii	ABCDE
	BBBB		ABCD
	CCC		ABC
	DD		AB
	E		A

32. Write a C program to read and store the roll no and marks of 20 students using array.
33. Write a program to find out which number is even or odd from list of 10 numbers using array
34. Write a program to find maximum element from 1-Dimensional array.
35. Write a C program to calculate the average, geometric and harmonic mean of *n* elements in an array.
36. Write a program to sort given array in ascending order (Use Insertion sort, Bubble sort, Selection sort, Mergesort, Quicksort, Heapsort).
37. Write a program to find a character from given string.
38. Write a program to replace a character in given string.
39. Write a program to delete a character in given string.
40. Write a program to reverse string.
41. Write a program to convert string into upper case
42. Write a program that defines a function to add first *n* numbers.
43. Write a function in the program to return 1 if number is prime otherwise return 0
44. Write a function Exchange to interchange the values of two variables, say x and y. illustrate the use of this function in a calling function.
45. Write a C program to use recursive calls to evaluate $F(x) = x - x^3 / 3! + x^5 / 5 ! - x^7 / 7! + \ldots x^n / n!$.
46. Write a program to find factorial of a number using recursion.
47. Write a C program using global variable, static variable.
48. Write a function that will scan a character string passed as an argument and convert all lowercase character into their uppercase equivalents
49. Write a program to read structure elements from keyboard.
50. Define a structure type *struct* personal that would contain person name, date of joining and salary using this structure to read this information of 5 people and print the same on screen.
51. Define structure data type called time_struct containing three member's integer hour, integer minute and integer second. Develop a program that would assign values to the individual number and display the time in the following format: 16: 40:51
52. Define a structure called cricket that will describe the following information:
    Player name
    Team name
    Batting average
    Using cricket, declare an array player with 50 elements and write a C program to read the information about all the 50 players and print team wise list containing names of players with their batting average.
53. Design a structure student_record to contain name, branch and total marks obtained. Develop a program to read data for 10 students in a class and print them.
54. Write a program to print address of variable using pointer.
55. Write a C program to swap the two values using pointers.

56. Write a C program to print the address of character and the character of string using pointer.
57. Write a program to access elements using pointer.
58. Write a program for sorting using pointer.
59. Write a program to write a string in file
60. A file named data contains series of integer numbers. Write a c program to read all numbers from file and then write all odd numbers into file named "odd" and write all even numbers into file named "even". Display all the contents of these file on screen

List of Open Source Software/learning website : Students must refer to following sites to enhance their learning ability.

1) Vlabs.iitb.ac.in
2) NPTEL tutorials
3) www.coursera.org
4) www.udacity.com

GUJARAT TECHNOLOGICAL UNIVERSITY
Bachelor of Engineering
Subject Code: 3110004

BASIC CIVIL ENGINEERING
1ST YEAR

Type of course: Engineering Science

Prerequisite:

Rationale:

Teaching & Examination Scheme:

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

Course Content:

Module	Content	Hours	Weightage
1.	**INTRODUCTION TO CIVIL ENGINEERING AND CIVIL ENGINEERING MATERIALS:** Introduction, Branches, Scope, Impact, Role of Civil Engineer, Units of measurement, Unit conversion (Length, Area, Volume). List of materials, Details (types, properties, uses) of materials: Cement, Aggregate, Brick, Steel, Concrete, Stone, Soil, Mortar, Timber, Plastic, Epoxy, Flyash, Steel slag, Copper slag, Bitumen, Optical fiber, Pipe, Wire, Cable, Smart material, Basic hand fill tests, FRP Water and waste water quality characteristics, drinking water standards, Road traffic, traffic control, traffic signals & Intersections.	10	20%
2.	**INTRODUCTION TO BUILDING AND TOWN PLANNING:** Definition and concept of plan of a simple residential building, Principles of planning, Elementary principles and basic requirements for building planning, elevation and section of a residential building. Principles of town planning, Necessity of town planning, Origin of town, Growth of town, Land use, Principles and objects of zoning, Advantages of zoning, Low cost housing, Prevention of slum, FSI.	08	20%
3.	**BUILDING CONSTRUCTION AND BUILDING SERVICES** **Building Construction:** Types of building, Components of building & its functions, types of loads acting on building, Types of brick bonds, Typical building layout, Symbols used in electrical layout, Symbols used for water supply, plumbing and sanitation. Nominal dimensions for door, window and furniture. **Building Services:** Types of building services like plumbing & sanitation, water supply& drainage system, electricity, building finishes, HVAC.	8	20%

4.	**INTRODUCTION TO SURVEYING AND LEVELLING:** Introduction, Fundamental principles, Classification. **Linear measurement:** Instruments used, Chaining on plane ground, Offset, Ranging. **Angular measurement:** Compass-Instrument used Meridian, Bearing, and Local attraction. **Leveling:** Instrument used, Terminology, Types of leveling, and Methods of leveling, Introduction to contour **Modern tools:** Introduction to Theodolite, Total Station, Introduction to GPS, GIS & RS	11	20%
5.	**ADVANCEMENTS IN CIVIL ENGINEERING:** Smart city and it's features, Solid waste management systems, Mass Transportation systems-BRTS, Metro, Rain water harvesting systems, Watershed Management, Green building, Energy efficient building, Development of River fronts, Heritage structures & its conservations, Features of Earthquake resistant structures	8	20%
		45 hrs	100%

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
35	**40**	**25**	**0**	**0**	**0**

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

Reference Book:

Title	**Author/s**	**Publication**
Surveying and leveling	N. N. Basak	Tata McGraw Hill Education
Civil engineering drawing	S.C. Rangwala	Charotar Publication
Building Construction	Dr.B.C.Punmia	Laxmi Pub. Delhi
Engineering Material	S.C. Rangwala	Charotar Publication
Town Planning	S. C. Rangwala	Charotar Publication
Heavy Construction	V. N. Vazirani and S. P. Chandola	Khanna Publication
Building planning, designing and scheduling	Gurucharan Singh	Standard Publisher
Basic Civil Engineering	S. Ramamrutham	Dhanpatrai Publication
Soil Mechanics and Foundation Engineering	B.C. Punamia	Laxmi Pub. Delhi
Environmental Engineering	H.S. Peavy, D.R. Rowe and G. Tchbanoglous	McGraw Hill International Edition
Estimation and Costing In Civil Engineering	B. N. Dutta	Ubs Publishers Distributors
Estimating and Costing	S. C. Rangwala	Charotar Publishing House
Basic Civil Engineering	M.S.Palanichamy	McGraw Hill

Basic Civil Engineering	Satheesh Gopi	Pearson Publisher

Course Outcome:

Sr. No.	CO statement	Marks % weightage
CO-1	describe the use of different materials in Civil Engineering	20
CO-2	interpret various aspect of the building and town planning	30
CO-3	identify the various building components, method of constructions , and services	10
CO-4	use different equipments for angular and linear measurements	30
CO-5	describe various public transportation system, water conservation methods, water -waste water quality and advances in civil engineering	10

List of Practical:

Sr No	**Name of Practical**	**Hours**
1.	Unit conversation Exercise.	02
2.	Chart preparation of various materials. Collection of rate and sample. (field visit)	02
3.	Components of building (field visit)	02
4.	Planning of a residential building(plan, elevation& section of simple 1 room)	04
5.	Assignment based upon town planning module 4	02
6.	Linear and angular measurements (Chain and Compass) (in field with instrument)	04
7.	Introduction to Theodolite & total station.	02
8.	Determine R.L of given point by Dumpy level. (in field with instrument)	02
9.	Assignment based upon estimation.(simple, 1 room only)	02
10.	Videos showing working of construction Equipment's	04
11.	Presentation on BRTS / mass transportation system (city bus)	04
12.	Seminar on green building & smart city	02
		32 hrs

Web Material Links:

- http://nptel.ac.in/courses/105107122/
- http://nptel.ac.in/courses/105107157/
- http://nptel.ac.in/courses/105101087/
- http://nptel.ac.in/courses/105104100/
- www.svnit.ac.in

GUJARAT TECHNOLOGICAL UNIVERSITY
Bachelor of Engienering
Subject Code: 3110005
BASIC ELECTRICAL ENGINEERING
1st Year

Type of course: Engineering Science

Prerequisite: NA

Rationale: Electricity has been the main source of energy for the developing and developed countries. Per capita consumption of electricity of a country can be considered as an indicator of the development of the country. In view of this, it is essential for all engineering graduates to know the basic aspects of electrical engineering. This subject deals with basic circuit solution methods, introduction to electrical machines and basics of domestic electrical installations.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	***DC Circuits:*** Electrical circuit elements (R, L and C), voltage and current sources, Kirchoff's current and voltage laws, analysis of simple circuits with dc excitation. Superposition, Thevenin and Norton Theorems. Time-domain analysis of first-order RL and RC circuits.	**8**	**20**
2	***AC Circuits*** Representation of sinusoidal waveforms, peak and RMS values, Phasor representation of AC quantities, real power, reactive power, apparent power, power factor. Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel), Series and parallel resonance. Three phase balanced circuits, voltage and current relations in star and delta connections, Power measurement in three phase circuits.	**10**	**25**
3	***Transformers*** Magnetic materials, BH characteristics. Construction and working principle of single phase and three phase transformers. Ideal and practical transformer. Auto-transformer and its applications**.**	**8**	**15**
4	***Electrical Machines*** Generation of rotating magnetic fields.	**8**	**20**

	Construction and working of following machines: • Three-phase induction motor • Single-phase induction motor. • Separately excited DC motor. • Synchronous generators.		
5	***Electrical Installations*** Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB. Types of Wires and Cables. Earthing – Types of earthing and its importance. Safety precautions for electrical appliances. Types of Batteries, Important Characteristics for Batteries. Elementary calculations for energy consumption. Basics of power factor improvement.	**8**	**20**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
40	**20**	**20**	**20**	**0**	**0**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

(i) D. C. Kulshreshtha, "Basic Electrical Engineering", McGraw Hill, 2009.
(ii) Basic Electrical Engineering - Nagsarkar and Sukhija, Oxford University Press
(iii) B. L. Theraja, "Electrical Technology – Part I and II", S. Chand and Co. 2012
(iv) D. P. Kothari and I. J. Nagrath, "Basic Electrical Engineering", Tata McGraw Hill, 2010.
(v) L. S. Bobrow, "Fundamentals of Electrical Engineering", Oxford University Press, 2011.
(vi) E. Hughes, "Electrical and Electronics Technology", Pearson, 2010.
(vii) V. D. Toro, "Electrical Engineering Fundamentals", Prentice Hall India, 1989.

Course Outcomes

Sr. No.	CO statement	Marks % weightage
CO-1	Apply fundamental electrical laws and circuit theorems to electrical circuits.	20
CO-2	Analyze single phase and three phase AC circuits.	25
CO-3	Describe operating principle and applications of static and rotating electrical machines.	35
CO-4	Comprehend electrical installations, their protection and personnel safety.	20

List of Experiments:

(1) Introduction and use of measuring instruments – voltmeter, ammeter, multi-meter, oscilloscope. Resistors, Capacitors and Inductors.
(2) To verify the DC circuit currents and voltages by calculations and actual measurements.
(3) To verify the Kirchoff's current and voltage laws.
(4) To verify the Network theorems.
(5) To obtain sinusoidal steady state response of R-L and R-C circuits – impedance calculation and verification. Observation of phase differences between current and voltage.
(6) Measuring the steady-state and transient time-response of R-L, R-C, and R-L-C circuits to a step change in voltage (transient may be observed on a Digital Storage Oscilloscope).
(7) To verify the resonance in R-L-C circuits.
(8) To measure the power in three phase circuits using two wattmeter method.
(9) To verify the current and voltage relationships in three phase star and delta connections.
(10) Demonstration of cut-section models and charts of various machines.
(11) Demonstration of domestic installations like MCB, ELCB, MCCB etc.
(12) Understanding of various safety precautions for electrical installations.
(13) Demonstration of various types of wires and cables.
(14) Understanding of various electricity bills and calculations for energy consumption.
(15) To verify the power factor improvement in single phase AC circuit.

Major Equipment:

Ammeters, Voltmeters, Wattmeters, Resistors, Capacitors and Inductors of appropriate rating. Multimeters, Digital storage oscilloscope, Cut section models/charts of various machines, Demo units for MCB, ELCB, MCCB etc, Samples of wires and cables. Charts for earthing and safety precautions.

List of Open Source Software/learning website:

www.vlabs.co.in

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3110006
Semester – I/II
Subject Name: Basic Mechanical Engineering

Type of course: Engineering Science

Prerequisite: Zeal to learn the subject

Rationale: Understanding of basic principles of Mechanical Engineering is required in various field of engineering.

Teaching and Examination Scheme:

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

Content:

Sr #	Topic	Total Hrs.
1	**Introduction:** Prime movers and its types, Concept of Force, Pressure, Energy, Work, Power, System, Heat, Temperature, Specific heat capacity, Change of state, Path, Process, Cycle, Internal energy, Enthalpy, Statements of Zeroth law and First law	**4**
2	**Energy:** Introduction and applications of Energy sources like Fossil fuels, Nuclear fuels, Hydro, Solar, Wind, and Bio-fuels, Environmental issues like Global warming and Ozone depletion	**3**
3	**Properties of gases:** Boyle's law, Charles's law, Gay-Lussac's law, Avogadro's law, Combined gas law, Gas constant, Relation between c_p and c_v, Various non-flow processes like constant volume process, constant pressure process, Isothermal process, Adiabatic process, Polytropic process	**5**
4	**Properties of Steam:** Steam formation, Types of steam, Enthalpy, Specific volume, Internal energy and dryness fraction of steam, use of steam tables, steam calorimeters	**6**
5	**Heat Engines:** Heat engine cycle and Heat engine, working substances, Classification of heat engines, Description and thermal efficiency of Carnot; Rankine; Otto cycle and Diesel cycles	**5**
6	**Steam Boilers:** Introduction, Classification, Cochran, Lancashire and Babcock and Wilcox boiler, Functioning of different mountings and accessories	**-**
7	**Internal Combustion Engines:** Introduction, Classification, Engine details, four-stroke/ two-stroke cycle Petrol/Diesel engines, Indicated power, Brake Power, Efficiencies	**4**
8	**Pumps:** Types and operation of Reciprocating, Rotary and Centrifugal pumps, Priming	**3**
9	**Air Compressors:** Types and operation of Reciprocating and Rotary air compressors, significance of Multistage	**3**
10	**Refrigeration & Air Conditioning:** Refrigerant, Vapor compression refrigeration system, Vapor absorption refrigeration system, Domestic Refrigerator, Window and split air conditioners	**4**

11	**Couplings, Clutches and Brakes:** Construction and applications of Couplings (Box; Flange; Pin type flexible; Universal and Oldham), Clutches (Disc and Centrifugal), and Brakes (Block; Shoe; Band and Disc)	-
12	**Transmission of Motion and Power:** Shaft and axle, Different arrangement and applications of Belt drive; Chain drive; Friction drive and Gear drive	-
13	**Engineering Materials:** Types, properties and applications of Ferrous & Nonferrous metals, Timber, Abrasive material, silica, ceramics, glass, graphite, diamond, plastic and polymer	**4**

Note: Topic No. 6, 11 and 12 of the above syllabus are to be covered in Practical Hours.

Distribution of marks weightage for cognitive level:

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	**40**	**40**	**-**	**-**	**-**

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Elements of Mechanical Engineering by N M Bhatt and J R Mehta, Mahajan Publishing House
2. Basic Mechanical Engineering by Pravin Kumar, Pearson Education
3. Fundamental of Mechanical Engineering by G.S. Sawhney, PHI Publication New Delhi
4. Elements of Mechanical Engineering by Sadhu Singh, S. Chand Publication
5. Introduction to Engineering Materials by B.K. Agrawal, McGraw Hill Publication, New Delhi

Course Outcome:

Sr. No.	CO statement	Marks % weightage
CO-1	Discuss the various sources of energy and basic terminology of Mechanical engineering	14
CO-2	Make calculations for commonly used working fluids i.e. ideal gases and steam	22
CO-3	Analyze various heat engine cycles and understand construction and working of IC engines	20
CO-4	Discuss working and applications of steam boilers and various energy conversion systems	28
CO-5	Discuss various power transmission elements and properties of various engineering materials with their applications	16

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3110006

List of Experiments:

1. To understand construction and working of various types of boilers.
2. To understand construction and working of different boiler mountings and accessories.
3. To understand construction features of two/four stoke petrol/diesel engines
4. To determine brake thermal efficiency of an I. C. Engine.
5. To understand construction and working of different types of air compressors.
6. To demonstrate vapor compression refrigeration cycle of domestic refrigerator OR window air conditioner OR split air conditioner.
7. To understand construction, working and application of clutches, coupling and brakes
8. To understand different arrangement and application of various power transmission drives

Major Equipment: Models of Cochran, Lancashire and Babcock and Wilcox boilers, models of various mountings and accessories, Models of various types of IC engines, Single cylinder two stroke /four stroke petrol/ diesel engine, models of pumps, compressors, Domestic refrigerator/window air conditioner/split air conditioner, models of various types of brakes, coupling, clutches, drives

List of Open Source Software/learning website: https://nptel.ac.in, www.vlab.co.in

GUJARAT TECHNOLOGICAL UNIVERSITY
Bachelor of Engineering
Subject Code: 3110007

ENVIRONMENTAL SCIENCE
1st Year

Type of course: Mandatory Course

Prerequisite: Interest in natural systems sustaining the life on the earth.

Rationale: To inculcate the environmental values translating into pro-conservation actions. Honorable Supreme Court of India has made it 'mandatory' to introduce a basic course on environment at the undergraduate level.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE(E)	PA (M)	ESE (V)	PA(I)	
2	2	0	0	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**INTRODUCTION TO ENVIRONMENT** Definition, principles and scope of Environmental Science. Impacts of technology on Environment, Environmental Degradation, Importance for different engineering disciplines	02	8
2	**ENVIRONMENTAL POLLUTION** a) Water Pollution: Introduction – Water Quality Standards, Sources of Water Pollution, Classification of water pollutants, Effects of water pollutants b) Air Pollution: Composition of air, Structure of atmosphere, Ambient Air Quality Standards, Classification of air pollutants, Sources of common air pollutants like PM, SO_2, NO_X, Auto exhaust, Effects of common air pollutants c) Noise Pollution: Introduction, Sound and Noise, Noise measurements, Causes and Effects d) Solid Waste: Generation and management e) Bio-medical Waste: Generation and management f) E-waste: Generation and management	14	44
3	**GLOBAL ENVIRONMENTAL ISSUES** Sustainable Development, Climate Change, Global Warming and Green House Effect, Acid Rain, Depletion of Ozone layer, Carbon Footprint, Cleaner Development Mechanism (CDM), International Steps for Mitigating Global Change	06	24

4	**BASIC CONCEPT OF GREEN BUILDING AND SMART CITIES** Green Building: Introduction, Objectives, Fundamental Principles, Benefits of Green Building, Examples of Green Building Smart Cities: Concept	04	16
5	**CONCEPT OF 4R's** Principles, Application of 4R's	02	8

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
40	**40**	**20**	**0**	**0**	**0**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Textbook of Environmental Studies for Undergraduate Courses by Erach Bharucha Second edition,2013 Publisher: Universities Press (India) Private Ltd, Hyderabad.
2. Basics of Environmental Studies by Prof Dr N S Varandani ,2013 Publisher: LAP -Lambert Academic Publishing , Germany
3. Environmental Studies by Anindita Basak ,2009 Publisher: Drling Kindersley(India)Pvt. Ltd Pearson
4. Textbook of Environmental Studies by Deeksha Dave & S S Kateva , Cengage Publishers.
5. Environmental Sciences by Daniel B Botkin & Edward A Keller Publisher: John Wiley & Sons.
6. Environmental Studies by R. Rajagopalan, Oxford University Press
7. Environmental Studies by Benny Joseph, TMH publishers
8. Environmental Studies by Dr. Suresh K Dhameja, 2007 Published by : S K Kataria & Sons New Delhi
9. Basics of Environmental Studies by U K Khare, 2011 Published by Tata McGraw Hill

Course Outcome:

Sr. No.	CO statement	Marks % weightage
CO-1	Identify the types of pollution in society along with their sources	45
CO-2	Realize the global environmental issues	25
CO-3	Conceptualize the principles of Green Buildings and Smart cities	15
CO-4	Implement the concept of recycle and reuse in all fields of engineering	15

List of Tutorials: Based on

1. Introduction to Environment
2. Water Pollution
3. Air Pollution
4. Noise Pollution
5. Solid Waste
6. Bio-medical Waste
7. E-waste
8. Global Environmental Issues
9. Concept of Green Building
10. Concept of Smart Cities
11. Concept of 4R's

List of Open Source Software/learning website: MOEF, NPTEL

GUJARAT TECHNOLOGICAL UNIVERSITY
Bachelor of Engineering
Subject Code: 3110012

WORKSHOP/ MANUFACTURING PRACTICES

B.E. 1st YEAR

Type of course: Engineering Science

Prerequisite: Zeal to learn the subject

Rationale: Workshop practice is the backbone of the real industrial environment which helps to develop and enhance relevant technical hand skills required by the technician working in the various engineering industries and workshops. Irrespective of branch, the use of workshop practices in day to day industrial as well domestic life helps to dissolve the problems.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
0	0	4	2	0	0	80	20	100

Contents:
Introduction to various shops / sections and workshop layouts. Safety norms safety equipment's to be followed in a workshop.
Demonstration of hand tools, power tools, basic measuring instruments, marking and measurement. Overview of Carpentry, Fitting, Smithy shop, Welding, Tin smithy, Electrical and Electronic, Plumbing, Machine shop and machine tools.

Practice:
Students are required to prepare one job each in the following shops: Fitting, Carpentry, Smithy /Tin smithy, Electric Arc welding/ Resistance welding.
Demonstrations of Jobs in following machine shops: Lathe Machine, Drilling Machine, Hacksaw Machine

Course Outcome:

Sr. No.	CO statement
CO-1	Understand various manufacturing processes in machine shop and perform basic operations of welding, fitting, smithy and carpentry work a) perform basic operations of welding, fitting, smithy and carpentry work b) Explain various manufacturing processes in machine shop
CO-2	Discuss application of plumbing fitting, masonry items and about plastic molding and glass cutting for various engineering application
CO-3	Measure different electrical quantities and trouble shoot electrical and electronics appliances.
CO-4	Conduct experiments with various kits such as Raspberry and Arduino for embedded system development
CO-5	Use basic commands of computer operating systems

Workshop Practice:

1) Machine shop
2) Fitting shop
3) Carpentry
4) Welding shop
5) Electrical
6) Electronics
7) Casting
8) Smithy
9) Plastic moulding & Glass Cutting
10) Plumbing and its fitting
11) Masonry Work
12) IOT
13) **Software Tools & OS Commands**

List of Experiments

Machine shop

1. Demonstration of job on Lathe machine
2. Demonstration of job on Drilling machine
3. Study of different types of power tools

Fitting Shop

Hands on Practice and job making in Fitting shop

Carpentry

Hands on Practice and job making in Carpentry shop.

Welding shop

1. Hands on Practice and job making using Electric arc Welding / Resistance welding process
2. Hands on Practice and job making using Soldering process

Casting:

Demonstration of Pattern Making by sand moulding

Smithy

Hands on Practice and job making in Smithy/ Tin smithy shop.

Plumbing and its fitting

1) Types of Pipes and Fittings
2) Joints (PVC and Metal)
3) Plumbers tools and equipment's
4) Cutting and bending of different mental pipes

5) Pipe fitting
6) Plumbing symbols
7) Plumbing services
8) Sanitary Pipes and Fittings
9) Joints

Plastic moulding & Glass Cutting

Masonry Work

1) Different types of Bricks
2) Different size and part of Bricks
3) Different types of Bonds
4) Types of tools used for various masonry works

Electrical

1. Measure voltage, current, frequency, phase difference, power, power factor for single and three-phase supply
2. Wire fan, tube light, two-way control (staircase wiring).
3. Wire MCB, ELCB for a given load circuit
4. Preparing the drawing for wiring a newly built room, without any electrical wiring along with a bill of materials with specifications; the room may be a class-room, an office, a shop, a clinic, a small workshop etc.
5. Identify and rectify open circuit, and short circuit faults in PCB/System
6. Solder and de-solder electronic components on different types of PCB
7. Identify various types of ports and connectors

Electronics:

1) Introduction to basic electronics components and its testing: Resistors, Inductors, Capacitor, Diode, BJT
2) Introduction to testing and Measurement Instruments: Power Supply, Function Generator, Oscilloscope

IOT

Arduino starter kits or raspberry pi

i.e. Arduino Starter kit mostly includes following:, Similarly for Raspberry pi use whatever required

- An Arduino or Raspberry
- Jumper wires
- Resistors
- Breadboard
- LEDs
- Buttons

Case Studies/Demonstration

1. Arduino LED On/Off

2. Or Raspberry LED/On

It requires

- LED
- Resistor
- Connecting wires

3. Arduino alarm system which detects movement of an intruder with a high pitched alarm sounds and flashing lights.

It requires

- An ultrasonic "ping" sensor –HC-SR04 or PIR
- A piezo buzzer
- LED strip light

4. Arduino Trafiic Light Controller

5. raspberry pi on screen keyboard app.

It requires

- Red, yellow and green LEDs.
- A breadboard.
- 6 x 220 resistors.
- Connecting wires.
- 1 x pushbutton switch.
- 1 x 10k resistor

Software Tools & OS Commands

- **Dream weaver Web development Too**l

Student Has to build his own Web Site consisting of basic profile about his department,his own personnel profile and basic Institute Details

Student Has to learn any of Two OS (Windows,Linux,Unix,MacOS,Apple,Android)

Student has to learn basic Windows and Linux/Ubuntu shell commands and have to develop simple shell script.

Journal is to be prepared covering the topics of demonstration and report about process / methodology /

inspection for making jobs.

Major Equipment: Lathe machine, drilling machine, grinding machine, Resistance and Arc Welding machine, Hacksaw machine, Fitting, Carpentry and Plumbing vice, various types of files for fitting shop, hand hacksaw, monkey spanner, die, chisels, jack plane, furnace, anvil, different types of hammers for various shops, tongs, scissors, hand shear machine, sheet cutter, welding goggles, welding gloves, Soldering iron, Moulding box, different wooden/ metal patterns.

List of Open Source Software/learning website: http://nptel.iitm.ac.in/courses.php

Reference Books:

1. Hajra Choudhury S.K., Hajra Choudhury A.K. and Nirjhar Roy S.K., "Elements of Workshop Technology", Vol. I 2008 and Vol. II 2010, Media promoters and publishers private limited, Mumbai.
2. Rao P.N., "Manufacturing Technology", Vol. I and Vol. II, Tata McGraw Hill House, 2017.
3. Workshop Technology Vol. 1 and 2 by Raghuvanshi B.S. Dhanpat Rai & Sons1998
4. Workshop Technology by Chapman W.A. J and Arnold E. Viva low priced student edition, 1998
5. Workshop Practices, H S Bawa, Tata McGraw-Hill,2009

P.S: Out of 13 activities, college has to opt for any 8 activities for a specific branch.

Each activity will be of 4 hours per semester.

GUJARAT TECHNOLOGICAL UNIVERSITY
Bachelor of Engineering
Subject Code: 3110013
ENGINEERING GRAPHICS & DESIGN
1st YEAR

Type of course: Engineering Science

Prerequisite: Zeal to learn the subject

Rationale: Engineering Drawing is an effective language of engineers. It is the foundation block which strengthens the engineering & technological structure. Moreover, it is the transmitting link between ideas and realization.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	**Introduction to Engineering Graphics:** Drawing instruments and accessories, BIS – SP 46. Use of plane scales, Diagonal Scales and Representative Fraction	2 (Lab teaching)	20%
2	**Loci of Points:** Path of the points moving on Simple mechanisms, Slider crank mechanism, Four bar mechanism	2	
3	**Engineering Curves:** Classification and application of Engineering Curves, Construction of Conics, Cycloidal Curves, Involutes and Spirals along with normal and tangent to each curve	6 (Lab teaching)	
4	**Projections of Points and Lines:** Introduction to principal planes of projections, Projections of the points located in same quadrant and different quadrants, Projections of line with its inclination to one reference plane and with two reference planes. True length and inclination with the reference planes	8	30%
5	**Projections of Planes:** Projections of planes (polygons, circle and ellipse) with its inclination to one reference plane and with two reference planes, Concept of auxiliary plane method for projections of the plane	6	
6	**Projections of Solids, Section of Solids and Development of Surfaces:** Classification of solids. Projections of solids (Cylinder, Cone, Pyramid and Prism) along with frustum with its inclination to one reference plane and with two reference planes, Section of such solids and the true shape of the section, Development of surfaces	10	15%
7	**Orthographic Projections:** Fundamental of projection along with classification, Projections from the pictorial view of the object on the	2	25%

	principal planes for view from front, top and sides using first angle projection method and third angle projection method, full sectional view		
8	**Isometric Projections and Isometric View or Drawing:** Isometric Scale, Conversion of orthographic views into isometric projection, isometric view or drawing of simple objects	2 (Lab teaching)	
9	**Computer Aided Drawing:** Introduction to AutoCAD, Basic commands for 2D drawing like : Line, Circle, Polyline, Rectangle, Hatch, Fillet, Chamfer, Trim, Extend, Offset, Dim style, etc..	4 (Lab teaching)	10%

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
25	**30**	**30**	**5**	**5**	**5**

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

Reference Books:

1. A Text Book of Engineering Graphics by P.J.Shah S.Chand & Company Ltd., New Delhi
2. Elementary Engineering Drawing by N.D.Bhatt Charotar Publishing House, Anand
3. A text book of Engineering Drawing by R.K.Dhawan, S.Chand & Company Ltd., New Delhi
4. A text book of Engineering Drawing by P.S.Gill, S.K.Kataria & sons, Delhi
5. Engineering Drawing by B. Agrawal and C M Agrawal, Tata McGraw Hill, New Delhi

Course Outcome:

Sr. No.	CO statement	Marks % weightage
CO-1	Know and understand the conventions and the methods of engineering drawing.	15
CO-2	Interpret engineering drawings using fundamental technical mathematics.	25
CO-3	Construct basic and intermediate geometry and comprehend the theory of projection.	25
CO-4	Improve their visualization skills so that they can apply these skills in developing new products.	25
CO-5	Improve their technical communication skill in the form of communicative drawings.	05
CO-6	Use computer software for engineering drawing.	05

List of Practical:

Students must prepare sketch book and drawing sheets on the following topics. **Minimum three problems must be given for sheet number 3 to 9.**

1. Practice sheet (which includes dimensioning methods, different types of line, construction of different polygon, divide the line and angle in parts, use of stencil)
2. Plane scale and diagonal scale
3. Loci of points (only sketch book)
4. Engineering curves
5. Projection of line
6. Projection of plane
7. Projection of solid, section of solid and development of surfaces
8. Orthographic projection
9. Isometric projection
10. At least one orthographic drawing (three views) using above mentioned AutoCAD commands.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3110014
SUBJECT NAME: Mathematics-1
1st Year

Type of course: Basic Science Course

Prerequisite: Algebra, Trigonometry, Geometry

Rationale: The study of rate of changes, understanding to compute area, volume and express the function in terms of series, to apply matrix algebra**.**

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	2	0	5	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs	% Weightage
01	Indeterminate Forms and L'Hôspital's Rule.	01	15 %
	Improper Integrals, Convergence and divergence of the integrals, Beta and Gamma functions and their properties.	03	
	Applications of definite integral, Volume using cross-sections, Length of plane curves, Areas of Surfaces of Revolution	03	
02	Convergence and divergence of sequences, The Sandwich Theorem for Sequences, The Continuous Function Theorem for Sequences, Bounded Monotonic Sequences, Convergence and divergence of an infinite series, geometric series, telescoping series, □□□ term test for divergent series, Combining series, Harmonic Series, Integral test, The p - series, The Comparison test, The Limit Comparison test, Ratio test, Raabe's Test, Root test, Alternating series test, Absolute and Conditional convergence, Power series, Radius of convergence of a power series, Taylor and Maclaurin series.	08	20 %
03	Fourier Series of *2*□ periodic functions, Dirichlet's conditions for representation by a Fourier series, Orthogonality of the trigonometric system, Fourier Series of a function of period *2*□, Fourier Series of even and odd functions, Half range expansions.	04	10 %
04	Functions of several variables, Limits and continuity, Test for non existence of a limit, Partial differentiation, Mixed derivative theorem, differentiability, Chain rule, Implicit differentiation, Gradient, Directional derivative, tangent plane and normal line, total differentiation, Local extreme values, Method of Lagrange Multipliers.	08	20 %
05	Multiple integral, Double integral over Rectangles and general regions, double integrals as volumes, Change of order of integration, double integration in polar coordinates, Area by double integration, Triple integrals in rectangular, cylindrical and spherical coordinates, Jacobian, multiple integral by substitution.	08	20 %
06	Elementary row operations in Matrix, Row echelon and Reduced row echelon forms, Rank by echelon forms, Inverse by Gauss-Jordan method,	07	15%

	Solution of system of linear equations by Gauss elimination and Gauss-Jordan methods. Eigen values and eigen vectors, Cayley-Hamilton theorem, Diagonalization of a matrix.		

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	25	35	0	0	0

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

Reference Books:

(1) Maurice D. Weir, Joel Hass, Thomas' Calculus, Early Transcendentals, 13e, Pearson, 2014.
(2) Howard Anton, Irl Bivens, Stephens Davis, Calculus, 10e, Wiley, 2016.
(3) James Stewart, Calculus: Early Transcendentals with Course Mate, 7e, Cengage, 2012.
(4) Anton and Rorres, Elementary Linear Algebra, Applications version,, Wiley India Edition.
(5) T. M. Apostol, Calculus, Volumes 1 & 2,, Wiley Eastern.
(6) Erwin Kreyszig, Advanced Engineering Mathematics, Wiley India Edition.
(7) Peter O'Neill, Advanced Engineering Mathematics, 7th Edition, Cengage.

Course Outcomes

The objective of this course is to familiarize the prospective engineers with techniques in calculus, multivariate analysis and matrices. It aims to equip the students with standard concepts and tools at an intermediate to advanced level that will serve them well towards tackling more advanced level of mathematics and applications that they would find useful in their disciplines.

Sr. No.	Course Outcomes	Weightage in %
1	To apply differential and integral calculus to improper integrals and to determine applications of definite integral. Apart from some other applications they will have a basic understanding of indeterminate forms, Beta and Gamma functions.	15
2	To apply the various tests of convergence to sequence, series and the tool of power series and fourier series for learning advanced Engineering Mathematics.	30
3	To compute directional derivative, maximum or minimum rate of change and optimum value of functions of several variables.	20
4	To compute the areas and volumes using multiple integral techniques.	20
5	To perform matrix computation in a comprehensive manner.	15

List of Open Source Software/learning website:

Scilab, MIT Opencourseware.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3110015
SUBJECT NAME: Mathematics-2
1st Year

Type of course: Basic Science Course

Prerequisite: Calculus, fourier series

Rationale: To compute line integrals, solution techniques of higher order ordinary differential equations, fourier integral representation**.**

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	2	0	5	70	30	0	0	100

Sr. No.	Content	Total Hrs	% Weightage
01	Vector Calculus: Parametrization of curves, Arc length of curve in space, Line Integrals, Vector fields and applications as Work, Circulation and Flux, Path independence, potential function, piecewise smooth, connected domain, simply connected domain, fundamental theorem of line integrals, Conservative fields, component test for conservative fields, exact differential forms, Div, Curl, Green's theorem in the plane (without proof).	9	20
02	Laplace Transform and inverse Laplace transform, Linearity, First Shifting Theorem (s-Shifting), Transforms of Derivatives and Integrals, ODEs, Unit Step Function (Heaviside Function), Second Shifting Theorem (t-Shifting), Laplace transform of periodic functions, Short Impulses, Dirac's Delta Function, Convolution, Integral Equations, Differentiation and Integration of Transforms, ODEs with Variable Coefficients, Systems of ODEs.	7	20
03	Fourier Integral, Fourier Cosine Integral and Fourier Sine Integral.	02	
04	First order ordinary differential equations, Exact, linear and Bernoulli's equations, Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type.	6	14
05	Ordinary differential equations of higher orders, Homogeneous Linear ODEs of Higher Order, Homogeneous Linear ODEs with Constant Coefficients, Euler–Cauchy Equations, Existence and Uniqueness of Solutions, Linear Dependence and Independence of Solutions, Wronskian, Nonhomogeneous ODEs, Method of Undetermined Coefficients, Solution by Variation of Parameters.	10	26
06	Series Solutions of ODEs, Special Functions, Power Series Method, Legendre's Equation, Legendre Polynomials, Frobenius Method, Bessel's Equation, Bessel functions of the first kind and their properties.	8	20

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering

Subject Code: 3110015

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**25**	**35**	**0**	**0**	**0**

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

Reference Books:

(1) Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, John Wiley and Sons.
(2) Peter O'Neill, Advanced Engineering Mathematics, 7th Edition, Cengage.
(3) Dennis G. Zill, 4th edition, Advanced Engineering Mathematics, 4th Edition, Jones and Bartlett Publishers.
(4) Maurice D. Weir, Joel Hass, Thomas' Calculus, Early Transcendentals, 13e, Pearson, 2014.
(5) Howard Anton, Irl Bivens, Stephens Davis, Calculus, 10e, Wiley, 2016.

Course Outcomes:

The objective of this course is to familiarize the prospective engineers with techniques in vector calculus, ordinary differential equations, fourier integrals and laplace transform. It aims to equip the students to deal with advanced level of mathematics and applications that would be essential for their disciplines.

Sr. No.	Course Outcomes	Weightage in %
1	To apply mathematical tools needed in evaluating vector calculus and their usage like Work, Circulation and Flux.	20
2	To apply the laplace transform as tools which are used to solve differential equations and fourier integral representation.	20
3	To apply effective mathematical tools for the solutions of first order ordinary differential equations.	14
4	To apply effective mathematical methods for the solutions of higher order ordinary differential equations.	26
5	To use series solution methods and special functions like Bessels' functions.	20

List of Open Source Software/learning website:

Scilab, MIT Opencourseware.

Induction Program

Preamble:

The goal of engineering education is to train engineering graduates well in branch of admission, have a holistic personality and must have desire to serve society and nation. It is expected that an engineering graduate work for solving the problems of society using the modern technologies and practices. That needs the broad understanding of the society and relationships. It is needed to cultivate the human values in engineering graduates to fulfil his responsibilities as an engineer, a citizen and a human being.

Considering the various social backgrounds and whether a student comes from the urban or rural areas they differ in many of the life skills and their abilities and thinking. There branch of admission may be due to rush; their interest in subject is question. They are facing the issues like hostel and settlements, pressures from peers and many related issues. To overcome such issues, it is necessary to create an environment for students so that they feel comfortable, find their interest and explore their inner beings, create bonding with other students, establish relation with teachers, work for excellence, get a broader view of life and practice human values to build characters. The Induction Program covers the various activities which enables them to overcome all such issues and motivates them to perform well in their chosen branch of admission.

Scheme:

Sr No	Phase and Activities Heads	Weightage
1.	**Initial Phase**	**1 day (6 Hrs)**
2	**Regular Phase**	**13 Days**
a)	Physical activity	24 Hours
b)	Creative Arts	12 Hours
c)	Universal Human Values	12 Hours
d)	Literary	12 Hours
e)	Proficiency Modules	6 Hours
f)	Lectures by Eminent People	3 Hours: 3 Expert Lectures, One per Week
g)	Visits to local Areas or Industry	1 Day
h)	Innovations	3 Hours
3	**Closing Phase**	**1 Day (6 Hrs)**
	Total	**90 Hours**

Phases, Modules, Activities and Guidelines:

The activity during Induction Program would have an Initial Phase, a Regular Phase and a Closing Phase. The initial and closing phaseswould be one day each. The following is the guidelines indicating the possible activities under eachphaseof the Induction Program.

Initial Phase (First Day)

Following are the activities to be carried on the first day:

- Orientation Programme
- Know your Department/Institute
- Know your university
- Know hostel and other amenities
- Information about Student Diary and Induction Program

Regular phase (13 Days)

The Regular Phase consists of 13 days, each day is of 6 hours. It covers all the 8 different activity modules. For each module, the objectives, suggested activities and guidelines are provided herewith. Institute can use additional relevant activities in additional in suggested activities for each of the phases.

Module Name	Objectives	Suggested Activities
1. Physical Activity **(24 hours)**	1. Improve bone health 2. Improve cardio respiratory and muscular fitness 3. Understand theanatomy, basic biomechanical principles and terminology. 4. Examine the effect of nutrition, rest and other lifestyle factors that contribute tothebetter health.	1. Running/Jogging 2. Brisk Walk 3. Cycling 4. Heavy yard work 5. Swimming 6. Yoga/Pranayam 7. Aerobics 8. Outdoor Sports/Indoor Games(In addition to cricket, Volleyball, Badminton, Chess, Carom, Table Tennis, Other games like Critical Thinking, Math skill developing Games, Memory Games can be included.) 9. Calculate Body mass index of each students and explain their fitness level from it. 10. Tree Plantation 11. Gardening

Guidelines:

- Half an hour Yoga/Pranayam followed by physical activities including various games.
- Refer this link for Yoga/Pranayam https://s3-ap-southeast-1.amazonaws.com/ministry-

of-yoga/images/1528106718.pdf		
Module Name	**Objectives**	**Suggested Activities**
2. Creative Arts **(12 hours)**	1. Develop creativity and imagination through a range of complex activities. 2. Improve the student's ability to control materials, tools and techniques. 3. Develop increasing confidence in the use of visual and tactile elements and materials.	1. Make a model of any physical object related to Engineering Design 2. Crafting 3. Painting 4. Sculpture 5. Pottery 6. Music 7. Dance
Guidelines: • Use any activities leading to creative thing and practice. • Show the video demonstrating the creative ideas and thinking. • Show the video demonstrating phenomenon performance using innovation in different areas of humanity and social science. • Demonstrate the story of leaders with the context of how with their creative vision, with all odds they achieved success.		
Module Name	**Objectives**	**Suggested Activities**
3. Universal Human Values **(12 hours)**	1. Impart universal human values in students. 2. Enable students to live in harmony within themselves, with family, with society and the nature 3. Initiate the process of self exploration and self investigation within themselves about their understanding of happiness.	1. Showing Motivational Movies. 2. Social Activities like visit of orphanage, old age home, blind peoples'school etc. 3. Swachchhata Mission Activities. 4. Awareness regarding environmental issues and remedies. 5. Spread awareness about blood donation, organ donation, precaution to avoid malaria in monsoon etc. 6. Discuss autobiography of legendary persons who practiced universal human values in their life and work. 7. Conduct universal human values group discussions.

Guidelines:

- Use the materials and activities covered in the FDP on Induction Program held at GTU organized by AICTE.
- The faculties trained from institute will take leadership role to rollout it at institute level.

Module Name	Objectives	Suggested Activities
4. Literary **(12 hours)**	1. Inculcate the habit of active (or interactive) consumption of the best content available in literature. 2. Develop thinking skills. 3. Improve reading abilities and attitude.	1. Digital literacy and use of Internet 2. Basic Mathematics for Solving Real World Problems 3. Use of Scientific Calculator in Engineering 4. General Knowledge Quiz Competition 5. Vedic Mathematics 6. Reading/writing/speaking/listening 7. Debating/Elocution 8. Enacting a play 9. Book review

Guidelines:

- Use the video lectures to literate students in different skills needed for day-to-day life and need.
- Motivate students to create the nature of inquiry and reading habits.
- Arrange the various competitions like Elocution, Essay writing, Storytelling, Book reviews etc.
- Writingthe review ofthe well known books, movies etc and sharing.

Module Name	Objectives	Suggested Activities
5. Proficiency modules **(6 hours)**	1. Determining English proficiency level of students and mentoring accordingly. 2. Learn the mining vocabulary, idioms, and expressions and understand their meanings in context. 3. Develop ability to write a paragraph about general topics by using the English language correctly.	1. English general diagnostic test to determine student's English proficiency level. 2. Mentoring students to improve in English proficiency according to his/her proficiency level based on test.

	4. Realize the importance of English language as a global business language.	

Guidelines:

- An MCQ test of **45 minutes** should be conducted covering basic grammar and vocabulary.
- Group the students in three groups based on test result in three proficiency levels:
  - Unsatisfactory
  - Satisfactory
  - Good
- Following activities are to be used to uplift proficiency levels of students.
  - Motivational movies, documentary
  - Language games
  - Essay/story writing
  - Ice breaking games.
- Separate set of activities from suggested list should be used for different groups.

Module Name	Objectives	Suggested Activities
6. Lectures by Eminent people **(3 hours)**	1. Motivation through knowing experience of successful person. 2. Meet and interact with eminent personalities of different fields.	1. To conduct lecture by eminent people. 2. Interaction with leaders, experts, entrepreneurs, contributorsandsuccessful personalities

Guidelines:

- 3 expert lectures each of 1 hour per week.
- Multiple divisions can be combined in an expert lecture.
- External expert should be invited.
- Expert can be from academic, industry, research organization, social organization etc.
- An individual successful person in any of the field can be invited.
- The aspect to be addressed may be social / economical / engineering / entrepreneurship/ spiritual/ humanity science.

Module Name	Objectives	Suggested Activities
7. Visit to Local Area and Industry **(1 Full day)**	1. To familiarize students with the local area. 2. Sensitise with the different aspects of the life including social services and heritage	1. A full day visit covering at least 2 or 3 places. 2. List of possible places A. Centre of excellence B. Elite Academic Institutes C. Research institute

		D. Hospitals E. Industry visit F. Heritage places

Guideline and References:

- Institute can arrange visit to public, social or specifies places to give insight of the activities and overall socio-economic contribution of such places.
- The uniqueness or impact of such visits should be highlighted.

Module Name	Objectives	Suggested Activities
8. Innovation **(3 hours)**	1. Introduce the student about innovation in different fields 2. Make students aware about innovative and modern practices and products in their own branch 3. Create awareness about support available for start-up and innovation	1. Lectures by senior faculties. 2. Showing videos demonstrating innovation. 3. Introducing innovative technology/products. 4. Awareness regarding SSIP Scheme of Government of Gujarat 5. Awareness about Government initiatives in areas of innovations and supports for start-up, Incubation, Entrepreneurship etc.

Guideline:

- Video lectures from leaders and innovators.
- TeDx Talks.
- Government Policy documents for different schemes.

Closing Phase (Last Day)

The closing phase is the last day of the Induction Program and covering conclusion and summary of the Induction Program.

Conclusion and summary:

- Guiding students for preparation of student report about Induction Program.
- Instruct students regarding submission and examination of the Induction Program.
- Address by HODs/Senior faculties regarding branch/discipline and career option in respective branch.
- Introduce about the engineering and its importance in life and their responsibilities towards the society.

General Regulations:

a) Every student has to maintain a daily diary. Format of the diary is already given.

b) After completion of the Induction program student has to prepare a report based on activities performed during the Induction program. Diary will be attached as Appendix in Report.

c) 75% Attendance is require during Induction Program.

d) This program will be noncredit subject but it will reflect in 1st Semester Marksheet as PASS or FAIL.
e) Institute should appoint a mentor for a group of 20 to 30 students. Mentor can take help of senior students.
f) If student gets admission transfer in other college during Induction Program the diary will be continued from previous college to new college.
g) If student gets admission in middle of the Induction Program or student gets admission after Induction Program, it is responsibility of the institute to fulfill the criteria of the Induction Program.
h) If student fails in the Induction program the student has to clear the same during subsequent Semester

Evaluation Pattern:

1. Induction Program is Mandatory course for each branch of Engineering.
2. It is mandatory for each student to clear Induction Program with PASS grade.
3. Grades for Induction Program are either PASS or FAIL and have no credits. Evaluation for Induction Program is based on the Induction Program Report prepared by a student from Student diary and student will be declared PASS or FAIL.
4. Student has to submit the Induction Program Report at the end of first semester dully approved by Mentor and HOD.
5. Evaluation of Induction Program will be done along with first Semester Term-Work Submission.
6. The evaluation is carried out by Internal Examiner from institute itself. The entry on the GTU portal will be PASS or FAIL, not marks.
7. The students who will FAIL have to reappear again after every 6 months as remedial exam.

Guidelines for Program Report:

1) Report should have minimum 20 pages.
2) Report must have One Photograph per Activity.
3) Report consists of Certificate, Index and Diary as Appendix.
4) Report should be dully signed by Mentor and HOD.
5) Index will have following sequence:

1.	**Initial Phase**
2	**Regular Phase**
a)	Physical activity
b)	Creative Arts
c)	Universal Human Values
d)	Literary
e)	Proficiency Modules
f)	Lectures by Eminent People
g)	Visits to local Areas or Industry
h)	Innovations
3	**Closing Phase**

Format of Diary

Enrolment/Roll No:

Name of Student:

Day ……		**Date:**
Hour	**Activities Done**	**Learning Outcomes**
1		
2		
3		
4		
5		
6		
Signature of the Student		**Signature of Mentor**

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3130004
Semester – III
Subject Name: Effective Technical Communication

Type of course: Communication and ethics

Prerequisite: Zeal to learn the subject

Rationale: The rationale of the curriculum is to help students learn technical communication along with necessary moral and ethical dimensions of engineering.

Teaching and Examination Scheme:

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

Contents:

Sr. No.	Topics	Teaching Hours	Module Weightage
1	**Dynamics of Communication**: Definition and process Kinesics Proxemics Paralinguistic features Importance of Interpersonal and Intercultural Communication in today's organizations	06	20%
2	**Technical Writing**: Report writing Technical proposal Technical description Business letters(sales, order, complaint, adjustment, inquiry, recommendation, appreciation, apology, acknowledgement, cover letter) Agenda of meeting, Minutes of meeting Resume writing	08	25%
3	**Technical Communication**: Public speaking Group discussion Presentation strategies Interview skills Negotiation skills Critical and Creative thinking in communication	06	20%
4	**Ethics in Engineering**: Scope of engineering ethics Accepting and sharing responsibility Responsible professionals and ethical corporations Resolving ethical dilemmas Making moral choices	04	12%
5	**Etiquettes**: Telephone etiquettes Etiquettes for foreign business trips Visits of foreign counterparts Etiquettes for small talks	05	16%

	Respecting privacy Learning to say NO Time management		
6	**Self-development and Assessment:** Change, Grow, Persist, Prioritize, Read, Learn, Listen, Record, Remember, Asses, Think, Communicate, Relate, Dream.	03	7%

Distribution of Theory Marks					
Remember	Understand	Analysis	Application	Evaluation	Creativity
05	**05**	**15**	**15**	**15**	**15**

Language Laboratory Activities:

Sr. No.	**Practical/ Exercise**	**Apprx. Hours required**
1	Role Play	02
2	Letter writing: Formal	02
3	Group Discussion	04
4	Presentations	04
5	Book Review(Preferably related to self-development)	04
6	Mock Interview	04
7	Report writing	02
8	Case studies related to unit 4, 5 and 6	06
9	Conducting meeting and minutes of meeting	02
10	Practical assessment	02

Suggested books for review:

1. You Can Win by Shiv Khera
2. How to Win Friends and Influence People by Dale Carnegie
3. Getting Things Done: The Art of Stress Free Productivity by David Allen
4. Quiet: The Power of Introverts in a World That Can't Stop Talking by Susan Cain
5. The Alchemist by Paulo Coelho
6. The 7 Habits of Highly Effective People by Stephen Covey
7. What to Say When You Talk to Yourself by Dr. Shad Helmstetter
8. The Big Leap by Gay Hendricks
9. Thinking Fast and Slow by Daniel Kahneman
10. The Art of Thinking Clearly by Ralf Dobelli
11. Upside Down Key by Sudha Murthy
12. Born to be Happy by Pramod Batra
13. Kiss That Frog by Brian Tracy
14. Build From Scratch by Vineet Bajpai
15. Ten Much by A G Krishnamoorthy
16. Poor Little Rich Slum by Rashmi Bansal
17. Our Ice Berg is Melting by John Paul Cotter
18. Most and More by Mahatria Ra

19. Third Curve by Mansoor Ali Khan
20. Selected Short Stories of Rabindranath Tagore edited by William Radice
21. That Thou Art by Dhruv Bhatt
22. Old Man and the Sea by Ernest Hemingway

Reference Books:

1. Raman and Sharma, *Technical Communications*, OUP, New Delhi, 2017
2. Lata and Kumar, *Communication Skills*, OUP, New Delhi, 2018
3. Mike Martin and Roland Schinzinger, *Ethics in Engineering*, McGraw Hill, New York, 2014
4. Mohapatra and Sreejesh S., *Case Studies in Business Ethics and Corporate Governance*, Pearson, UP, 2013
5. Ramesh and Ramesh, *The Ace of Soft Skills*, Pearson, UP, 2019
6. Sherfield, Montgomery and Moody, *Cornerstone: Developing Soft Skills*, UP, 2009

Open Sources:

https://www.scu.edu/ethics/focus-areas/more/engineering-ethics/engineering-ethics-cases/

Course Outcomes:

At the end of the course students will be able to:

Sr. No.	Course Outcome	Weightage
1	Define and discuss dynamics of Verbal and Non Verbal aspects of Communication	20%
2	Write various formal documents of technical and professional communication	25%
3	Communicate in diverse formal situations taking place in organizations	20%
4	Illustrate and examine the knowledge of ethical aspects of engineering	12%
5	Demonstrate and explain social and professional etiquettes	16%
6	Plan self-development and practice self-assessment	7%

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3130007
Semester – III
Subject Name: Indian Constitution

Type of course: Mandatory course

Prerequisite: NA

Rationale: NA.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
2	0	0	0	50	0	0	0	50

Contents:

Sr. No.	Topics
1	Meaning of the constitution law and constitutionalism
2	Historical perspective of the Constitution of India
3	Salient features and characteristics of the Constitution of India
4	Scheme of the fundamental rights
5	The scheme of the Fundamental Duties and its legal status
6	The Directive Principles of State Policy – Its importance and implementation
7	Federal structure and distribution of legislative and financial powers between the Union and the States
8	Parliamentary Form of Government in India – The constitution powers and status of the President of India
9	Amendment of the Constitutional Powers and Procedure
10	The historical perspectives of the constitutional amendments in India
11	Emergency Provisions : National Emergency, President Rule, Financial Emergency
12	Local Self Government – Constitutional Scheme in India
13	Scheme of the Fundamental Right to Equality
14	Scheme of the Fundamental Right to certain Freedom under Article 19
15	Scope of the Right to Life and Personal Liberty under Article 21

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3130502
Semester – III
Subject Name: Fluid Flow Operations

Type of course: Core course

Prerequisite: Elements of Physics

Rationale: This Subject is essential for Chemical engineering to know the effect of pressure and stress of fluid on different bodies. Further, it is useful for students to know the metering devices for different type of fluids.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
4	0	2	5	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	Fluid static and its application: Nature of fluids, Pressure concept, Hydrostatic equilibrium, decanters like continuous gravity, centrifugal etc. Fluid Flow Phenomena: Velocity fluid, Velocity gradient and rate of shear, Newtonian and NonNewtonian fluids, Viscosity and momentum flux, Reynolds number and its significance, laminar and turbulent flow; Laminar and Turbulent flow in boundary layers, boundary layer formation in straight tubes, boundary separation and wake formation.	9
2	Basic equations of Fluid Flow: Mass velocity; average velocity; potential flow; streamlines, stream tubes, macroscopic momentum balance, momentum correction factor, Equation of continuity, Bernoulli's equation, corrections for fluid friction, pump work in Bernoulli's equations, angular momentum equations.	6
3	Flow of incompressible fluids: in Conduits and Thin Layers: Flow of incompressible fluids in Conduits and Thin Layers in pipes, relation between skin friction and wall shear, friction factor laminar flow in pipes, kinetic energy correction factor and momentum correction factor for laminar flow of Newtonian fluids, Hagen-Poiseuille equation, effect of roughness, friction factor chart, friction factor inflow through channels of non-circular cross section, equivalent diameter, hydraulic radius, friction from changes in velocity or direction, flow through sudden enlargement of cross section, flow through sudden contraction of cross section, effect of fittings and valves, form friction losses in Bernoulli's equations, separation of boundary layers in diverging channel.	10
4	Flow of Compressible fluids: Mach number, continuity equation total energy balance equation, velocity of sound. Introduction of isentropic expansion, adiabatic frictional flow, isothermal frictional flow, velocity in nozzles.	8

	Flow past immersed bodies: Introduction to Drag, drag coefficient, form drag, and stream lining, friction in fluids through bed of solids. Dimensional Analysis: Different methods of dimensional analysis applied to fluid flow problems.	
5	Transportation and Metering of fluid: Pipe and tubing, joint and fittings selection of pipe sizes, prevention of leakage around moving parts, stuffing boxes, mechanical seals, valves like Gate, Globe, Plug cocks, Ball, Check valves. Fluid moving machinery: Pumps its characteristics like developed head power requirement suction lift and cavitations; positive displacement pumps like reciprocating, rotary pumps, centrifugal pumps and its theory, characteristic of head capacity relation, pump priming, fans, blowers like positive displacement, centrifugal blowers, compressor efficiency, vacuum pumps, jet ejectors, comparison of devices for moving fluids. Measurement of flowing fluids: Full bore meter like venturimeter, orifice meter, coefficient of discharge of venturimeter, orifice meter, area meters like Rotameter, target meters, vortex-shedding meters, coriolis meters, magnetic meters etc., insertion meters like pitot tubes.	**12**

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

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

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

Reference Books:

"Unit Operations of Chemical Engineering", McCabe W L, Smith J C, Harriott P, Mc Graw Hill Publication, 7th edition 2005.
"Chemical Engineering" Vol. I – Fluid flow, Heat Transfer and Mass Transfer; Coulson & Richardson's, Butterworth – Heinemann Publication, 6 th Edition.
"Fluid Dynamics and Heat Transfer", James G. Knudson and Donald L. Katz, Mc Graw Hill Publication.

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Identify fluid properties and memorize the concepts of pressure.	15
CO-2	Classify different types of fluid and generalize the concepts of boundary layer and its estimation in different flows.	20

CO-3	Apply and demonstrate the basic equations of fluid flow.	25
CO-4	Calculate and examine the flow in compressible and incompressible fluid along dimensional analysis for problems in fluid flow.	15
CO-5	Propose appropriate pipe size, joints, fitting and valve for chemical processes.	15
CO-6	Evaluate and compare the performance of various fluid flowing machinery i.e pumps and compressor and metering devices i.e. flow meters.	10

List of Experiments:

Any five experiments from below list need to be performed for the course.

1. To study and verify Bernoulli's Theorem
2. To calibrate Venturi meter and obtain it's coefficient of discharge.
3 To calibrate an Orifice meter and obtain it's coefficient of discharge.
4. To study a Rota meter and obtain it's coefficient of discharge.
5. To Study Notched Weirs Apparatus and obtain its discharge coefficient.
6. Study of Pressure measurement devices.
7. Friction Vs Re losses in Pipe Friction using water.
8. To study Reynolds's Experiment Apparatus. 9. Centrifugal Pump testing.

Major Equipment:

Bernoulli’s experiment, Reynolds experimental set up.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering (Chemical Engineering)
Subject Code: 3130506
Semester III
Subject Name: Applied Chemistry

Type of course: Basic Science**.**

Prerequisite: Zeal to learn the subject.

Rationale: Applied Chemistry is considered as Basic Science subject.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE Pr/Viva (V)	PA (I)	
3	0	4	5	70	30	30	20	150

Contents:

Sr. No.	Content	Total Hrs.
1	**Physical Properties and Chemical Constitution of matter**: Additive & Constitutive properties: Parachor, Viscosity, Dipole Moment, Molar Refraction, Optical activity, Magnetic properties. Preparation and theory of Solution: Mole Fraction, Normality, Molality, Molarity, Lowering of vapor pressure, Elevation of Boiling point, Depression of Freezing point, Osmosis & Osmotic pressure.	4
2	**General Principle of Organic Reactions:**Electronegativity, Electron Displacement Effect, Fission of Covalent Bond, Reactive Intermediate, Organic Species based on Carbon and Nitrogen, Types of Organic reaction and Mechanism.	5
3	**Stereochemistry::** Optical, Geometrical and Conformational Isomerism: Optical activity, Polarimeter, Specific rotation, Enantiomers, Diasteromers, Optical activity in Lactic and Tartaric acid, R and S configuration of Optically active compound and E and Z designation of Geometrical isomers. Resolution of racemic mixture.Conformations of cyclic and acyclic systems.	4
4	**Introduction to quantum theory for chemical systems/Co-ordination Chemistry (Chemical Bonding):** Wave Mechanical approach of atom, Heisenberg Uncertainty Principle, Schrodinger Wave Equation, Applications to Hydrogenatom, Atomic orbitals& MO theory, Types of Hybridisation, Structure-Bonding and shapes of certain molecules. Understanding of different bonds.	6
5	**The Phase Rule:** Introduction, Phase, Components, Degree of freedom, Derivation of Gibb's Phase, Three & Four Phase-One component system like water, sulphur systems, Two component -Eutectic systems like Silver-Lead, Zinc-Cadmium, Ferric Chloride-Water system	5
6	**Chemical Kinetics:** Introduction, Reaction rate, Units of rate, Rate laws, Order of a reaction, Zero order reaction, Molecularity of a reaction, Pseudo-order reaction, first order reaction with numerical, second order reaction, third order reaction, units of rate constant.	5
7	**Thermochemistry:**	5

	Introduction, Internal Energy, Enthalpy of reaction, Endothermic reaction, Exothermic reaction, ΔH and ΔE and numerical. Thermo-chemical equations like heat of reaction, heat of combustion, heat of neutralisation, heat of transition, Hess's Law of constant heat summation and its application, Experimental measurement of heat of reaction.	
8	**Semi&Non-crystalline/amorphous materials**: Classification, structure and configuration of Ceramics, Refractories & Insulators, polymers,copolymers, liquid crystals and amphiphiles: Silicates, glass transition temperature and viscoelasticity.NanoComposites: role of reinforcement-matrix interface. Strength on composite behaviour, Biomaterials, material related to catalyst such as zeolites, silica.	5
9	**Analytical Techniques:** Principles of Electronic, Florescence, NMR & Mass spectroscopy, Surface characterization techniques: SEM and TEM.Introduction to experimental techniques:XRD, PSA, etc. for material characterizationhighlighting links between molecular structure and macroscopic properties.	6

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
07	42	11	10	-	-

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

Reference Books:

1. Essential of Physical Chemistry by B. S, Bahl and Tuli., Publisher: S Chand & Co. Ltd, New Delhi

2. A textbook of Physical Chemistry by A S Negi& S C Anand, Publisher: New Age International Publisher Private Ltd. New Delhi

3.A textbook of Organic Chemistry by ArunBahl& B S Bahl, Publisher: S Chand & Co. Ltd, New Delhi.

4. A textbook of Inorganic Chemistry by P L Soni, Publisher: Sultan Chand & Sons, New Delhi

5. Physical Chemistry, by Peter Atkins, Julio de Paulo, Publisher: W H Freemann, UK

6. Engineering Chemistry by B K. Sharma, Publisher: Krishna Prakashan Media (P) Ltd.

7. A textbook of Engineering Chemistry by Shashi Chawla, Publisher:Dhanpatrai Publishing Co. Ltd.

8. Principle of Instrumental Analysis by Douglas A Skoog, F. James Holler, Stanely R Crouch, Publisher: Cencage.

9. Instrumental Method of Chemical Analysis by B K Sharma, Publisher: Krishna Prakashan Media.

10. Materials Science and Engineering: A First Course, byV. Raghavan5th Edition Prentice HallIndia, 2004.

11. B. S. Mitchell,An Introduction to Materials Engineering and Science for Chemical and Materials Engineers, John Wiley & Sons, 2004.

Course Outcomes:

Sr. No.	CO Statements	Marks % Weightage
1.	Identify and describe reactivity patterns in organic reaction.	**15**
2.	Explain theoretical principles underlying molecular structure, bonding and properties	**20**
3.	Describe the importance and relevance of Hard and soft materials and also their characterization, properties and uses in engineering applications.	**15**
4.	Distinguish the difference between the different orders of reaction and apply accordingly.	**15**
5.	Utilize different thermo dynamical laws to explain course of reactions.	**15**
6.	Apply the different spectroscopic techniques to explain the inner & surface characteristic of molecules.	**20**

List of Experiments : (Minimum 8 to be performed in Physical and 8 to be performed in Inorganic/Organic Chemistry.)

1. Heat of Solution.
2. Ester Hydrolysis (Ist&IInd Order reaction).
3. Measurement of Conductance.
4. Lambert's Beers Law.
5. Turbidity.
6. Potentiometer.
7. Viscosity Measurement.
8. pH Meter.
9. Polarimeter.
10. Inorganic Qualitative Analysis.
11. Inorganic Quantitative Analysis.
12. Organic Qualitative Analysis.
13. Organic Quantitative Analysis.

Reference Books:

1. Experimental Physical Chemistry, by Athawale. V D, Publisher: New Age International Publishing Ltd.
2. Vogel's Textbook of Practical Organic Chemistry by Hannaford, Smith &Tatchell, Publisher: Elbs with Longman
3. Vogel's textbook of Quantitative/ Qualitative Chemical Analysis, by Arthur I Vogel, Revised by Jeffery et al, Publisher: Addison Wesley,Longman Ltd, England
4. Engineering Vogel's Textbook of Quantitative Chemical Analysis by Jeffery. G H Publisher: Addison Wesley Longman/Pearson Education Asia.

Major Equipments:

1. Spectrophotometer, Conductometer, Potentiometer, pH meter, Polarimeter.
2. Laboratory Oven, Stirrer Hot Plate, Hot plates.
3. Turbidity Meter, Viscometer, Temperature Control Bath,
4. Electronic Balance.

List of Open Source Software/learning website:

NPTEL, World Wide Web, etc.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering (Chemical Engineering)
Subject Code: 3130507
Semester –III
Subject Name: Chemical Engineering Thermodynamics-I

Type of course: Engineering Science

Prerequisite: None

Rationale: Knowledge of thermodynamics from a chemical engineering view point is essential to study principles and applications of laws of thermodynamics to real systems. This subject is also useful to calculate thermodynamic properties of any chemical species and their mixtures.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	1	0	4	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs
1	**INTRODUCTION AND FIRST LAW OF THERMODYNAMICS:** The scope of thermodynamics, Dimensions and units, Measures of amount or size, Force, temperature, pressure, work, energy, heat, etc. Internal Energy, Enthalpy, The first law of thermodynamics, Thermodynamic state, state functions, Energy balance for closed systems, Equilibrium, The Phase rule, The reversible process, Heat capacity, Application of first law of thermodynamics to steady state flow process.	9
2	**VOLUMETRIC PROPERTIES OF PURE FLUIDS :** PVT behavior of pure substances, Ideal and non-ideal gases, Equation of states, Virial, Cubic, Vanderwaals EOS, Redlich/Kwong (RK) EOS etc., Calculation of constants in terms of Pc, Tc, Vc. Generalized Correlations for gases and liquids.	9
3	**HEAT EFFECTS:** Sensible heat effects, Temperature dependence of the heat capacity, Latent heats of pure substances, Approximate methods for the estimation of the latent heat of vaporization, Standard heat of reaction, Standard heat of formation, Standard heat of combustion, Temperature Dependence of ΔH^{o}, Heat effects of Industrial Reactions.	6
4	**SECOND LAW OF THERMODYNAMICS:** Statements of second law of thermodynamics, Heat engines, Thermodynamic Temperature Scales, Concept of entropy, Entropy changes of an Ideal Gas, Third law of thermodynamics.	6
5	**THERMODYNAMIC PROPERTIES OF FLUIDS:** The fundamental property relations for homogeneous phases, Maxwell's equations, Residual properties, Mathematical relations among thermodynamic properties, Two phase systems, Thermodynamic diagrams.	5

6	**THERMODYNAMICS OF FLOW PROCESS:** Fundamental equations and relationships, flow in pipes, maximum velocity in pipe flow, nozzles, Single and Multistage compressors and ejectors.	**5**
7	**REFRIGERATION AND LIQUEFACTION:** Carnot refrigerator, Vapor compression cycle, Absorption refrigeration, Choice of refrigerant, Heat pump, Liquefaction processes.	**5**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
18	**24**	**23**	**5**	**0**	**0**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. "Introduction to Chemical Engineering Thermodynamics"; J. M. Smith, H. C. Vanness, M. M. Abbott, The McGraw-Hill Companies, Inc.
2. "Chemical, Biochemical and Engineering Thermodynamics"; S.I. Sandler, Wiley India Edition.
3. "A text book of Chemical Engineering Thermodynamics"; K. V. Narayanan, Prentice-Hall of India Pvt. Ltd.
4. "Chemical and Process Thermodynamics"; B.G. Kyle, Prentice-Hall Inc.
5. " Introduction to Thermodynamics"; Y.V.C. Rao, 2nd Edition, Wiley Eastern Limited

Course Outcomes:

Students should be able to

Sr. No.	**CO statement**	**Marks % weightage**
CO-1	Develop fundamental understanding of the basic principles of thermodynamics and related calculations.	20
CO-2	Demonstrate the use and applications of the first and second laws of thermodynamics.	25
CO-3	Evaluate changes in different thermodynamic properties for pure fluids using equations of state (EOS).	20
CO-4	Apply mass and energy balance to closed and open systems.	15
CO-5	Apply thermodynamic principles to the analysis of chemical processes and equipment such as turbines, compressors, heat pumps etc.	10
CO-6	Solve problems of refrigeration and liquefaction processes.	10

List of Tutorials: Numerical/problems based on topics of each theme of content.

List of Open Source Software/learning website:

1. Students can refer to video lectures available on the websites including NPTEL.
2. Students can refer to the CDs which are available with some reference books for the solution of problems using softwares. Students can develop their own programs for the solutions of problems.
3. XSEOS–an Open Software for Chemical Engineering Thermodynamics

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3130508
Semester – III
Subject Name: Material and Energy Balance Computations

Type of course: Professional Core Course

Prerequisite: Basics of Mathematics and Chemistry

Rationale: The main objective of course is to make a clear conceptualized knowledge regarding various unit operations carried out in Chemical Engineering. This will provide a background for applying these principles to industrial problems

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
4	1	0	5	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs
1	**Units & Dimensions:** Dimensions & system of units, Fundamental and derived units, Unit conversion and its significance, Dimensional consistency, Dimensional Equations	03
2	**Basic Chemical Calculations** Concepts of atomic weight, equivalent weight and mole. Composition of solids, liquids and solutions (weight percent, mole percent, molarity, normality etc.), other expressions for concentration, Average molecular weight and density, Gaseous mixtures, Ideal gas laws and its applications, Raoult's law, Henry's law, Amagat's Law & Dalton's law, Humidity and Saturation	08
3	**Material Balance without Chemical Reactions:** Introduction, Process flow sheet, solving material balance problems without chemical reactions of unit operations like Absorption and Stripping, Distillation, Extractions and Leaching, Drying, Evaporation, crystallization, Mixing/Blending, etc., Material balance of unsteady state operations, Material balance with and without recycle; Bypass and Purge streams.	08
4	**Material balances with Chemical reaction:** Concept of limiting and excess reactants, percentage conversion, selectivity and yield. Material balance involving reactions with special reference to fertilizers, petrochemicals, dyestuffs, electrochemical industries. Complex material balances	10
5	**Energy balances:** Heat capacity of gases and gaseous mixtures, liquids & solids, Sensible heat change in liquid & gases, enthalpy changes during phase transformation, enthalpy changes	08

	accompanied by chemical reactions, standard heat of reaction, Hess's law, dissolutions of solids, Adiabatic reactions, heat of solution by partial molar quantities	
6	**Fuel & Combustion** Types of fuels, calorific value of fuels, liquid fuels, gaseous fuel etc. Proximate and ultimate analysis, combustion calculations, Air requirement and flue gases.	**08**

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**10**	**20**	**20**	**20**	**20**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Basic Principles & Calculations in Chemical Engineering, D.M.Himmelblau. 6th Ed., 2004
2. Stoichiometry, B.I.Bhatt &Thakore, Tata McGraw Hill Book Company, 5th Ed, 2010
3. Chemical Process Principles, Vol.1, O.A.Hougen, K.M.Watson, R.A.Ragatz., Indian print, CBS Publishers, 2nd Ed., 1995
4. Stoichiometry & Process Calculations, Narayanan K.V., &Lakshmikutti B., Prentice Hall, 2006
5. Process Calculations, V Venkataramani and N Anantharaman, PHI Learning, 2004
6. Chemical Process Calculations Manual, David Carr Igbinoghene, McGraw Hill Professional, 2004
7. Optimization of Chemical Processes, T F Edgar, D M Himmelblau and L S Lasden, Tata McGraw Hill, 2001

Course Outcomes:

Sr. No.	**CO statement**	**Marks % weightage**
CO-1	To identify different system of units and dimensions with conversion	7
CO-2	To distinguish concepts for expressing compositions and behaviour of different gases and solutions.	18

CO-3	To demonstrate material balance in steady and unsteady state unit operations with and out recycle.	18
CO-4	To analyze Material balance involving Chemical reactions in fertilizer, petrochemicals, dyestuff and electrochemical industries.	21
CO-5	To describe energy changes in liquid and gases accompanying various chemical reactions with terms used to associate energy changes in different phases.	18
CO-6	To evaluate fuel quality and to device requirement of gases in combustion.	18

List of Open Source Software/learning website:

- Reference to NPTEL lectures can be made for a better understanding regarding various unit operations.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3140503
Semester – IV
Subject Name: Heat Transfer

Type of course: Professional core course

Prerequisite: A good understanding regarding basic modes of heat transfer viz. conduction, convection and radiation with governing laws underlying this heat transport mechanisms. Mathematical background is also essential in this respect

Rationale: Heat transfer is a necessary process in virtually all forms of energy generation and use; from coal fired to nuclear power stations, from automobile engines to rocket motors, from refrigerating cold stores to air conditioning space vehicles. This subject is intended to make students aware about mechanisms involved in heat transfer process in many of aforementioned applications. This ultimately will enable the students to design the equipments for heat process viz., shell and tube heat exchangers, evaporators, condensers.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
4	0	2	5	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Introduction:** Overview of applications of heat transfer in different fields of engineering, modes of heat transfer- conduction, convection and radiation, heat transfer with and without change of phase. **Conduction:** Mechanism of heat conduction, Fourier's law, thermal conductivity of solids, liquids and gases, effect of temperature on thermal conductivity, General heat conduction equation in Cartesian coordinates, Boundary conditions, Formulation of heat transfer problems without generation of heat, Conduction through systems of constant thermal conductivity :- conduction through plane, cylindrical and spherical wall, combined boundary condition systems (conduction-convection systems), conduction through composite slab, cylindrical and spherical shells. Electrical analogy to heat flow, Critical and Optimum thickness of Insulation. Unsteady State heat Conduction	12
2	**Convection:** Mechanism, thermal and velocity boundary layers, boundary layer thickness, relationship between hydrodynamic and thermal boundary layer thickness for flow over flat plates, the convective heat transfer coefficient, reference temperatures, thermal boundary layers for the cases of flow over a flat plate and flow through pipe, dimensionless numbers in heat	12

	transfer and their significance. **Forced Convection:** General methods for estimation of convection heat transfer coefficient, Correlation equations for heat transfer in laminar and turbulent flow for external and internal flows for constant heat flux and wall temperature conditions- flow in a circular tube Analogy between momentum and heat transfer: Development of Reynold's and Prandtl analogy. Overview of Colburn and Von-A **Natural Convection:** Dimensional analysis, natural convection from vertical and horizontal surfaces under laminar and turbulent conditions for plates, cylinders, physical significance of Grashoff and Rayleigh numbers.	
3	**Heat transfer by radiation:** Introduction- theories of radiation, electromagnetic spectrum, thermal radiation, spectral emissive power, surface emission- total emissive power, emissivity. Radiative properties, Emission, irradiation, absorptivity, reflectivity and transmissitivity. Concept of black and grey body, radiation intensity, Laws of black body radiation, non-black surfaces- Grey, white and real surface, radiation between black surfaces and gray surfaces	**6**
4	**Heat Exchangers:** Classification of heat exchangers: Classification according to transfer processes, number of passes, surface compactness, construction features, flow arrangements, heat transfer mechanisms. Shell and tube heat exchanger, fouling, concept of overall heat transfer coefficient, LMTD, correction factor for LMTD, Sizing and rating problem using LMTD method in parallel flow, counter flow exchanger, cross flow and multi-pass heat exchangers, Temperature – distance plots for different flow arrangements in single and multi-pass heat exchangers. Determination of area, length, number of tubes required for a given duty in different configurations using LMTD method of analysis. Concept of Effectiveness- NTU method, definition of effectiveness, effectiveness NTU relations for single pass exchangers in counter-flow and parallel flow configurations. Double pipe heat exchangers: - construction, various steps for the design of double pipe heat exchangers. Plate and spiral heat exchangers, Condensers	**12**
5	**Boiling and Condensation:** Pool boiling - Boiling curve, hysteresis in the boiling curve, mechanism of nucleate boiling, Forced convection boiling - Brief over view of internal forced convection boiling. Condensation: Physical mechanisms, types of condensation, factors affecting condensation.	**8**
6	**Evaporation:** Principle of Evaporation, types of evaporators- their construction and operation, Natural circulation evaporators, short tube vertical or calendria type evaporators, basket type vertical evaporators, long tube vertical evaporators, forced circulation evaporators, falling film evaporators, climbing or rising film evaporators, agitated thin film evaporators, the plate evaporator. Single effect and multiple effect evaporators, Performance of evaporators, capacity and economy of evaporators, Overall heat transfer coefficient, effect of liquid head and boiling point elevation. Material and energy balances for single effect evaporator and the calculations on single effect evaporator. Multiple effect evaporators, Energy Balance.	**10**

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3140503
Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	**15**	**20**	**10**	**10**	**0**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Kern D Q, Process Heat Transfer, McGraw Hill Book Co. (1997).
2. Binay. K. Dutta, "Heat Transfer Principles and applications" Prentice Hall of India
3. Coulson J M and Richardson J F, Chemical Engineering Volume 1, Pergamon Press (1999).
4. Holman J. P, "Heat Transfer", McGrawHill.
5. Ozisik M. N, "Heat Transfer - A Basic Approach", McGraw-Hill.
6. Incropera F. P. and DeWitt D. P, "Introduction to Heat Transfer". John Wiley & Sons.
7. Sachdeva R.C, "Fundamentals of Engineering Heat and Mass transfer", New Age International, India
8. Rao Y.V.C, "Heat Transfer", University Press, India
9. Cengel A. Yunnus. "Heat Transfer – A Practical Approach", McGraw Hill
10. Geankopolis C J, Transport Processes and Separation Process Principles, Prentice Hall of India, 4th Edition, Eastern Economy Edition (2004)
11. Kothandaraman C.P, "Heat and Mass Transfer Data Book" New Age International, India
12. Ramesh K. Shah and Dušan P. Sekulic, Fundamentals of Heat Exchanger Design, John Wiley & Sons, Inc. 2003

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To identify different different modes of heat transfer and understand basic mechanism of conduction.	22
CO-2	To explain heat transfer under different convective regimes.	22
CO-3	To predict extent of heat flow by radiation through grey, white and real surfaces.	12
CO-4	To analyze heat transfer through different types of heat exchangers used for various applications	18

CO-5	To describe industrial applications and regimes involved in boiling and condensation	12
CO-6	To categorize different types of evaporators with their performance evaluation and to analyze material and energy balance for single and multi-effect systems	14

List of Experiments: (Minimum 10 experiments need to be performed)

1. Determination of thermal conductivity of insulating powder
2. Determination of thermal conductivity of given metal rod
3. Determination of heat transfer coefficient by natural convection
4. Determination of heat transfer coefficient by forced convection
5. Determination of overall heat transfer coefficient for counter flow in laminar regime in double pipe heat exchanger
6. Determination of overall heat transfer coefficient of shell and tube heat exchanger
7. Heat Transfer in Composite walls- Determination of effective thermal conductivity and overall resistance
8. Determination of overall heat transfer coefficient and efficiency in finned tube heat exchanger
9. Determination of overall heat transfer coefficient and efficiency in plate type heat exchanger
10. Determination of heat transfer coefficient in turbulent flow regime in a double pipe heat exchanger
11. Determination of Stephan boltzmann constant experimentally.
12. Determination of economy and capacity of open pan evaporator.
13. Determination of economy and capacity of multiple effect evaporator

Major Equipments

Thermal conductivity measurement apparatus, stefan boltzmann apparatus, composite wall apparatus, emissivity apparatus, lagged pipe apparatus, various heat exchange equipment like shell and tube heat exchanger, plate type heat exchanger, open pan evaporator, multi effect evaporator etc.

List of Open Source Software/learning website :

Reference to NPTEL lectures can be made for a better understanding regarding heat transfer under different conditions.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3140507
Semester –IV
Subject Name: Chemical Engineering Thermodynamics-II

Type of course: Professional Core Course

Prerequisite: Chemical Engineering Thermodynamics-I

Rationale: This subject introduces the concepts of fugacity, activity coefficient and other important thermodynamic properties and its evolution for pure components and solutions. Starting with ideal gas mixtures and ideal solutions, the concepts of bubble and dew points are introduced to enable flash calculations and design of process components. Subsequently, various levels of non-ideality and complexity are introduced. The course also provides fundamental insight into the underlying thermodynamic principles of phase equilibria and reaction equilibria to solve complex problems.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	1	0	4	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs
1	**PHASE EQUILIBRIA:** **VAPOUR/LIQUID EQUILIBRIUM (VLE):** Introduction, The Nature of Equilibrium, The Phase Rule; Duhem's Theorem, VLE-Qualitative Behaviour, Azeotropic Mixtures, Retrograde condensation, Simple Models for Vapour/Liquid Equilibrium ,Raoult's Law, Dewpoint and Bubblepoint Calucations with Raoult's Law , Henry's law, VLE by Modified Raoult's Law, VLE from K-Value Correlations, Flash Calculations, The Gamma / Phi Formulation of VLE, An introduction to Equilibrium and stability, liquid- liquid equilibrium (LLE), solid-liquid equilibrium, Vapor-Liquid-liquid equilibrium (VLLE), Solid-Liquid equilibrium (SLE), Solid-Vapor equilibrium (SVE) etc..	15
2	**SOLUTION THERMODYNAMICS:** **THEORY** Fundamental Property Relation, The Chemical Potential as a Criterion for Phase Equilibria, Partial Properties, Equations Relating Molar and Partial Molar Properties , The Partial Molar Gibbs Energy and the Generalized Gibbs-Duhem Equation, Partial Properties in Binary Solutions, Relations among Partial Properties, The Ideal Gas Mixture model, The Partial Molar Gibbs Energy and Fugacity, Fugacity and Fugacity Coefficient: Pure Species and for Species in Solution ,The Ideal Solution Model , The Lewis/Randall	18

	Rule , Excess Properties , The Excess Gibbs energy and activity coefficient, nature of excess property **APPLICATIONS** Liquid-Phase Properties from VLE Data ,Composition Dependence of Liquid- Phase Fugacities for Species in a Binary Solution, Excess Gibbs Energy, Data Reduction, Thermodynamic Consistency by Integral or Area Test Method, Models for the Excess Gibbs Energy, Margules Equations, VanLaar Equations, Local Composition Models such as NRTL Equation, UNIQUAC Equation, UNIFAC Method	
3	**CHEMICAL REACTION EQUILIBRIA:** The reaction coordinates, Application of equilibrium criteria to chemical reactions, The standard Gibbs free energy change and the equilibrium constant, Effect temperature on equilibrium constant, Evaluation of the equilibrium constant, Relation of equilibrium constant to composition for gas phase and liquid phase reactions, calculation of equilibrium conversion for single reaction, The phase rule and Duhem's theorem for reacting systems, introduction to multi-reaction equilibria	12

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
7	28	28	7	0	**0**

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

Reference Books:

1. Smith J.M, Van Ness H.C., Abbott M. M, "Introduction to Chemical Engineering Thermodynamics", the McGraw Hill Companies, Inc., USA, 7th Ed., 2005.
2. Elliot J. R. and Lira C.T., "Introductory Chemical Engineering Thermodynamics", Prentice Hall, 1999.
3. Hougen O.A., Watson K.M., and Ragatz R.A., "Chemical Process Principles Part,II" Thermodynamics, John Wiley 1970.
4. Perry's chemical engineers handbook, 7th edition, McGraw,Hill, USA, 2000.
5. K.V.Narayanan "A Text book of chemical Engineering thermodynamics", Prentice Hall of India
6. Stanley I. Sandler, "Chemical, Biochemical and Engineering Thermodynamics", Wiley India Pvt. Ltd., 4th ed., 2007.
7. B.G. Kyle,"Chemical Process Thermodynamics", 2nd Edn., Prentice Hall of India Pvt.Ltd., New Delhi, 2000.
8. J.M.Prausnitz, R.N. Litchtenthaler, Molecular thermodynamics of fluid phase Equilibria, 3rd Edition,Prentice Hall.
9. Stanley M. Walas, Phase-Equilibria in Chemical Engineering,Wiley India Private Limited

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3140507

Course Outcomes:

Students should be able to

Sr. No.	CO statement	Marks % weightage
CO-1	Explain fundamentals of Solution thermodynamics, phase equilibria and reaction equilibria.	10
CO-2	Apply fundamental property relations to find thermodynamic properties of solutions	15
CO-3	Calculate maximum extent of separation possible under prevailing operating conditions for various multiphase multi component systems	30
CO-4	Determine thermodynamic properties like fugacity, activity coefficients, constants of model equations etc.. for solutions	20
CO-5	Determine equilibrium conversions of reaction systems and its dependence on various operating parameters	25

List of Tutorials: Numericals/problems based on topics of each theme of content.

Major Equipment: None

List of Open Source Software/learning website:
1. Students can refer to video lectures available on the websites including NPTEL.
2. Students can refer to the CDs which are available with some reference books for the solution of problems using softwares. Students can develop their own programs for the solutions of problems.
3. XSEOS–an Open Software for Chemical Engineering Thermodynamics

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3140508
Semester – IV
Subject Name: Unit Processes & Chemical Technology

Type of course: Basic Science**.**

Prerequisite: Basic Organic and Inorganic Chemistry

Rationale: Chemical Unit Processes is essential for chemical engineering as it gives an overview of all chemical process industries.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE Pr/Viva (V)	PA (I)	
4	0	2	5	70	30	30	20	150

Contents:

Sr. No.	Topics	Teaching Hrs.
1	**Mechanisms and recent advances of following unit processes:** Alkylation and Acylation, e.g. alkylation of benzene, phenols, etc. Halogenation, e.g. chlorination of toluene, Nitration and Sulfonation, e.g. nitration, sulfonation of benzene, etc. Hydrogenation and Reductive Alkylations, e.g. hydrogenation of nitrobenzene, reductive alkylation reactions of anilines, Oxidation, e.g. oxidation of xylenes, etc.	06
2	**Sulphur, Sulphuric acid & Fertilizer Industries:** Mining and manufacturing of Sulphur, Manufacture of Sulphuric acid by DCDA process and its applications. Sulphur trioxide, Sodium Sulphate, Sodium Thiosulphate, Manufacturing technologies & associated Engineering problems. Introduction to Fertilizer industries, manufacturing processes of Ammonia, Urea, Nitric acid, Phosphoric acid their uses and applications, major engineering problems, NPK fertilizer.	10
3	**Chlor-alkali and Heavy Inorganic industry:** Manufacturing of Caustic Soda and Chlorine by membrane cell, mercury & diaphragm process, Manufacturing of Sodium Bicarbonate.	04
4	**Dye & its Intermediates, Paints and Pigment Industries:** Classification of Dyes according to its Constitution and Application, Introduction to Disperse, Reactive, Azo, Anthraquinone & Vat dyes, Manufacturing Processes of Chrome blue black, H-acid, Koch acid, Vinyl sulphone, Vat dyes. Introduction to Paints classification & its constituents, PVC of Paints, Different types of pigments such as white, blue, red, yellow, green, brown. Introduction to Varnishes, Solvent & Thinners & Industrial Coatings.	08

5	**Drugs and Pharmaceuticals:** Classification of various drugs and pharmaceuticals, Introduction of Antibiotics, Manufacturing of penicillin, Introduction of vitamins, Manufacturing processes of Aspirin, Vitamin-D, B-12, & C (Ascorbic acid), Introduction to Barbital & Phenol Barbital.	06
6	**Sugar & Fermentation Industries:** Manufacturing of Sugar. Fermentation, Industrial Alcohol, Absolute Alcohol, Beers, Wines and Liquors, Manufacturing of Butyl Alcohol & Citric acid by fermentation.	05
7	**Cement & Ceramic Industries:** Cement & Its types, Settling & Hardening of Cement, Cement manufacturing by wet & dry process. Introduction to Ceramic Industry, Manufacturing of Building bricks, Refractory & its types.	06
8	**Introduction to pulp and paper industries:** Pulp manufacturing by Kraft process, Difference between sulphate & sulphite process, Manufacturing of Paper.	04
9	**Petroleum Refinery and Petrochemicals:** Introduction to basics of refinery, Important properties of petroleum products, Processing of petroleum and treatment techniques, cracking etc. Introduction of C1, C2, C3, Petrochemical aromatics and polymers.	08

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
20	**15**	**20**	**05**	**05**	**05**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Dryden, C. E. "Outlines of Chemical Technology" (Edited and Revised by M. Gopala Rao and M. Sittig) East West Press. Pvt. Ltd, New Delhi, 3 rd Edition (1997).
2. Austin G. T. Shreve's Chemical Process Industries", 5th Edition, McGraw Hill (1984).
3. B K. Sharma, "Industrial Chemistry (Including Chemical Engineering)" Krishna Publishing House.
4. James A Kent, "Riegel's Handbook of Industrial Chemistry" Springer Publication.
5. A H Patel, "Industrial Microbiology" Trinity Press, Laxmi Publication Pvt Ltd.
6. M Gopala Rao, Marshall Sittig, "Outlines of Chemical Technology" Affiliated East West Press (Pvt) Ltd.
7. Encyclopedia of Industrial Chemistry ,Ullmann, VCH, 1996.
8. Industrial Organic Chemistry ,Weissermel K &Arpe H.J., Weinheim, 1978.
9. Pandey G.N., "A Text Book of Chemical Technology", Volume 1 and 2, Vikas Publications11. B. S. Mitchell.

10. An Introduction to Materials Engineering and Science for Chemical and Materials Engineers, John Wiley & Sons, 2004.

11. Kirk and othmer ,"Encyclopedia of Chemical Technology", III Edition.
12. Srikumar Koyikkal,"Chemical Process Technology and Simulation", PHI Learning Ltd (2013).
13. Unit Process by G H Groggins.

Course Outcome:

Sr. No.	CO Statements	Marks % Weightage
1.	Develop fundamental understanding of the process carried out in chemical industry.	**30%**
2.	Explain the basic reaction steps involved in the production of various grades of products.	**21%**
3.	Construct process flow diagrams for different chemical manufacturing plants.	**28%**
4.	Predict all possible trouble shootings arise in chemical plants.	**7%**
5.	To review the practical importance and relevance of process takes place in chemical industry.	**7%**
6.	Resolve all technological and economical problems arise in the chemical manufacturing plants.	**7%**

LIST OF PRACTICALS: (Minimum 10 need to be performed)

Sr. No.	List of Experiments
1.	To prepare soap in the laboratory and carry out its cost analysis.
2.	To determine saponification value of oil sample
3.	To prepare detergent in the laboratory and to carry out its cost analysis.
4.	To determine the acid value of the given sample of oil.
5.	To prepare hydrated lime from the given calcium carbonate powder
6.	To prepare caustic soda by chemical method.
7.	To synthesis aspirin from salicylic acid.
8.	Preparation of phenyl azo – β – Naphthol from aniline.
9.	Preparation of disperse dye.
10.	To prepare mordant yellow dye.
11.	Preparation of fast green o dye.
12.	Preparation of nitro benzene from benzene.
13.	To study Alcohol Fermentation by Saccharomyces cereviceae (Baker's Yeast).
14.	Fermentative production of citric acid using the fungi Aspergillus niger.

Reference Books:

1. Vogel's Textbook of Practical Organic Chemistry by Hannaford, Smith &Tatchell, Publisher: Elbs with Longman
2. Vogel's textbook of Quantitative/ Qualitative Chemical Analysis, by Arthur I Vogel, Revised by Jeffery et al, Publisher: Addison Wesley,Longman Ltd, England
3. Engineering Vogel's Textbook of Quantitative Chemical Analysis by Jeffery. G H Publisher: Addison Wesley Longman/Pearson Education Asia.

Major Equipment:

1. Laboratory Oven, Stirrer Hot Plate, Hot plates.

2. Electronic Balance.

List of Open Source Software/learning website:

NPTEL, World Wide Web, etc.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3140509
Semester – IV
Subject Name: Pollution control & Safety Management

Type of course: Humanities and social science

Prerequisite: Basic Concepts of chemistry and environmental science.

Rationale: This course is intended to familiarize students with the concepts of various traditional and modern pollution control methods along with identifying various pollutants and prevalent industrial laws and acts pertaining to safety, health and environment under Indian context. This course would enable students to identify and assess hazards in any stage of operation, to quantify and manage them as well.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs
1	Impact of man on the environment; ecological systems and pollution, hydrologic and nutrient cycles. Various types of environmental pollution in general and in chemical and allied industry in particular, sources and causes of environmental pollution, effect of pollution on environment.	5
2	Air pollution: Classification and properties of air pollutants, Emission sources, behavior and fate of air pollutants with special reference to chemical reactions in atmosphere, reactions at the earth's surface, photochemical smog etc., air pollution meteorology (generation, transportation and dispersion of air pollutants). Outlines of industrial air pollution control and particulate control equipment: selection, design and performance analysis; cyclone separator, fabric filters, gravity settling chambers, ESPs, wet scrubbers. Control of gaseous emissions Stack sampling and analysis of air pollutants.	7
3	Water pollution: sources and classification of water pollutants, Physico-chemical characterization of wastewater, water quality standards, Industrial water pollution management: Wastewater treatment processes; Pretreatment, primary and secondary treatment processes. Advanced wastewater treatment processes. Design of sedimentation tanks and biological treatment processes.	6
4	Solid waste management: sources and classification, public health aspects, methods of collection, potential methods of disposal: sanitary landfill, incineration, composting, recovery and recycling.	4

5	Introduction to Material Safety Data Sheet (MSDS), Sources of exposure, exposure evaluation, exposure-hazard control, Fire and explosion: types of fire, detonation and deflagration, UVCE and BLEVE, Regulatory bodies and regulations; Safety by design-sizing of specific devices such as, safety release valves, vents, flare systems; Instrumentation for safety - specific devices such as alarms, interlocks, shutdown systems, Hazard Identification Checklist procedure, Preliminary hazard analysis, What if analysis, Failure mode effect analysis, Hazard and operability (HAZOP) studies, Hazard analysis techniques: Fault tree analysis, Event tree analysis, General outline of DOW index.	**7**
6	Rules, regulations, laws etc. regarding environmental protection, pollution prevention and control, waste disposal etc. Standards and legislation EIA, EIS and EMP. Air and water pollution management through waste minimization. Industrial air pollution management, Role of government, semi/quasi govt. and voluntary organizations. Industries Factory act, concept of energy audit, environment Audit.	**7**
7	Safe industrial practices, Development of safety movement, Need for safety-general introduction, historical background and growth of safety science, basic concepts of safety audit	4
8	Concept of Cleaner Production(CP), End of Pipe Solution, Good House Keeping checklist, CP Methodology, Barriers and Drivers in cleaner production, Principles of sustainable developments, Principles of green chemistry, atom economy, waste prevention and minimization of waste generation.	**5**

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
14	26	23	7	0	0

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Environmental Pollution Control Engineering by C.S.Rao, New Age International Publishers, New Delhi.

2. Wastewater Engineering: Treatment & Reuse by Metcalf and Eddy, McGraw Hill Publication

3. Pollution control in process industries, S P Mahajan, Tata McGraw Hill Publishing Company, New Delhi

4. Safety and Accident Management in the Chemical Process Industries Ed. by H. Heinmann, M. Dekker3Instrumental Methods of Analysis, B. K. Sharma, Goel Publishing house.

5. .HAZOP and HAZAN by Trevor Kletz, 4th Edition, Institution of Chemical Engineers, IChemE, UK

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

Sr. No.	CO statement	Marks % weightage
CO-1	To understand the impact of engineering solutions in a global and societal context	20
CO-2	To uunderstand and apply appropriate control and preventive measures for different types of pollution	35
CO-3	To identify major process and health hazards and apply hazard analysis techniques for risk assessment	20
CO-4	To acquire knowledge about the various environmental and safety standards and legislations	25

List of Open Source Software/learning website:

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

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

1. Characterization of a given sample of wastewater by determining its pH, conductivity, TDS, TSS.
2. To find out the quantity of Dissolved Oxygen (DO) present in the given water sample by Winkler's Method.
3. Determination of acidity, alkalinity & hardness of a given sample of water or wastewater.
4. To determine Biochemical Oxygen Demand (BOD) exerted by the given wastewater sample.
5. To find out Chemical Oxygen Demand (COD) of the given wastewater sample.
6. Determination of total residual chlorine in a given water sample.
7. To determine the color intensity of the dye contaminated wastewater using spectrophotometer.
8. To determine the ion exchange capacity of a given cation or anion exchanger.
9. Study of adsorption of dye from aqueous solution on any adsorbent (e.g. activated carbon) and examine the validity of (i) Freundlich isotherm and (ii) Langmuir iostherm

10. Determination of composition of volatile organic compounds dissolved in water by using (i) Refractometer or (ii) Karl-Fisher Apparatus.
11. Determination of efficiency of cyclone separator for separation of dust particles from mixtures.
12. Analysis of SOx and NOx compounds present in gaseous mixture using GC or any other techniques.
13. Separation of mixture of dyes using thin layer chromatography.
14. Separation of metallic ions by paper chromatography.
15. Characterization of municipal solid waste (physical and chemical).
16. To study the quality of a sample of water collected or provided.
17. To make an audit of the electrical energy consumption by various household appliances.
18. Preparation/compilation and study of MSDS of certain chemicals used in your laboratory.
19. Demonstration of portable fire extinguisher and other personal protective equipments used in the laboratories.

List of Open Source Software/learning website: Software:

PollutionTech - Air Pollution Control Software

Safety Management Software, MSDS Software, CSafe, DR software's ChemGes, Periscope¬ software, MAUS OHS Planning software (Occupational, Health & Safety Planner), CINTELLATE

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

Students can refer to the CDs which are available with some reference books for the solution of problems using softwares.

Students can develop their own programs for the solutions of problems.

Websites: www.safetyforlife.com.au , SmartOHS.com.au

https://www.cpcb.nic.in/PollutionControlLaw.pdf

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3140510
Semester – IV
Subject Name: Numerical methods in chemical engineering

Type of course: Core Professional course

Prerequisite: Algebra

Rationale: It is necessary for Chemical Engineering students to solve complex problem.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	1	0	4	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs
1	**Approximations and Errors:** Types of Errors, Significant figures, Accuracy of Numbers, Precision, Error Propagation, Applications in Chemical Engineering	3
2	**Solution of Algebraic and Transcendental Equations:** Basic Properties of Equations, Relations between Roots and Coefficients, Descartes Rule of Sign, Synthetic Division of a Polynomial by a Linear Expression, Bracketing Methods (Bisection, Secant, Method of False Position or Regula Falsi, etc.), Convergence of Iterative Methods, Newton-Raphson Method, Newton-Raphson Method for Non Linear Equations in Two Variables (Numericals based on application in chemical engineering)	8
3	**Solution of Linear Equations:** Mathematical Background, Matrix inversion, Gauss Elimination, Gauss-Jordan Method, Gauss-Seidel Iteration Method, Jacobi's Method, Gauss-Seidel Method, Eigen Value Problem (Numericals based on application in chemical engineering)	7
4	**Curve Fitting** Method of Least Squares, Fitting a Straight Line and a Polynomial, Fitting a Non-linear Function, Fitting Geometric and Exponential Curves, Fitting a Hyperbola, a Trigonometric Function, etc (Numericals based on application in chemical engineering)	7
5	**Finite Differences & Interpolation:** Finite Differences: Forward, Backward and Divided Differences Table, Central Differences, Newton's Forward, Backward and Divided Differences Interpolation Formula, Interpolation Polynomials, Lagrange Interpolation Formula, Inverse Interpolation (Numericals based on application in chemical engineering)	6
6	**Numerical Differentiation & Integration:** Differentiation Formula based on Tabulator at Equal and Unequal Intervals, Newton-Cotes	6

	Integration Formulas, Trapezoidal Rule and Simpson's 1/3 and 3/8 Rule (Numericals based on application in chemical engineering)	
7	**Ordinary Differential Equations :** Taylor's Series and Euler's Method, Modifications and Improvements in Euler's Method, Runge-Kutta 2nd Order & 4th Order Methods, Milne's Predictor-Corrector Methods, Boundary Value Problems (Numericals based on application in chemical engineering)	**8**

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
17	**18**	**10**	**11**	**7**	**7**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. S C Chapra and R P Canale, Numerical Methods for Engineers, McGraw Hill International Edition.
2. S S Shastry, Introductory Methods of Numerical Analysis, Prentice Hall of India.
3. B S Grewal, Numerical Methods in Engineering & Science, Khanna Publishers.
4. M K Jain, S R K Iyengar and R K Jain, Numerical Methods for Scientific and Engineering Computation, Wiley Eastern.

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Find accuracy of numbers, errors and propagation of errors.	25
CO-2	Differentiate types of equation based on linearity and order	25
CO-3	Find the root of linear, non-linear and linear algebraic equations	15
CO-4	Analyze and solve finite difference-interpolation and numerical integration problems.	15
CO-5	Arrange the data and find out coefficient of equation for curve fitting	10
CO-6	Compare variety of numerical methods for solving ordinary differential equation	10

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject code: 3150004
Subject Name: Contributor Personality Development Program
Semester V

Type of course: Work-Personality Development

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 confidence with which they can go into any job and contribute meaningfully.
- Improve their ability to engage better in the workplace and to be able to handle the challenges that come up there.
- Build their career-worthiness and help them develop into future-ready contributors with ability to navigate a career in a volatile, changing world.
- 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.
- Enable them to recognize how they, as technical professionals, can participate and make a positive contribution to their communities and to their state.

Towards this goal, the Contributor Program has been designed to awaken and strengthen students from within, in terms of building positive self-esteem, increasing their confidence level and I-can attitude, improving their aspirations, giving them new methods of thinking, building their cognitive capacities, exposing them to the skills and practices associated with being contributors in the workplace (not mere employees).

The Program content is also designed to expose students to real-world workplace scenarios and sensitize them to some of the challenges faced in society around them, especially in the local communities around them and in their own state of Gujarat.

The Contributor Program syllabus has been evolved and fine-tuned over several years, (a) to address the changing need and contemporary challenges being faced by industry and what employers of today are looking for in the people they hire and (b) by working extensively with universities and students building an appreciation of their challenges and concerns. At the core, the program is guided by the higher ideas and principles of practical Vedanta in work.

Teaching and Examination Scheme per semester:

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

Note:

- Weekly 2 hours of Classroom facilitated sessions are planned which include Solutioning and Self-discovery sessions.

- In addition, there will be individual/ team projects as part of Practicals. Students can do this on their own, with faculty as guide.

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.

Content:

Sr. No.	Content	Total Hrs
1	**The Contributor Work Ideal** *In this topic, students explore what is their "ideal" of work - is the ideal to be a "worker" or to be a "contributor"? For example, an employee who has the ideal of a "worker" goes to work to pass time, earn a living, get benefits; in contrast to an employee with the ideal of a "contributor" who wants to make a difference, get things done well, create value for the company. This enables students to transform their expectation of themselves in work*	1.5 hrs Classroom engagement *(including self-discovery/ solutioning sessions)*
2	**Identity & Self-esteem** *In this topic, students engage with the question "who am I?" or on what basis do they define themselves. Is their identity defined by what others think of them (extrinsic self-esteem) or by what they think of themselves (intrinsic self-esteem)? Further, they discover positive identities that lead to intrinsic self-esteem, such as an I-can identity based on one's capacity and inner strength. This enables them to build confidence and self-esteem.*	Same as above
3	**Become a Creator of one's destiny** *In a "victim stance", 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 of destiny stance" to challenges and situations. This stance frees them to try out new things, open up new possibilities, take on responsibility, see the opportunity hidden in their environment.*	Same as above
4	**Achieving Sustainable Success** *In this topic, students discover how to achieve sustainable or lasting success, by building one's "engine of success", making them success-worthy. Where their focus shifts to building one's "engine of success" rather than being on chasing the "fruits of success". This is important,*	Same as above

	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. And with a strong engine of success, fruits come to them in time.	
5	**Career Development Models** *In this topic, students explore a range of diverse "career development models" and the possibilities for contribution each opens up to them (e.g. start-up career model, change-maker career model, etc.). This opens their mind to different and even unconventional career models possible, beyond the usual (such as "stable large company career model" where one gets an engineering degree, then MBA, then get a job in a large company). This frees them from a herd mentality when making career choices.*	Same as above
6	**Expanding contribution in every role** *In this topic, students explore the many roles they can play in their life & discover the power they have to expand the contribution possible in any role. (E.g. role of student, role of manager, role of a project site engineer). So, the potential of a role is in the individual's hands. This opens their mind to an alternative way of career growth.*	Same as above

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks (for B.Pharma)					
R Level	U Level	A Level	N Level	E Level	C Level
-	**15**	**20**	**-**	**25**	**20**

Distribution of Theory Marks (for B.E., Diploma, MCA)					
R Level	U Level	A Level	N Level	E Level	C Level
-	**15**	**15**	**-**	**20**	**20**

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

Reference resources:

A. Basic reference for both students and teachers

1. Contributor Personality Program textbook cum workbook developed by Illumine

2. Web-based ActivGuide™ for self-exploration of rich media resources to vividly understand many of the ideas, watch role models, learn from industry people, get reference readings – that help them enrich the understanding they gained in the class published by Illumine Foundation

B. Advanced reference for teachers

1. On Contributors, Srinivas V.; Illumine Ideas, 2011
2. Enlightened Citizenship and Democracy; Swami Ranganathananda, Bharatiya Vidya Bhavan, 1989
3. Eternal Values for a Changing Society – Vol I-IV, Swami Ranganathananda; Bharatiya Vidya Bhavan
4. Karma Yoga, Swami Vivekananda; Advaita Ashrama
5. Vivekananda: His Call to the Nation, Swami Vivekananda; Advaita Ashrama
6. Six Pillars of Self Esteem, Nathaniel Branden; Bantam, 1995
7. Mindset: The New Psychology of Success, Carol S. Dweck; Random House Publishing Group, 2007
8. Lasting Contribution: How to Think, Plan, and Act to Accomplish Meaningful Work, Tad Waddington; Agate Publishing, 2007
9. Why not?: how to use everyday ingenuity to solve problems big and small, Barry Nalebuff, Ian Ayres; Harvard Business School Press, 2003
10. The value mindset: returning to the first principles of capitalist enterprise (Ch 8 & 9); Erik Stern, Mike Hutchinson; John Wiley and Sons, 2004
11. 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
12. Creating Shared Value, Michael E. Porter and Mark R. Kramer; Harvard Business Review; Jan/Feb2011, Vol. 89 Issue 1/2
13. The Speed of Trust: The One Thing That Changes Everything, Stephen M. R. Covey, Rebecca R. Merrill, Stephen R. Covey; Free Press, 2008
14. The Courage to Meet the Demands of Reality, Henry Cloud; HarperCollins, 2009
15. 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 theory sessions		
CO-1	Students will be able to recognize & appreciate two alternative ideals of work – ideal of a "worker" and ideal of a "contributor". And why organizations of today expect people they employ to be contributors and not just workers.	10-12%
CO-2	Students will be able to recognize & appreciate alternative ways in which they could define themselves or "who am I" (their identity) – and which are positive identities that will lead to building intrinsic self-esteem and confidence in oneself; in contrast to identities that will lead to extrinsic self-esteem that makes them	10-12%

	more dependent on their environment.	
CO-3	Students will be able to recognize & appreciate a "victim" stance as distinct from a "creator of destiny" stance in the way people approach challenges and situations; and how the latter frees individuals to take on challenges and open up opportunities.	10-12%
CO-4	Students will be able to differentiate between two alternative approaches to success - 'building one's engine of success' and 'chasing the fruits of success'; they also appreciate the payoffs/ consequences of both and which is more likely to lead to sustainable or lasting success in the long run.	10-12%
CO-5	Students will be able to recognize & appreciate different career models and their value; to help them make more informed career-related choices.	10-12%
CO-6	Students will be able to recognize & appreciate how one can expand the contribution possible in any role, thereby opening up an alternative way of career growth to them.	10-12%
Outcome of practical sessions		
CO-7	Students learn to re-interpret their life and college experiences to showcase their contribution affinities which are relevant for employers.	15%
CO-8	Students learn to apply contributor thinking to real-world or career relevant challenges.	15%

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150005
Semester – V
Subject Name: INTEGRATED PERSONALITY DEVELOPMENT COURSE

Type of Course –
Value-based holistic personality development course for university students.

Rationale -
This course aims to help a person understand and know his / her purpose in life, get a positive thought pattern, gain confidence, improve behaviour, learn better communication and develop a healthy physique with morality and ethics in its core.

Today youth lack the guidance to face insecurity about their health and career, premature relationships and family breakdown, addictions and substance abuse, negative impact of internet and social media etc. This course includes such topics that will cover all aspects and provide solution to the current challenges through creative and interactive activities.
This course will allow students to enjoy, understand and practice invaluable lessons preparing them for a successful future.

Teaching and Examination Scheme:

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

Content:

Lecture No.	Content	Hours
	IPDC-1 (Semester-1)	
1	**Remaking Yourself** - Restructuring Yourself	2
2	**Remaking Yourself** - Power of Habit	2
3	**Learning from Legends** - Tendulkar & Tata	2
4	**Mass Management** - Project Management	2
5	**From House to Home** - Affectionate Relationships	2
6	**Facing Failures** - Factors Affecting Failures	2
7	**Facing Failures** - Failures are not Always Bad	2

8	**Remaking Yourself** - Being Addiction-Free	2
9	**Soft Skills** - Teamwork & Harmony	2
10	**Remaking Yourself** - Handling the Devil - Social Media	2
11	**From House to Home** - Forgive & Forget	2
12	**From House to Home** - Listening & Understanding	2
13	**Financial Wisdom** - Basics of Financial Planning	2
14	**Soft Skills** - Networking - Decision Making - Leadership	2
15	**Review Lecture** - Student Voice-1	2

BASIC STUDY MATERIAL / MAIN COURSE WORK-BOOK -

1. IPDC Workbook-I
2. IPDC Workbook-II

IPDC REFERENCES –

- *These are the reference material for each lectures of IPDC.*

Module No.	Module/ Course Topics	Lectures	References

1	Facing Failures	Factors Affecting Failures Failures are not Always Bad Insignificance of Failures Power of Faith Practicing Faith	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
2	Learning from Legends	Tendulkar & Tata Leading Without Leading	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	Mass Management	Project Management	1. Project Management Absolute Beginner's Guide, Gregory Horine, Que Publishing, 2017 2. The Fast Forward MBA in Project Management, Eric Verzuh, Wiley, 2011 3. Guide to Project Management: Getting it right and achieving lasting benefit, Paul Roberts, Wiley, 2013

4	My India My Pride	Glorious Past - Part 1 Glorious Past - Part 2 Present Scenario An Ideal Citizen - 1 An Ideal Citizen - 2 An Ideal Citizen - 3	1. Hidden Horizons, Dr. David Frawley and Dr. Navaratna S. Rajaram, 2006 2. Rishis, Mystics and Heroes of India, Sadhu Mukundcharandas, Swaminarayan Aksharpith, 2011 3. Physics in Ancient India, Narayan Dongre, Shankar Nene, National Book Trust, 2016 4. The Rise of Civilization in India and Pakistan, Raymond Allchin, Bridget Allchin, Cambridge University Press, 1982 5. The Āryabhaṭīya of Āryabhaṭa: An Ancient Indian Work on Mathematics and Astronomy (1930), Walter Eugene Clark, University of Chicago Press, reprint, Kessinger Publishing, 2006
5	Remaking Yourself	Restructuring Yourself Power of Habit Being Addiction-Free Begin with the End in Mind Handling the Devil – Social Media	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
6	Financial Wisdom	Basics of Financial Planning Financial Planning Process	1. Rich Dad Poor Dad, Robert Kiyosaki, Plata Publishing, 2017 2. The Warren Buffett Way, Robert Hagstrom, Wiley, 2013 3. The Intelligent Investor, Benjamin Graham, Harper Business, 2006 4. Yogic Wealth: The Wealth That Gives Bliss, Gaurav Mashruwala, TV18 Broadcast Ltd, 2016
7	From House to Home	Affectionate Relationships Forgive & Forget Listening & Understanding Bonding the Family	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

8	Soft Skills	Teamwork & Harmony Networking - Decision Making - Leadership	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, Harper Perennial, Dan Ariely, 2010
9	Review	Student Voice – 1 Student Voice – 2 Words of Wim	

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150501
Semester –V
Subject Name: Mass Transfer Operations -I

Type of course: Professional Core course

Prerequisite: Basics of fluid dynamics, heat transfer and thermodynamics

Rationale: The objective of this course is to study the principles of mass transfer and their applications to separation and purification processes in chemical industry. This course is intended to explain detailed fundamentals of mass transfer operations such as diffusion, mass transfer coefficient, inter phase mass transfer etc.. and its application for in depth study and for solving problems pertaining to some mass transfer operations such as in detail. This course also enables the students to understand principal and working of various mass transfer equipments like gas absorption columns, crystallizers, and extractors etc..

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
4	0	2	5	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Introduction:** Definition and aim of mass transfer operations, Classification of mass transfer operation with examples, Direct Vs Indirect Mass transfer operations, choice of separation method, Methods of conducting mass transfer operations, Design principles	4
2	**Molecular Diffusion in Fluids:** Definition of molecular and eddy diffusion, Ficks law, Concept of N & J Flux, Steady state molecular diffusion in fluids at rest and in laminar flow, concept of effective diffusivity. Diffusivity of gases, Diffusivity of liquids.	10
3	**Mass Transfer Coefficients:** Mass transfer in laminar and turbulent regions, F and k type mass transfer coefficients, Film, Penetration and surface renewal theories, Analogies between momentum, heat and mass transfer, Dimensionless numbers	6
4	**Inter Phase Mass Transfer:** Concept of equilibrium, diffusion between phases, Two resistance theory, Local overall mass transfer coefficient, controlling mass transfer resistances.	4
5	**Gas Absorption:** Equilibrium Solubility of gases in liquids, Ideal and non-ideal solutions, Choice of solvent for absorption, Material balance and liquid to gas ratio for absorption, Counter current multi stage operation (isothermal), Absorption factor, Continuous contact	8

	equipments, Overall coefficient and Transfer units, Concept of HETP and HTU, NTU and jH factor, Industrial absorbers. Dilute solutions, Absorption with chemical reaction	
6	**Equipments for Gas Liquid Operations:** *Gas Dispersed*: Sparged vessels, Mechanically agitated vessels, Gas-Liquid contact, Tray Tower, Tray tower internals, Different types of trays, Weirs, Downcomers and criteria of their selection, Flooding, Loading, Coning, Weeping & dumping in tray tower *Liquid Dispersed*: Ventury scrubber, Wetted wall towers, spray towers, Packed Towers, Packed tower internals, Different types of packings and their selection criteria, mass transfer coefficient for packed towers, Co-current flow of gas & liquid, End effects and axial mixing, Tray tower vs. Packed tower.	8
7	**Liquid-Liquid Extraction:** Ternary liquid- liquid equilibrium and tie line data, system of three liquids-one pair partially soluble, two partially soluble, two partially soluble liquids and one solid, multi-component system, stage wise contact, Single stage & multistage extraction, Co-current and cross current extraction, Continuous counter current multistage extraction with and without reflux, Theory & performance of continuous contact equipments, Single stage & multistage equipments, Applications of liquid-liquid extraction.	10
8	**Leaching:** Steady state and unsteady state leaching operations, Single stage leaching, Multistage cross current and counter current leaching, Rate of leaching, Recovery of solvent vapors, Application of leaching, Leaching equipments	6
9	**Crystallization:** Saturation, Nucleation, Principle of crystallization, Crystallization rate, Equilibria and yields, Nucleation, Crystal growth, Caking of crystals, Application of crystallization, Crystallization equipments	4

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	30	20	10	-	-

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. R. E. Treybal, Mass transfer operations, 3rd edition, Mc-Graw Hill international, New Delhi, 1983.
2. J. F. Richardson, J H Harkar, Coulson and Richardson's Chemical Engineering, Volume-2, 5th edition, Butterworth Heinemann, 2002.
3. Binay K. Dutta, Principles of mass transfer and separation processes, 2nd edition, Prentice Hall of India, 2007.
4. W. L. McCabe, J.C .Smith & Harriott, Unit Operations of Chemical Engineering, 6th edition Mc-Graw Hill international, 2001.
5. C. J. Geankoplis, Transport processes and unit operations, 3rd edition, Prentice Hall of India, 1993.

Course Outcomes:

Students should be able to

Sr. No.	CO statement	Marks % weightage
CO-1	Describe fundamentals of diffusion; inter phase mass transfer and mass transfer coefficients.	40
CO-2	Explain various mass transfer operations and their equipments used in chemical industries.	20
CO-3	Apply theoretical and analytical aspects of mass transfer operations to deal with complex problems of separations.	20
CO-4	Solve problems pertaining to various mass transfer operations like gas absorption, liquid-liquid extraction, crystallization and leaching	20

List of Experiments:

1. To determine the diffusion co-efficient of CCl_4 in air & it's variation with temperature.
2. Determine mass transfer co-efficient of liquid (water) evaporation to atmospheric air at elevated temperature.
3. To find out the liquid side mass transfer coefficient K_{La} for the absorption of CO_2 in NaOH in the packed column.
4. To prepare ternary diagram for a system of three liquid –one pair partially soluble.
5. To determine the % extraction for the benzoic acid from dilute aqueous solution using toluene as solvent.
6. To study multistage (cross current) liquid-liquid extraction for extracting acetic acid from benzene using water as solvent.
7. To determine the stage efficiency and the overall recovery of NaOH for multistage cross current leaching operation for leaching of NaOH from mixture of NaOH and $CaCO_3$ using water as a solvent.
8. To find out crystal yield with & without seeding

Major Equipments:

Gas Absorption column, batch crystallizer, Diffusion assembly, Packed column etc.

List of Open Source Software/learning website:

1. Students can refer to video lectures available on the websites including NPTEL.
2. Students can perform experiments on Virtual Lab

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150502
Semester –V
Subject Name:Mechanical Operations

Type of course: Professional elective course

Prerequisite: Chemical engineering consists of several unit operations and unit processes. Before the reaction step, the raw materials should be processed through various unit operations and similarly after the reaction step as well the products are passed through various unit operations either for product separation or for purity. Thus unit operations are very essentially part of the chemical engineering; and hence, basic knowledge about the principles and equipment of solid-solid unit operations and solid-liquid unit operations is mandatory for any professional chemical engineer.

Rationale:
The main objective of this subject is to study the basic mechanical operation (crushing, grinding, screening, filtration, etc.) takes place during the process in chemical industry. It also provides platform to study and analyze various properties associated with the solid when it is in flow condition. This subject provides the fundamental knowledge regarding to particle size reduction and enlargement by various methods and also deals with the detail construction & working of equipment's used for mechanical operations.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs
1	**Solids and Its Flow Properties:** Solids, Characteristics of Solid particles, Properties of particulate masses, Particle size, mixed particle size analysis, Average particle size, Specific surface area of mixture, No of particles in mixture, Screen analysis, Standard screens, Capacity and effectiveness of screen, Ideal and actual screens, Screening Equipment – Grizzly screens, Gyrating screens, Trommels, Shaking screens, Oscillating screens.	8
2	**Size Reduction, Enlargement, Screening:** Principles of comminution,Rittinger's and kick's laws, Bond's crushing law and work index,Size reduction equipments, crushers, grinders, Ultra fine grinders,Dry versus wet grinding, Cutting machines, Open circuit and closed circuit operation,	10

	Screening equipment, Comparison of ideal and actual screens, Screen effectiveness.	
3	**Fluidization and Conveying:** Conditions for Fluidization, Types of fluidization, minimum fluidization velocity and pressure drop in fluidised bed, Equations for Kozeny–Carman, Burke – Plummer, Ergun, liquid – solid and gas solid systems, Applications of batch and continuous fluidization, Slurry and pneumatic transport, mechanical and pneumatic conveying, elevators, storage bins and silos for solid/liquid/gases.	**12**
4	**Filtration and Sedimentation :** Introduction, Cake filters, Filter media, Filter aids, principles of cake filtration,Filter press, Shell and leaf filters, Rotary drum vacuum filters, Centrifuges, Gravity classifiers, clarifying filter, Sink and float method, Clarifiers and thickeners, Batch sedimentation, Rate of sedimentation, Differential settling methods, sedimentation zones in continuous thickeners, Cyclones, Hydrocyclones.	**7**
5	**Mixing and Agitation:** Different types of agitators and their selection criteria,Types of Impellers, flow patterns in un-baffled and baffled tanks, Calculation of power required for agitation, Scale up of agitated vessel. Mixing of pastes/liquid/dry powder, pony mixer, ribbon blender, tumbler mixer, and static mixers.	**8**

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	**20**	**15**	**10**	**10**	**0**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Foust A. S. & associates, "Principles of Unit Operations" John Wiley and Sons (1980).
2. McCabe Smith, "Unit Operation in Chemical Engineering" 5th ed. McGraw Hill (1985).
3. Perry R.H. & Chilton C.H., "Chemical Engineers Hand Book", 7th ed. McGraw hill.
4. Badger and Bencharo, "Introduction to Chemical Engineering". Tata McGraw hill.
5. Coulson and Richardson: Chemical Engineering, Vol. 2.Butterworth Heinemann Pub
6. Welty, Wicks, Wilson &Rorrer, Fundamentals of Momentum, Heat and Mass Transfer, 4th ed. Wiley Narayanan C.M.& Bhattacharya B.C. "Mechanical Operations for Chemical engineers", Khanna Publishers. 3 rd Ed.1999

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150502

Sr. No.	CO statement	Marks % weightage
CO-1	To characterize particles and perform size reduction and size analysis of particles to meet the need of chemical industries	20
CO-2	To review the practical importance and relevance of unit operations used for crushing, grinding and size separation in chemical industry.	20
CO-3	To understanding fluid flow through fluidized bed	20
CO-4	To evaluate the parameters of various filtration equipment and sedimentation	25
CO-5	To identify the different types of mixing, agitation and conveying of solids and estimating the power requirement	15

List of Experiments: (Minimum 08 experiments need to be performed)

1. To determine the screen efficiency for the given sample by sieve analysis
2. To determine the screen efficiency for the given sample by vibrating screen
3. To determine nip angle, Reduction Ratio, Ribbon Factor, Rittinger's constant, Bond's constant, Kick's constant , Work Index as well as Theoretical & Actual Capacity using roll crusher.
4. To determine Rittinger's constant, Bond's constant, Kick's constant and Work Index using jawCrusher
5. To calculate the overall efficiency of the cyclone separator.
6. To carry out the batch sedimentation tests.
7. To carry out gravity filtration test
8. To determine Rittinger's constant, Bond's constant, Kick's constant and Work Index for ball mill
9. To study filter press
10. To study size reduction of material by drop weight crusher
11. To determine separation efficiency by using froth flotation cell

Major Equipments

Jaw crusher, Gyratory crusher, Roll crusher, Ball mill, Cyclone separator, Plate & Frame filter press, Sieve shaker apparatus etc.

List of Open Source Software/learning website:

Reference to NPTEL lectures can be made for a better understandingregarding mechanical operation done in industriesunder different conditions.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150504

Semester – V
Subject Name: Instrumentation and Process Control

Type of course: Professional Core Corse

Prerequisite: Material and Energy Balance Calculations, Basics of differential equations.

Rationale: The course is designed to introduce the fundamentals of process control along with instrumentation and its applications. The course will teach the students about mathematical models based on transfer function approach for single loop systems, how to obtain dynamic response of open loop and closed loop systems, stability analysis in transient and frequency domains, and controller tuning methods. The course introduces P, PI, and PID controllers and their applications. The course would end with more advanced concepts like feed-forward control, ratio control, model-predictive control, dead-time compensation, etc. The instrumentation for process control is also focused along with hands-on practical experience. Principles of operation of different measuring devices for temperature, level, pressure, flow, pH, humidity, density, and viscosity. Students will be introduced to transmitters, transducers, converters, control valves, digital and analog components related to PLC, DCS, and SCADA systems.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
4	0	2	5	70	30	20	30	150

Content:

Sr. No.	Content	Total Hrs
1	**Introduction of Process Control:** Need for control and automation, Steady state and dynamic system, control logic, servo and regulatory, control, block diagrams, control structures (feedback vs. feedforward)	3
2	**Laplace Transforms:** Definition, Transforms of simple functions, Ramp functions, Sine functions, Solutions of differential equations. Inversions of transform function by partial fractions, qualitative nature of solutions, Final value and initial value theorems, Translation of transforms, Transforms of unit impulse functions, Transforms of integral.	4
3	**Response of First Order Systems:** Mercury thermometer, Transient response of step functions, Sinusoidal input, Impulse functions. Physical Examples of First Order Systems: Liquid level, Mixing process, linearization. First Order System in Series: Non-interacting system of liquid level, Generalization of several non-interacting systems in series, Interacting systems.	5
4	**Second Order Systems:** Development of transfer functions, Damped vibrator, Liquid manometer, Thermometer in thermo-pocket, Step response & impulse response,	4

	Overshoot, Decay ratio, Rise time, Response time, Period of oscillation, Natural period of oscillation, Sinusoidal response, Transportation lag.	
5	**The Control Systems:** Block diagram, Standard block diagram symbols, Negative and positive feedback, Servo problem v/s regulator problems, Development of block diagrams, Process measuring element, Controller, Final control element. Closed Loop Transfer Functions: Block diagram reduction, Overall transfer function for single loop system, Overall transfer function for change in load, Overall transfer function for multi loop control system, process and instrumentation diagrams , parts of control system.	**4**
6	**Controllers and Final Control Elements:** Actual v/s Ideal controller, Pneumatic controller mechanism of proportional control, Proportional integral (PI) control, Proportional derivative (PD) control, Proportional integral derivative (PID) control. Control valve, Control valve characteristics. Transfer functions of P, On-off, PI, PD, and PID control, Motivation for addition of integral and derivative modes, Block diagram of chemical reactor control system.	**4**
7	**Transient Response of Simple Control Systems:** Proportional control for Set point change (Servo Problem), Proportional control for load change (Regulator Problem), Proportional integral control for load change, Proportional Integral control for set point change, Proportional control for system with measurement lag.	**3**
8	**Stability:** Concept of stability, Definition of stability (linear system), Stability criterion, Characteristic equation, Routh test for stability, Routh array, Method of Root Locus for stability analysis, Nyquist stability criterion.	**5**
9	**Frequency Response analysis:** Fortunate circumstances, Transportation lag, First order system, First order system in series, Bode diagrams, Bode stability criterion, Graphical rules for Bode diagrams. Transient response phase margin, magnitude ratio, phase shift, open loop bode diagrams of various controllers.	**5**
10	**Controller tuning and advance controllers:** Ziegler-Nichols method, Cohen-Coon method, introduction to cascade control, feed forward control, ratio control, Smith-predictor, IMC, MPC, dead-time compensation, digital control.	**5**
11	**Introduction of Process Measurement:** Elements of instruments, Parts of instruments, Static and dynamic characteristics.	**2**
12	**Temperature Measurement:** Scales, Expansion thermometers like constant volume gas, Mercury in glass, Bimetallic, Filled system thermometer like pressure spring thermometer, Static accuracy of thermometer, Dip effect in thermometer, Errors in thermometer of liquid and gas filled type like cross ambient effect, Head effect, Methods of compensation, Thermoelectric temperature measurement: Thermo couples, Pyrometers: Radiation pyrometer, Photo electric pyrometers, Optical pyrometers, Errors in optical pyrometers.	**4**
13	**Pressure Measurement:** Liquid column manometer, Enlarged leg manometer, Inclined tube manometer, Ring manometer, Tilting U tube manometer, Bourdon gauge, Bellows, Bellows differential pressure gauge, Vacuum Measurement: Ionization gauge, Pirani vacuum gauge, Thermocouple vacuum gauge, McLeod gauge	**3**
14	**Liquid Level Measurement:** Direct measurement, Float and tap, Float and shaft, Hydraulic remote transmission, Bubbler system, Diaphragm & air trap system, Differential pressure manometer, Float and spring pneumatic balance, Displacement float, Magnetic float gauge.	**2**

15	**Flow Measurement:** Head flow meter, Orifice plate, Flow nozzle, Venturi tube, Pitot tube, Differential pressure meter, Electric type head flow meter, Bellows type meter, Rota meter, Piston type area meter and Positive displacement meter, Flow control actuators: different types of valves.	**3**
16	**Humidity measurement & pH Measurement:** Psychometer method, wet bulb and dry bulb thermometer, hygrometer method, dead point method, electrolytic water analyzer. Electrode for pH measurement, calomel reference electrode, measuring circuits.	**2**
17	**Density & Viscosity Measurement:** Liquid level method, displacement meters, hydrometer. Viscosity meter, continuous viscosity meters, capillary type viscometers, rotating bowl type viscometer.	**2**
18	Introduction to advance topics like Electrical and pneumatic signal conditioning and transmission, Computer process control, PLC, DCS, and SCADA.	**4**

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	20	15	10	10	**5**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Coughanowr, D. R., LeBlanc, S. "Process Systems Analysis and Control", 3rd edition,McGraw-Hill (2008).
2. Stephanopoulos, G. "Chemical Process Control: An Introduction to Theory and Practice", Pearson Education (1984)
3. Seborg, D.E., Edgar, T.F., Mellichamp, D.A. "Process Dynamics and Control", 2nd edition, John Wiley (2003)
4. William C. Dunn, Fundamentals of Industrial Instrumentation and Process Control, Mc-GrawHill (2005).
5. S.K. Singh, Industrial Instrumentation and Control, 3rd edition, McGraw-Hill (2008).
6. R. P. Vyas, "Process Control and Instrumentation", Denett & Co.
7. Donald .P. Eckman, "Industrial Instrumentation", John Wiley & Sons Inc, New York.

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

Sr. No.	CO statement	Marks % weightage
CO-1	understand concepts of open and close loop control system	10
CO-2	construct mathematical models of chemical process with its transfer function	25
CO-3	evaluate the performance of control system with controllers and control strategies along with instrumentation	25
CO-4	design control loop with appropriate controllers and control valve	20
CO-5	apply appropriate instruments for various application in chemical plant	20

List of Open Source Software/learning website:

Scilab Xcos open source software can e used for process control modelling and analysis.

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

Students can refer website of "*The International Federation of Automatic Control (IFAC)*" https://www.ifac-control.org/ for international conference proceedings.

List of Experiments: (Minimum 10 experiments to be performed)

1. Response of first order system: thermometer
2. Response of first order liquid level system
3. Response of mixing process
4. Reponses of second order system: U-tube manometer or damped vibrator
5. Response of Interacting tanks
6. Response of Non-interacting tanks
7. Calibration of thermos couple test rig
8. Characteristics of flow control valves
9. Temperature and pressure measuring devices
10. Level measuring devices (Bubble system)
11. Viscosity and pH measuring devices (pH Control trainer)
12. Transmitters and transducers
13. Open loop systems: lagged thermometer
14. Temperature, level, flow, and pressure control trainers
15. Flow-level cascade control

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150505
Semester –V
Subject Name: Particle and Fluid Particle Processing

Type of course: Professional elective course

Prerequisite: Basic knowledge of fluid mechanics and particles are required to study the course. However, the course gives insight of both fluid and particles processing in detail.

Rationale:
The main objective of this subject is to study the basic fluid particle processingto understand the basic physical unit operations in a chemical process industry. It also provides platform to study and analyze various properties associated with the solid when it is in flow condition.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs
1	Introduction: Solid- Fluid operations, characterization and classification	**6**
2	Mixing and agitation: Mixing, Agitation, Different types of agitators and their selection criteria, Calculation of power required for agitation, Scale up of agitated vessel, static mixers, intensive mixers, heating and cooling mixers.	**8**
3	Fluidization and Transportation: Fluid flow in porous solid beds, Conditions for Fluidization, Types of fluidization, Applications of fluidization Transportation: Mechanic, Slurry, hydraulic and pneumatic transport, conveyors	**11**
4	Filtration and sedimentation: Cake filters, Constant rate filtration, constant pressure filtration,Filter press, Shell and leaf filters, vacuum filters, Centrifugal filters, Filter media, Filter aids, Clarifying filters, Gravity classifiers, Sink and float method, Clarifiers and thickeners, Batch sedimentation, Rate of sedimentation, Thickeners, Cyclones, Hydrocyclones, Centrifuges.	**8**
5	Solid- Fluid Mass Transfer: Leaching, Crystallization, Nucleation, Growth of crystals, Drying, Solid- Fluid Reactors: Fluidized bed reactor, moving bed reactor, slurry bed reactor, fixed bed reactor.	**12**

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150505

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	**20**	**15**	**10**	**10**	**0**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Foust A. S. & associates, "Principles of Unit Operations" John Wiley and Sons (1980).
2. McCabe Smith, "Unit Operation in Chemical Engineering" 5th ed. McGraw Hill (1985).
3. Perry R.H. & Chilton C.H., "Chemical Engineers Hand Book", 7th ed. McGraw hill.
4. Badger and Bencharo, "Introduction to Chemical Engineering". Tata McGraw hill.
5. Coulson and Richardson: Chemical Engineering, Vol. 2.Butterworth Heinemann Pub
6. Welty, Wicks, Wilson &Rorrer, Fundamentals of Momentum, Heat and Mass Transfer, 4th ed. Wiley Narayanan C.M.& Bhattacharya B.C. "Mechanical Operations for Chemical engineers", Khanna Publishers. 3 rd Ed.1999

Sr. No.	CO statement	Marks % weightage
CO-1	To characterize particles and perform size reduction and size analysis of particles to meet the need of chemical industries	20
CO-2	To understand the performance of solid-fluid reactors	20
CO-3	To understanding fluid flow through fluidized bed	20
CO-4	To evaluate the parameters of various filtration equipment and sedimentation	25
CO-5	To identify the different types of mixing, agitation and conveying of solids and estimating the power requirement	15

List of Experiments: (Minimum 08 experiments need to be performed)

1. To determine the screen efficiency for the given sample by sieve analysis
2. To determine the screen efficiency for the given sample by vibrating screen
3. To determine nip angle, Reduction Ratio, Ribbon Factor, Rittinger's constant, Bond's constant, Kick's constant , Work Index as well as Theoretical & Actual Capacity using roll crusher.
4. To determine Rittinger's constant, Bond's constant, Kick's constant and Work Index using jawCrusher
5. To calculate the overall efficiency of the cyclone separator.
6. To carry out the batch sedimentation tests.
7. To carry out gravity filtration test
8. To determine Rittinger's constant, Bond's constant, Kick's constant and Work Index for ball mill
9. To study filter press
10. To study size reduction of material by drop weight crusher
11. To determine separation efficiency by using magnetic separator
12. To determine separation efficiency by using froth flotation cell

Major Equipments

Jaw crusher, Gyratory crusher, Roll crusher, Ball mill, Cyclone separator, Plate & Frame filter press, Sieve shaker apparatus etc.

List of Open Source Software/learning website:

Reference to NPTEL lectures can be made for a better understandingregarding mechanical operation done in industriesunder different conditions.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150506
Semester – V
Subject Name: Chemical Process Plant Design & Economics

Type of course: Humanities and social science

Prerequisite: Basic Concepts of material and energy balance, fluid flow operations and unit process and chemical technology.

Rationale:

This course brings together the concepts of engineering and economics with special reference to chemical process and plant design along with the hierarchy of decisions in synthesis and analysis of a chemical process and its alternatives. This course is intended to challenge chemical engineer to combine basic technical principles learned in other courses in the general curriculum with practical elements of economics, business practices and organization along with principles of safety, environmental and sociological issues to design an integrated chemical process plant.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs
1	**Introduction and Process design aspects:** Basic design, optimization, selection of process-factors affecting process selection. Types of project design, Importance of Laboratory development pilot plant, safety factors, types of flow diagrams.	6
2	**Selection of process equipments:** Standard versus special equipment-material of construction for process equipments, selection criteria, and specification sheets.	4
3	**Process auxiliaries and Process utilities**: Piping design, layout, and supports for piping insulations. Pipe fittings, types of valves, selection of valves, process control and instrumentation control system design. Process water, boiler feed water, water treatment, waste treatment and disposal, disposal, steam, oil heating system, chilling plant, compressed air and vacuum	6
4	**Plant location and layout:** Factors affecting plant location, factors in planning layouts, principles of plant layout, Unit plot plan, vertical and horizontal lay out	4
5	**Cost estimation:** Cash flow and cumulative factors affecting estimation of investment and production cost, breakeven point and its significance, total capital investment, fixed and working capital investment & their estimations, type of estimates, cost indexes, method for	5

	estimating capital investment. Simple and compound interest.	
6	**Estimation of total product cost:** manufacturing cost, general expenses, Manufacturing cost: direct production cost, fixed charges, plant overhead cost.	**5**
7	**Depreciation:** Types of depreciation, Method for determining depreciation: straight line method, decline balance method, sum of the year digit method, shrinking fund method etc, single unit and group depreciation, adjustment of depreciation account, evaluation of depreciation methods	**5**
8	**Profitability, alternative investments and replacement:** Methods for profitability evaluation, Evaluation of Break Even Point, % rate of return, Practical factors in alternative investment and replacement Studies.	**5**
9	**Project management:** Planning of project schedule by BAR CHART, Inventory control scheduling a project using CPM/PERT methods.	**5**

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
14	26	23	7		

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Peters, Max S., K.D. Timmerhaus and R.E. West, Plant Design and Economics for Chemical Engineers (5th Ed), McGraw-Hill International Editions (Chemical Engineering Series), New York, USA (2003).

2. Douglas, James M., Conceptual Design of Chemical Processes, McGraw-Hill International Editions (Chemical Engineering Series), New York, USA (1988).

3. Biegler, L.T., I.E. Grossmann and A.W. Westerberg, Systematic Methods of Chemical Process Design,Prentice Hall (Pearson Education), New Jersey, USA (1997).

4. Mahajani,V.V., Chemical Project Economics, Macmillan Indian Ltd., New Delhi, India (2005).

5. Smith, R., Chemical Process: Design and Integration, John Wiley and Sons, West Sussex, UK (2005).

6. Coulson and Richardson's Chemical Engineering, Vol. 6: Chemical Engineering Design. By R.K. Sinnott, Butterworth-Heinemann, Oxford, 3rd, Ed., 1999, 1994

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

Sr. No.	CO statement	Marks % weightage
CO-1	State the basic concepts of economics, selection of equipment, process plant design and project management.	25
CO-2	Discuss Plant auxiliaries, process utilities, plant location and layout	20
CO-3	Calculate capital investment, total product costs, break even analysis and depreciation.	30
CO-4	Explain alternative investment, replacements and profitability analysis.	25

List of Open Source Software/learning website:

NPTEL lecture series Literature available on Plant design and project Economics

Suggested activities/mini-project on plant design and cost estimation:

The plant design project involves a small group of students working as a team to design a nominated chemical manufacturing plant. The tasks include the study of the available processes, process selection, calculation of material and energy balances, preparation of flow sheets, design of selected plant items, an assessment of factors affecting plant safety, sustainability and environmental impact, estimation of plant cost and process economics, preparation of a design report and drawing of the plant layout.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150507
Semester – V
Subject Name: Energy Technology

Type of course: Open elective course

Prerequisite: None

Rationale:
To provide an idea of the challenges in the field of energy management and to provide a perspective on energy technology. Students will learn the systems dimensions of the energy problems and its historical perspective on energy technology and system development. For different types of energy sources utilization in industries, the procedure of power generation, transportation along with conventional and advanced application in different sectors should be known by the student. This subject will guide students in the same direction.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination marks				Total marks
				Theory marks		Practical marks		
L	T	P	C	ESE (E)	PA (M)	PA (I)	ESEV)	
3	0	0	4	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs	%weigh tage
1	**An Introduction to Energy Sources:** Energy consumption, world energy future, energy sources and their availability**,** Conventional and Non-conventional energy, primary and secondary energy resources, energy and environment, energy needs for growing economy, energy sector reforms, energy security, energy audit, energy conservation and its importance	7	15
2	**Energy Efficiency in Thermal Utilities** **Fuels and Combustion:** Introduction to fuels, properties of fuel oil, coal and gas, storage, handling and preparation of fuels, principles of combustion, proximate and ultimate analysis, calorific values, gasification, composition of coal. **Steam System:** Properties of steam, assessment of steam distribution losses, steam leakages, steam trapping, condensate and flash steam recovery system, identifying opportunities for energy savings. **Insulation andRefractories:** Insulation-types and application, economic thickness of insulation, heat savings and application criteria, Refractory-types, selection and application of refractories, heat loss. **Waste Heat Recovery:** Classification, advantages and applications, commercially viable waste heat recovery devices, saving potential.	10	20

3	**Solar energy** Solar radiation and related terms, measurement of solar radiation, solar energy collectors-flate plate collector, air collector, concentrating collectors, application and advantages of various collectors, solar energy storage system (thermal, chemical, mechanical), solar pond, application of solar energy	**10**	**15**
4	**Fuel cell** Introduction, hydrogen- oxygen fuel cell, ion exchange membrane cell, fossil fuel cell, molten carbonate cell. Advantages and disadvantages, conversion efficiency, polarization, type of electrodes, application of fuel cell	**07**	**20**
5	**Energy from biomass** Introduction, biomass conversion technology, photosynthesis, biogas generation, factors affecting biogas generation, classification of biogas plants and their comparison, types of biogas plant, biogas from plant wastes, community plants and site selection, digester design consideration, design calculations, methods of maintaining and starting of biogas plant, properties and utilization of biogas, thermal gasification of biomass, pyrolysis	**10**	**15**
6	**Wind energy** Basic principles, power in wind, force on blades and turbines, wind energy conversion, site selection, basic components of wind energy conservation system (WECS), classification of WECS, wind energy collectors, applications of wind energy.	**07**	**15**

Reference Books:

1. Fuels & combustion by Samir Sarkar, Orient Longmans(1974)
2. Solar Energy: Principles of Thermal Collections and Storage, S. P. Sukhatame and J. K. Nayak, Tata McGraw Hill, New Delhi
3. Energy Technology by Rao &Parulaker.
4. Energy Sources 2nd Ed. by G. D. Rai, Khanna Publications, NewDelhi

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
30	**15**	**15**	**5**	**5**	**0**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Course Outcomes:

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150507

Sr. No.	CO statement	Marks % weightage
CO-1	To understand the basic knowledge of available energy sources, energy conservation and energy audit	15
CO-2	To Evaluate the energy saving & conservation in different thermal utilities	20
CO-3	To understand the design and applications of power generating devices using solar energy	15
CO-4	To understand the basics of fuel cell and able to design different types of cells	20
CO-5	To classified various biomass conversion methods and able to design/develop biogas plant	15
CO-6	To understand the design and applications of power generating devices using wind energy	15

List of Tutorials: Students can select any type of renewable energy and try to find out the application in chemical or other industries and can suggest modification in the energy production techniques, which can make the surrounding of plant environmental friendly and economical at the same time. Each group of students are expected to create a way to utilize renewable energy in innovative way and prepare report of project assigned to his/her group. In addition, each group is expected to give a power point presentation during the semester. The presenter will be selected randomly just prior to the presentation.

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

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150508
Semester – V
Subject Name: Materials Science & Engineering

Type of course: Open elective

Prerequisite: Basic Concepts of physics and chemistry.

Rationale: This course is intended to familiarize students with essential concepts in material science with an emphasis on particulate solids, their behavior and processing in various engineering applications. It will briefly cover basic concepts behind the chemistry of organic and inorganic compounds, chemical bonding and structure, and structure-property relationships in different engineering materials.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs
1	**Introduction** : Classification of Engineering Materials; Levels of Structure; Structure–Property Relationships in Materials	5
2	**Atomic structure & Chemical bonding**: Quantum states, Ionization Potential, Electron Affinity and Electronegativity, Types of chemical bonds- Ionic, covalent, metallic and secondary bonding, Bond Energy, Bond Type and Bond Length	7
3	**Structure of solids**: The Crystalline and the Noncrystalline States, ionic solid, covalent solids, metals and alloys, Classification of Polymers, Structure of Long Chain Polymers	6
4	**Crystal defects**: Point Imperfections, The Geometry of Dislocations, Other Properties of Dislocations, Surface Imperfections	6
5	**Phase rule**: Single-component Systems, Binary Phase Diagrams, Some Typical Phase Diagrams and applications, phase transfornmation, nucleation and growth, transformations in steel, precipitation process, solidification and crystallization, glass transition	7
6	**Plastic deformation and creep in crystalline materials:** The Tensile Stress-Strain Curve, Plastic Deformation by Slip, The Shear Strength of Perfect and Real Crystals, The Effect of Temperature on the Stress to Move a Dislocation, mechanism of creep and creep resistant materials	7
7	**Oxidation and corrosion**: Mechanisms of Oxidation, Oxidation Resistant Materials, The Principles of Corrosion, Protection against Corrosion	7
8	**Conductors, resistors and semiconductor materials**, resistivity range, free electron theory, superconducting materials, intrinsic and extrinsic semiconductors, fabrication of	7

	integrated circuits, Magnetic and dielectric materials: Ferromagnetism and Related Phenomena, soft and hard magnetic materials,	

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
14	26	23	7		

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Materials Science and Engineering: A first course, by V Raghavan, (5th Edition) PHI learning Centre, New Delhi.

2. Materials Science and Engineering: An Introduction, 10th Edition, William D. Callister Jr., David G. Rethwisch (WILEY)

3. Introduction to Materials Science for Engineers (8th Edition) 8th Edition by James F. Shackelford, Pearson

4. Elements of Materials Science and Engineering, L. H. Van Vlack (Addison-Wesley)

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

Sr. No.	CO statement	Marks % weightage
CO-1	To understand the basic structure of materials at the molecular, microscopic, and macroscopic scales	20
CO-2	To promote an understanding of the relationship between material structure, processing and properties	35
CO-3	To acquire basic knowledge of crystal defects, phase rule, plastic deformation and corrosion in materials	25
CO-4	To Gain a broad perspective on materials chemistry and physics for selection of engineering materials for specific applications.	20

List of Open Source Software/learning website:

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

List of Open Source Software/learning website: Software:

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

Students can refer to the CDs which are available with some reference books for the solution of problems using softwares.

Collaborative Open Resource Environment – for Materials

The CORE-Materials repository contains 1670 open educational resources (OERs) in Materials Science and Engineering, freely available under a range of Creative Commons licenses. (Source: CORE webpage)

Suggested topics for tutorials:

The tutorials will be consisting of solving the numerical problems/critical evaluation/higher order thinking problems based on the following topics:

1. Bonding Properties of Atoms
2. Properties of Crystals & Defects
3. Diffusion
4. Mechanical Properties
5. Plastic Deformation & Strengthening
6. Failure, Creep, Fatigue, & Fracture
7.Phases and Phase Diagrams
8. TTT (Time-Temperature-Transformation)Diagrams
9. Ceramics, Polymers, & Electronic Properties

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150509

Semester – V
Subject Name: Fuels and Combustion

Type of course: Open Elective Corse

Prerequisite: Material and Energy Balance Calculations

Rationale: Fuels and combustion course introduces basic knowledge about solid, liquid and gaseous fuels, their origin, classification, preparation procedure and characterization in terms of physico-chemical properties. Coal being the main solid fossil fuels, its mining, cleaning and combustion processes covered in detail. Petroleum is the liquid fuel which is elaborated in terms of exploration, evaluation, distillation and secondary processing. Different important gaseous fuels are also included. It also covers fundamentals of combustion along with and combustion appliances. Emphasis is given to combustion of various fuels considering thermodynamics. Combustion appliances are discussed in Combustion technology section. Basic knowledge of advance topics like continuous industrial furnaces and oxy-rich combustion is also incorporated for wide exposure and realising importance of the subject.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs
1	**Introduction :** Types of fuels, solid, liquid and gaseous fuels, History of solid liquid and gaseous fuels, production, present scenario and consumption pattern of fuels, fundamental definitions, properties and various measurements, properties of solid liquid fuels and their measurement techniques.	5
2	**Solid fuels :** Coal origin, its classification, composition, and properties. Coal mining, preparation, and washing. Combustion of coal and coke making, different types of coal combustion techniques, coal tar distillation, coal liquefaction: direct and Indirect liquefaction, coal gasification, oxidation and hydrogenation. Efficient use of solid fuels.	7
3	**Liquid Fuels :** Origin and classification of petroleum, refining, properties & testing of petroleum products, various petroleum products, petroleum refining in India, liquid fuels from other sources, storage and handling of liquid fuels.	5

4	**Gaseous Fuels :** Types of gaseous fuels: natural gases, methane from coal mines, manufactured gases, producer gas, water gas, biogas, refinery gas, LPG, hydrogen, acetylene, other fuel gases. Cleaning, purification and quality enhancement of gaseous fuels.	**7**
5	**Manufactured fuels :**Agro fuels, solid fuel handling, properties related to combustion, handling, and storage. bio-Fuels: types of bio-fuels, production processes and technologies, Bio-fuel applications.	**6**
6	**Stoichiometry of combustion :** Estimation of minimum amount of air required for a fuel of known composition, theoretical and actual combustion processes - Air fuel ratio, estimation of dry flue gases for known fuel composition, calculation of the composition of fuel and excess air supplied from exhaust gas analysis, dew point of products. calorific value of fuels, adiabatic flame temperature, mechanism and kinetics of combustion,	**9**
7	**Combustion Technology:** Stoichiometry and thermodynamics of combustion, calculation of heat of formation and heat of combustion, first law analysis of reacting system, combustion of oil, combustion of coal, combustion of gas, flue gas analysis, flame properties, draft system, combustion appliances, gas burners, functional requirement of burners, gas burner classification, stoker firing, pulverized system of firing, fluidized bed combustion process, combustion controls. Introduction to different types of furnaces: heat treatment furnaces, industrial furnaces, process furnaces, and kilns. Applications of batch and continuous furnaces, oxy-rich combustion.	**9**

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	25	20	10	5	**0**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Irvin Glassman, "Combustion" 2nd ed., Academic Press.
2. John Griswold, "Fuels Combustion and Furnaces" Mc-Graw Hill Book Company Inc.
3. S.P. Sharma & Chander Mohan, "Fuels & Combustion", Tata McGraw Hill Publishing Co. Ltd.
4. Gupta O.P, "Elements of Fuels, Furnaces & Refractories", 3rd ed., Khanna Publishers.
5. Dr. Samir Sarkar, "Fuels & Combustion", 2nd ed., Orient Longman.

6. B. I Bhatt & S. B. Thakore, "Stoichiometry", 5th ed., Tata McGraw Hill Publishing Co. Ltd.
7. James G, "Chemistry and Technology of Petroleum", Marcel Dekker, NY
8. B. K. Sharma, "Fuels and Petroleum Processing" , 1st ed., Goel publishing, Meerut.
9. Blokh A.G, "Heat Transmission in Steam Boiler furnaces", Hemisphere Publishing Corpn.

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

Sr. No.	CO statement	Marks % weightage
CO-1	summaries importance of solid liquid and gaseous fuels	20
CO-2	understand basic processing of fuels	25
CO-3	select appropriate equipment for combustion and fuel	25
CO-4	apply stoichiometry to evaluate combustion performance	30

List of Open Source Software/learning website:

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

Students can refer website of FurnXpert "https://www.furnxpert.com/casestudy" for case studies of furnace simulation and analysis.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject code: 3160002
Contributor Personality Development Program

SEMESTER VI

Type of course: Work-Personality Development

For Year: Pre-final year for all Diploma, Degree & Masters programmes over 2 semesters. For e.g. for Bachelors of Pharmacy and Engineering, the course will be conducted in Semesters V & VI.

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 confidence with which they can go into any job and contribute meaningfully.
- Improve their ability to engage better in the workplace and to be able to handle the challenges that come up there.
- Build their career-worthiness and help them develop into future-ready contributors with ability to navigate a career in a volatile, changing world.
- 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.
- Enable them to recognize how they, as technical professionals, can participate and make a positive contribution to their communities and to their state.

Towards this goal, the Contributor Program has been designed to awaken and strengthen students from within, in terms of building positive self-esteem, increasing their confidence level and I-can attitude, improving their aspirations, giving them new methods of thinking, building their cognitive capacities, exposing them to the skills and practices associated with being contributors in the workplace (not mere employees).

The Program content is also designed to expose students to real-world workplace scenarios and sensitize them to some of the challenges faced in society around them, especially in the local communities around them and in their own state of Gujarat.

The Contributor Program syllabus has been evolved and fine-tuned over several years, (a) to address the changing need and contemporary challenges being faced by industry and what employers of today are looking for in the people they hire and (b) by working extensively with universities and students building an appreciation of their challenges and concerns. At the core, the program is guided by the higher ideas and principles of practical Vedanta in work.

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

COURSE CONTENT :

Sr. No.	Content	Total Hrs
1	**Finding Solutions** The market environment in which organizations are operating, is becoming increasingly dynamic and uncertain. So, employers are increasingly seeking out people who can innovate and figure out solutions in the face of any challenge (unlike in the past when it was the	1.5 hrs Classroom engagement (including self-discovery/ solutioning sessions)

	people who were most efficient and productive, who were valued by organizations). At the heart of innovation lies this way of thinking of "finding solutions" rather than "seeing problems or roadblocks". Students learn how to build this way of thinking, in this topic.	
2	**Creating Value** Companies are also looking for employees who do not just work hard, or work efficiently or productively - but those who will make a valuable difference to the fortunes of the company. This difference may come from innovation, but it may also come from focusing on the right things and identifying what really matters – both to the company and to the customers. In this topic, students learn how to build this capability.	Same as above
3	**Engaging deeply** The environment we live in is becoming increasingly complex because more and more things are getting interconnected, new fields are emerging, technologies are rapidly changing, capabilities and knowledge one is trained in will become fast obsolete. In such a scenario, the student's ability to quickly understand and master what is going on, dive deep, get involved in any area, rapidly learn new capabilities that a job demands, is important. Engaging deeply is a core way of thinking that can help them in this. In this topic, students learn how to engage deeply.	Same as above
4	**Enlightened self-interest & collaboration at work** The changing nature of work in organizations and in the global environment is increasingly demanding that people work more collaboratively towards shared goals and more sustainable goals. A key to working successfully when multiple stakeholders are involved is "thinking in enlightened self-interest". In this topic, students learn how to develop this way of thinking (going beyond "narrow self-interest").	Same as above
5	**Human-centered thinking & Empathy** In this topic, students explore a human-centric approach to work – where the ability to recognize and respond to other people (whether they are users or customers or team members) as a human being with human needs and difficulties, is essential. This is at the heart of user-centric design of products and solutions, at the heart of genuine customer-centricity in services, and of any successful interaction with other people.	Same as above
6	**Trust Conduct** The biggest currency in a sustainable career is "trust" i.e. being trusted by team members, bosses, and customers. When we are trusted, people listen to us, they are willing to give us the chance to grow, give us the space to make mistakes, and work seamlessly with each other without always having to "prove ourselves". In this topic, students learn how to demonstrate conduct that builds the trust of people.	Same as above
Showcase Lab Sessions		3 hrs
Project work		Beyond classroom

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject code: 3160002

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
-	**15**	**15**	**-**	**20**	**20**

Reference resources:

A. Basic reference for both students and teachers

1. Contributor Personality Program textbook cum workbook developed by Illumine
2. Web-based ActivGuide™ for self-exploration of rich media resources to vividly understand many of the ideas, watch role models, learn from industry people, get reference readings – that help them enrich the understanding they gained in the class published by Illumine Foundation

B. Advanced reference for teachers

1. On Contributors, Srinivas V.; Illumine Ideas, 2011
2. Enlightened Citizenship and Democracy; Swami Ranganathananda, Bharatiya Vidya Bhavan, 1989
3. Eternal Values for a Changing Society – Vol I-IV, Swami Ranganathananda; Bharatiya Vidya Bhavan
4. Karma Yoga, Swami Vivekananda; Advaita Ashrama
5. Vivekananda: His Call to the Nation, Swami Vivekananda; Advaita Ashrama
6. Six Pillars of Self Esteem, Nathaniel Branden; Bantam, 1995
7. Mindset: The New Psychology of Success, Carol S. Dweck; Random House Publishing Group, 2007
8. Lasting Contribution: How to Think, Plan, and Act to Accomplish Meaningful Work, Tad Waddington; Agate Publishing, 2007
9. Why not?: how to use everyday ingenuity to solve problems big and small, Barry Nalebuff, Ian Ayres; Harvard Business School Press, 2003
10. The value mindset: returning to the first principles of capitalist enterprise (Ch 8 & 9); Erik Stern, Mike Hutchinson; John Wiley and Sons, 2004
11. 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
12. Creating Shared Value, Michael E. Porter and Mark R. Kramer; Harvard Business Review; Jan/Feb2011, Vol. 89 Issue 1/2
13. The Speed of Trust: The One Thing That Changes Everything, Stephen M. R. Covey, Rebecca R. Merrill, Stephen R. Covey; Free Press, 2008
14. The Courage to Meet the Demands of Reality, Henry Cloud; HarperCollins, 2009
15. Responsibility at work: how leading professionals act (or don't act) responsibly, Howard Gardner; John Wiley & Sons, 2007

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject code: 3160002

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
Outcome of theory sessions		
CO-1	Students will be able to recognize & appreciate the thinking required to find solutions in the face of any challenge.	10-12%
CO-2	Students will be able to recognize & appreciate different types of value that can be created and the different ways to create value for others.	10-12%
CO-3	Students will be able to recognize & appreciate how to engage deeply, and its need, value, payoffs and consequences in different contexts.	10-12%
CO-4	Students will be able to differentiate between 'enlightened self-interest' and 'narrow self-interest' & appreciate the payoffs/ consequences of both when working with multiple stakeholders.	10-12%
CO-5	Students will be able to recognize & appreciate the human side of situations or interactions or projects that will help them develop a more human-centric approach/ response to work.	10-12%
CO-6	Students will be able to recognize & appreciate conduct which builds trust of people in contrast to conduct which breaks trust of people - in teams / organization & the value of trust conduct in various situations.	10-12%
Outcome of practical sessions		
CO-7	Students complete their 'Contributor Showcase Profile' on the Showcase Platform. This includes (a) completing Illumine's Contributor Mindset Assessment (b) building evidence to demonstrate their functional orientations as contributors.	15%
CO-8	Students learn to apply contributor thinking to think-through and address real-world challenges.	15%

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject code: 3160003
IPDC - 2 (Integrated Personality Development Course)

SEMESTER VI

Type of Course –

Value-based holistic personality development course for university students.

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.

Teaching and Examination Scheme:

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

The assessments should include both continuous evaluation and end-of-semester examinations. The assessment scheme should include student attendance, assignments, mid-term exams, viva, workbook submission, and end-of-semester examinations.

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 -Lecture	Lecture Description	Hours
IPDC-2			
1	**Remaking Yourself-** Begin with the End in Mind	Students will learn to visualize their future goals and will structure their lives through smart goals to give themselves direction and ultimately take them to where they want to go.	2
2	**Remaking Yourself-** Being Addiction-Free	Students will explore the detrimental effects of addictions on one's health, personal life, and family life. They will learn how to take control of their life by becoming addiction free.	2
3	**Selfless Service-** Case Study: Disaster Relief	Students will apply previous lessons of seva, to analyse the case study of the Bhuj earthquake relief work.	2
4	**Soft Skills-** Teamwork & Harmony	Students will learn the six steps of teamwork and harmony that are essential for students' professional and daily life.	2
5	**My India My Pride-** Present Scenario	To implement the transformation of India from a developing country into a developed country it is necessary to have a value-based citizen. Students will see how the transformation to a greater India relies on the vision and efforts of themselves as a youth.	2

6	**Learning from Legends-** Leading Without Leading	Students will explore a new approach to leadership, through humility.	2
7	**My India My Pride-** An Ideal Citizen - 1	Students will learn that to become value-based citizens, they must first develop good values in their lives. They start by exploring the values of responsibility and integrity.	2
8	**My India My Pride-** An Ideal Citizen - 2	Students will learn that by developing the values of loyalty, sincerity, and punctuality; they become indispensable and can leave a strong impression. They will start developing these values by trying to keep perfection in every small task and by looking at the bigger picture.	2
9	**Facing Failures** Timeless Wisdom for Daily Life	Students will learn the role wisdom plays in finding long-term stability. They will use ancient wisdom to solve their modern-day challenges.	2
10	**From House to Home-** Forgive & Forget	Students will understand the importance and benefits that forgiveness plays in their personal and professional life. They will learn to apply this knowledge in realistic situations.	2
11	**Remaking Yourself-** Stress Management	Students will learn to cope with current and future causes of stress.	2
12	**Remaking Yourself-** Better Health Better Future	A healthy body prevents disease and stress; increases positivity, productivity, and brainpower. Students will learn to maintain good health through regular exercise, healthy eating habits, and regular and sufficient sleep.	2
13	**Learning from Legends -** Words of Wisdom	A panel of learned and experienced mentors will personally answer practical questions that students face in their daily life.	2
14	**Soft Skills –** Financial Planning	Students will develop a variety of practical financial skills that prepare them to become financially stable throughout their future careers.	2
15	**Remaking Yourself** Impact of Company	Students will understand that the type of company that we keep, has a crucial role in determining who we are and who we will become. They will develop the ability to create a positive environment around them.	2
Concluding	Life After IPDC	This concluding lecture encourages students to keep practising these priceless lessons and prepares them for the next steps in their lives.	2

- **COURSE MATERIAL / MAIN COURSE WORKBOOK -**

1. IPDC Workbook-2 *(presented by B.A.P.S. Swaminarayan Sanstha)*

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 workbooks.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject code: 3160003

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]

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.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160501
Semester –VI
Subject Name: Mass Transfer Operations II

Type of course: Professional Core course

Prerequisite: Mass Transfer Operations- I

Rationale: The objective of this course is to apply principles of mass transfer operations for detail study and for solving problems pertaining to conventional unit operations such as distillation, humidification, adsorption, drying etc. for separation

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
4	0	2	5	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Distillation:** Introduction, Vapor-liquid Equilibria, P-x-y T-x-y diagrams, concept of relative volatility and effect of Pressure and Temperature on equilibrium data, Ideal solutions, Raoult's law as applied to distillation operations, Deviation from ideality, steam distillation, Minimum and maximum boiling azeotropic mixtures, Enthalpy concentration diagrams, Flash distillation, steam distillation, simple distillation, continuous rectification, Binary systems, Batch fractionation etc., Determination of number of stages by Ponchon and Severit method and McCabe-Thiele method, q line, Feed tray location, Concept of minimum, total and optimum reflux ratio, Reboilers, Use of open steam, , Partial condensers, cold reflux, etc., Azeotropic Distillation, Extractive Distillation, Vaccum distillation etc. **Multicomponent distillation :** key components, minimum and total reflux, short cut method: FUG (Fenskey-Underwood-Gilliland) method, Rigorous methods: Lewis-Matheson calculations, Thiele and Geddes method, etc.	26
2	**Humidification Operations:** VLE and Enthalpy for a pure substance, Saturated and unsaturated vapour-gas mixtures and related terminologies such as absolute humidity, dry bulb temperature, dew point, wet bulb temperature, percentage & relative saturation, adiabatic saturation temperature, humid heat, humid volume etc. Psychometric chart & Psychometric relations for air-water system, adiabatic saturation curves, wet bulb temperature theory, Lewis relation, Adiabatic operations, cooling towers.	11
3	**Adsorption and Ion exchange:** **Adsorption:** Definitions and industrial applications, Types of adsorption, nature of	13

	commonly used adsorbents, Adsorption Equilibria, Single gases and vapors, Adsorption hysterises, Effect of temperature on adsorption, Heat of adsorption, Adsorption of solute from dilute liquid solution, Adsorption from concentrated liquid solution, Material balance and application of Freundlich's equation for single stage operation, multistage cross-current operation and multistage countercurrent operation, Equipments for adsorption such as fluidized bed & Teeter beds, steady state moving bed & unsteady state fixed -bed adsorbers, concepts of adsorption wave, break-through curve, Pressure swing adsorber, elution and chromatography etc. **Ion-Exchange** : Principles, Techniques, Applications, Equilibria and Rate of ion exchange	
4	**Drying:** Equilibrium relationship & hysteresis, various types of moisture in drying, Batch drying, rate of batch drying, time of drying, Cross-circulation drying, Through-circulation drying, concept of N_{toG} and H_{toG}, Drying at low temperature, Freeze drying etc. Batch & continuous drying equipments-Tray dryer, Tunnel dryer, Rotary dryers, Spray dryers, Fluidized bed dryer, etc.	10

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	25	25	10	-	-

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. R. E. Treybal, Mass transfer operations, 3rd edition, Mc-Graw Hill international, New Delhi, 1983.
2. J. F. Richardson, J H Harkar, Coulson and Richardson's Chemical Engineering, Volume2, 5th edition, Butterworth Heinemann, 2002.
3. Binay K. Dutta, Principles of mass transfer and separation processes, 2nd edition, Prentice Hall of India, 2007.
4. W. L. McCabe, J.C .Smith & Harriott, Unit Operations of Chemical Engineering, 7th edition Mc-Graw Hill international, India, 2014.
5. C. J. Geankoplis, Transport processes and unit operations, 3rd edition, Prentice Hall of India, 1993.

Course Outcomes: Students should be able to

Sr. No.	CO statement	Marks % weightage
CO-1	Explain concepts and applications of distillation, humidification, adsorption and drying.	15
CO-2	Describe theories, derivations and equipments of distillation, humidification, adsorption and drying.	35
CO-3	Solve problems of frequently encountered separation systems using	35

	conventional mass transfer operations.	
CO-4	Compare among various mass transfer operations for desired separation.	15

List of Experiments:

1. To measure the vapor pressure of acetone and calculate its latent heat of vaporization.
2. To study the humidification operation and calculate all psychometric parameters for air – water system.
3. To study the characteristics of adsorption of moisture on Silica gel.
4. To study and verify the Freundlich's adsorption isotherm for aqueous oxalic acid – charcoal system.
5. To verify Rayleigh's Equation for Differential Distillation.
6. To find out the critical moisture content of a given material using rate of drying curve.
7. To study the distillation with rectification in bubble cap distillation column
8. To verify the Equilibrium Relationship for n-Butanol-Water System.
9. To validate the basic principles of steam distillation.
10. To determine pressure drop data and values of K_G for various air and liquid velocities in a counter current cooling tower.

Major equipments:

Distillation column, Adsorption column, Cooling tower, dryer etc.

Open Source Software/learning website:

1. Students can refer to video lectures available on the websites including NPTEL.
2. Students can perform experiments on Virtual lab by IITs.
3. FOSSEE –DWSIM https://dwsim.fossee.in/

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160506
Semester – VI
Subject Name: Chemical Reaction Engineering 1

Type of course: Professional core

Prerequisite:
Basic knowledge of material and energy balances in chemical engineering applications, laws of thermodynamics.

Rationale:
The course is intended to familiarize the students with concepts of reaction rate, derivation of rate expressions from reaction mechanism, ideal reactor types, integral method of analysis, differential method of analysis, principles of chemical reactor analysis and design, experimental determination of rate equations, design of batch and continuous reactors, how to choose the most appropriate reactor for a given feed, optimization of selectivity in multiple reactions, consideration of temperature and pressure effects, etc.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs
1	**Overview of chemical reaction engineering**, Classification of reactions, Variables affecting rate, Definition of reaction rate, single and multiple reactions, Elementary and non-elementary reactions, molecularity and order of reaction, extent of reactions, conversion, Selectivity, Reaction rate fundamentals - elementary reaction sequences, steady state approximation and rate limiting step theory	7
2	**Kinetics:** Constant volume and variable volume batch, CSTR and PFR reactor data, data collection & plotting, linearization of rate equations. Analysis of total pressure data obtained from a constant-volume batch reactor, Integral and differential methods of analysis of data, Autocatalytic reactions, Reversible reactions, and Bio-chemical reactions.	8
3	**Homogeneous Single Reactions:** Performance equations for ideal batch, Plug flow, Back-mix flow and semi batch reactors for isothermal condition, Size comparison of single reactors, Multiple-reactor systems, Recycle reactor, Optimum recycle operations	8
4.	**Multiple Reactions:** Parallel reactions of different orders, Yield and selectivity, Product distribution and design for single and multiple-reactors, Series reactions: first-order reactions and zero-order reactions, Mixed series parallel complex reactions,	8

5.	**Temperature Effects for Single and Multiple Reactions:** Thermal stability of reactors and optimal temperature progression for first order reversible reactions, Adiabatic and heat regulated reactions, Design of non-isothermal reactors, Effect of temperature on product distribution for series and parallel reactions.	**7**
6.	RTD theory and analysis of non-ideal reactors	**7**

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
14	26	23	7		

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Octave Levenspiel, Chemical Reaction Engineering, 3rd Edition, Wiley-India Pvt. Ltd.
2. H. Scott Fogler, Elements of Chemical Reaction Engineering, 4th Edition, Prentice Hall of India Pvt. Ltd
3. Froment, G.B., and K.B. Bischoff, 1990, Chemical Reactor Analysis and Design, 2nd Ed., Wiley, New York
4. Smith, J.M., 1981, Chemical Engineering Kinetics, 3rd Ed., McGraw-Hill, New York.
5. L. D. Schmidt, the Engineering of Chemical Reactions, Oxford Press.
6. Carberry, J.J., 1976, Chemical and Catalytic Reaction Engineering, McGraw-Hill, New York.

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

Sr. No.	CO statement	Marks % weightage
CO-1	To classify reactions based on reaction mechanisms and reaction rates and reactors based on flow patterns	10
CO-2	To determine kinetics of single and multiple homogeneous reactions	20
CO-3	To choose an appropriate reactor type and operating conditions to achieve a desired output such as reactant conversion, selectivity and yield.	25
CO-4	To formulate a set of consistent material and energy balance equations to describe operation of batch, semi-continuous and continuous reactor systems with single or multiple reactions	25
CO-5	To summarize the effect of temperature and pressure on equilibrium conversion and choice of reactors.	10

List of Open Source Software/learning website:

Preparation of power-point slides, which include videos, animations, Pictures, graphics for better understanding theory – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus of Chemical Reaction engineering -1 is covered.

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

The analysis will include various experiments with the objective of sample preparation, measurement of concentration, prediction of kinetics and modeling of kinetics data. Learning outcomes: Students will (a) Familiarize with suitable measurement techniques and devices to measure concentration and temperature (b) Learn to employ various methods to determine the kinetics of reactions. (c) Quantify the effect of non-ideality of flow in chemical reactors. (d) Calculate the effects of mass transfer on chemical reactions, (e) Predict errors in experimentation and compare experimental data with models

1	To determine the activation energy of the reaction between sodium thio-sulphate and HCl using Arrhenius Equation.
2	To determine order of reaction for the reaction between sodium thiosulphate and HCl
3	To measure the kinetics of a reaction between ethyl acetate and sodium hydroxide under condition of excess ethyl acetate at room temperature.
4	To determine the kinetics of the reaction between ethyl acetate and sodium hydroxide at room temperature by the integral method of analysis.
5	To determine the activation energy and frequency factor for reaction between ethyl acetate and sodium hydroxide at room temperature & at different temperature.
6	To determine the kinetics of the reaction between ethyl acetate and sodium hydroxide at room temperature by the differential method of analysis.
7	To determine the kinetics of the reaction between n- butyl acetate and sodium hydroxide at room temperature by the integral method of analysis.
8	To determine the kinetics of the reaction between n- butyl acetate and sodium hydroxide at room temperature by the differential method of analysis
9	To study and analyze Residence Time Distribution (RTD) of a straight tubular flow reactor without helical coils and as a helical coil
10	To study and analyze Residence Time Distribution (RTD) for single tank reactor, two tanks in series and three tanks in series.
11	To analyze Residence Time Distribution (RTD) of packed bed reactor and prediction of extent of dispersion.
12	To study and analyze Kinetics of Dye degradation using Microwaves.

13	To study and interpret Kinetics of Bio-diesel synthesis from vegetable oils by Transesterification
14	To study Multiphase reaction: Effect in mass transfer limited reaction.
15	To study Oscillating reactions, pattern formation and reduced order modeling
16	To conduct Kinetic study of any biochemical reaction

List of Open Source Software/learning website: Software:

Students can refer to video lectures available on the websites including NPTEL, Students can refer to the CDs which are available with some reference books for the solution of problems using software. Students can develop their own programs for the solutions of problems.

Open Source Software/learning website:

1. Students can refer to video lectures available on the websites including NPTEL.
2. Students can perform experiments on Virtual lab by IIT Bombay.
3. FOSSEE –DWSIM https://dwsim.fossee.in/

GUJARAT TECHNOLOGICAL UNIVERSITY

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

Type of course: Professional Elective

Prerequisite: Basic Concepts of unit operations including mass transfer.

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

Teaching and Examination Scheme:

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

Content:

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

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

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
14	26	23	7		

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

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

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

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

List of Open Source Software/learning website:

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

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

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

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

In the beginning of the academic term, students may be allotted at least one Open-ended Project / Study Report /Latest outcome in technology. Literature survey including patents and research papers of fundamental process - Design based small project or - Study report based on latest scientific development or - Technology study report/modeling/ simulation/collection report or - Computer based simulation/web based application/analysis presentations of basic concept field which may help them in chemical engineering. These can be done in a group containing maximum three students in each. 4.

List of Open Source Software/learning website: Software:

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

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160510
Semester – VI
Subject Name: Petroleum Refining and Petrochemicals

Type of course: Professional Elective Course

Prerequisite: Basics of Chemical Technologies

Rationale: Petroleum refining as well as petrochemical industries constitute a major part of chemical sector. Every chemical engineer has to invariably handle the enormous consumption of petroleum products, their diversity and increasing applications. Chemical engineer has to apply the relevant concepts for operating petroleum refinery or petrochemical plant in a safe manner. Beside this, a chemical engineer must be aware about the various properties of petroleum fractions as well as petrochemicals. Hence, this course has been designed to develop such expertise and skills.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs
	PETROLEUM REFINING	
1	**Basics of Petroleum:** Role of Crude Oil in Global Economy, Present Scenario of Crude Oil Refinery, Origin(Formation), Composition, Classification and Evaluation of Crude Oil, Crude Assay Analysis, Distillation Characteristics such as TBP,ASTM & EFV etc.	04
2	**Properties of Petroleum Products:** Types of Gases and their Composition**,** Types of Gasoline & it's Important Properties and Tests such as ASTM Distillation , RVP, Octane number , Oxidation stability , Sulphur Content etc., Various types of Naphtha and their Important Properties and Application, Important tests and Properties of Kerosene such as Flash & Fire Point , Smoke Point , Aniline Point etc., Types of Diesel & its Important Properties and Tests such as Pour Point, Diesel Index , Cetane Number etc. , Heavy Fractions Like Lube Oil, Bitumen ,Asphalt etc. and their Important Properties Such as Viscosity Index, Carbon Residue, Penetration Index, Softening Point etc.	06
3	**Processing of Petroleum:** Pretreatment of Crude (Dehydration & Desalting), Pumping of Waxy Crude , Heating of Crude , Distillation of Petroleum & Types of Reflux , ADU & VDU etc	05

4	**Treatment Techniques:** Physical Impurities Found in Crude & their Removal, Sweetening Techniques, Production and Treatment of LPG, Gasoline Treatment Such as Lead Doctoring, Merox Sweetening, Catalytic Desulphurization etc. Various Methods of Treatment of Lubes Such as Phenol Extraction , Furfural Extraction, etc.	06
5	**Thermal & Catalytic Cracking :** Necessity and types of cracking **Thermal cracking:** Mechanism of Thermal Cracking, Properties of Cracked Materials, Visbreaking, Dubb's Two Coil Process, Delayed Coking, Naphtha Cracking etc. **Catalytic cracking:** Advantages & Theory of Catalytic Cracking, Fixed Bed, Moving Bed & Fluidized Bed Technology, FCC, Hydrocracking, Catalytic Reforming, Platforming, Continuous Catalyst Regeneration Reforming, Catalytic Polymerization, Catalytic Alkylation, Catalytic Isomerization etc.	09
	PETROCHEMICALS **Properties, Uses, Manufacturing Processes, Flow-Sheets etc. of following Petrochemicals**	
6	**C1 and C2 Petrochemicals:** Methanol, Formaldehyde, Chlorome thane etc. Ethylene, Ethylene Dichloride, Vinyl Chloride, Ethylene Oxide, Ethylene Glycol, Ethanol amines etc.	05
7	**C3, C4, Aromatics and Polymers:** Propylene, Butadiene, etc. BTX Separation, p-xylene, Styrene, p-terephthalic acid, etc. PVC, LDPE, LLDPE, HDPE, Polypropylene , Polypropylene Co-polymers , Polystyrene , SBR ,PBR, Polyesters etc.	10

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
14	28	14	14	0	0

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference books:

1. B. K.Bhaskar Rao, Modern Petroleum Refining Processes, Oxford and IBH 2007.
2. M Gopal Rao, Dryden's Outlines of chemical technology, 3rd Edition East-West press pvt. Ltd, Delhi
3. B.K.Bhaskar Rao, A Text on Petrochemicals, 2ndEdition, Khanna Publishers, Delhi, 1998

4. George Austin, Shreve's Chemical Process Industries, 5th edition McGraw Hill publication –New Delhi.
5. W.L.Nelson, Petroleum Refinery Engineering, McGraw Hill, New York, 1958.
6. James H, Gary & Glenn E. Handwerk, ' Petroleum Refining, Technology & Economics', 4th Edition, Marcel Dekker, Inc, 2001.
7. Speight, J. G., The Chemistry and technology of Petroleum, 5th Edition, M. Dekker, 1991.
8. Watkins, R. N., Petroleum Refinery Distillation, 2nd Edition Gulf Pub. Co., Houston, Tex, 1979.

Course Outcomes:

Students should be able to

Sr. No.	CO statement	Marks % weightage
CO-1	Define various test properties of crude oil and petroleum products and also explain their physical significance.	20
CO-2	Explain crude oil processing, treatment techniques and cracking reactions taking place in a petroleum refinery.	40
CO-3	Apply acquired knowledge of refinery processing and manufacturing technologies of producing petrochemicals for problem solving.	20
CO-4	Compare various routes of production of widely used petrochemicals.	20

List of Experiments:

1.	To determine the carbon residue of given sample by rams bottom apparatus.
2.	To determine the carbon residue of given sample by Conradson apparatus.
3.	To determine the calorific value of given sample by bomb calorimeter.
4.	To determine the viscosity of given sample using Engler viscometer at different temperatures.
5.	To determine the viscosity of given sample using say bolt viscometer at different temperatures.
6.	To determine the flash & Fire point of given oil sample using Cleveland open cup apparatus.
7.	To determine the smoke point of given kerosene (with and without acid treatment) sample using smoke point apparatus.
8.	To determine the percentage of corrosive sulfur in a given petroleum product using constant temperature bath.
9.	To characterize the given petroleum product (Diesel, petrol etc.) by A.S.T.M distillation (To plot ASTM curve)
10.	To find out the flash point of given oil sample using Able's apparatus
11.	To determine the flash and fire point of given sample of oil using Pensky-Martin apparatus.
12.	To determine the softening point and penetration index of Bitumen
13.	To determine the cloud and pour point of a given oil sample
14.	To determine the aniline point of a given sample.

Major Equipments:

1. Penskey Martin apparatus
2. Cleaveland Flash and Fire Point Apparatus:

3. Softening point Apparatus
4. Ram's bottom Apparatus
5. Conradson carbon residue Apparatus
6. Cloud and pour point Apparatus
7. ASTM Distillation Apparatus
8. Red wood viscometer:
9. Saybolt Viscometer
10. Engler Viscometer
11. Constant Temperature bath
12. Bomb calorimeter
13. Able's apparatus

Open Source Software/learning website:

- Video lectures available on the websites including NPTEL lecture series
- Open access Literature available for Petroleum Refining
- MIT Open course lecture on Petroleum Refining

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160511
Semester – VI
Subject Name: Polymer Science & Technology

Type of course: Professional elective course

Prerequisite: Basic knowledge of Chemistry.

Rationale: The main theme of the course on Polymer Science and Technology is to focus understanding of polymer science and technology, Polymer synthesis and its characterization. Knowledge of properties of polymers will enable their proper selection for applications in domestic as well as industrial appliances.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs
1	Introduction: Basic concepts of Monomer ,Types of Monomer, Functionality of Monomer, Basic concepts of Polymer, Effect of functionality on Polymer Structure, Chemical and geometric structure of polymer, Configuration and conformation, Linear, branched and cross-linked structure, Random, alternating, block and graft polymers, Stereo regular polymer, Classification of Polymer	**6**
2	Basic concept of polymer: structures, configuration, application, tacticity crystalline, mechanism and kinetics of polymerization, mode of formation, Poly dispersity and molecular weight distribution, Concept of Mn(Number average molecular weight), Mw((Weight average molecular weight), Mv(Viscosity average molecular weight) and Mz(Z average molecular weight) and measurement techniques, effect of molecular weight on polymer end use properities Functionality principle, Theory of polymer solutions: solubility parameter, Mark-Houwink-Sakurda equation.	**8**
3	Polymerization reactions: 1. Addition Polymerization reactions: a. Free radical polymerization b.Ionic polymerization c.Co-ordination polymerization 2.Condensation Polymerization a.Poly condensation polymerization b.Poly addition polymerization 3.Rearrangements and Stereo Polymerization 4.Co-Polymerization	**10**
4	Techniques of Polymerization: Bulk polymerization, Solution polymerization, Suspension polymerization, Emulsion polymerization, Comparison of bulk, solution, emulsion and suspension polymerization techniques	**7**

5	Polymer Degradation : Polymer degradation (chain and random), Methods of degradation of polymers such as mechanical, thermal, photo, oxidative and bio degradation	**6**
6	Polymer processing: Unit operations in polymer industries. Compression molding, transfer molding, injection molding, blow molding, reaction injection molding, extrusion, pultrusion, calendaring, rotational molding, thermoforming, rubber processing in two-roll mill, internal mixer.	**9**

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	**20**	**15**	**10**	**10**	**0**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Polymer science and technology, Joel R. Fried, Prentice Hall India Pvt. Ltd.
2. Textbook of Polymer Science, Fred W. Billmeyer, John Willy and Sons.
3. Rubber chemistry, Brydson, Elsevier Appl.
4. Principles of polymer system, Ferdinend &Rodrigues, Tata McGraw-Hill Pub.
5. Polymer Science, Gowariker, Eastern Wiley Pub.

Sr. No.	**CO statement**	**Marks % weightage**
CO-1	To Synthesize and characterize polymers based on their properties and applications.	20
CO-2	To know the various types of polymerization reactions.	20
CO-3	To Discuss techniques of polymerization.	25
CO-4	To be able to utilize the knowledge for the processing of polymers.	20
CO-5	To build a bridge between theoretical and practical concept used in industry.	15

List of Experiments: (Minimum 05 experiments need to be performed)

1. Bulk polymerization of styrene.
2. Solution polymerization of acrylonitrile.
3. Emulsion polymerization of methylacrylate.
4. Synthesis of urea - formaldehyde by condensation polymerization.
5. To study injection moulding machine: Different materials and moulds; and optimization of cycle Time.
6. Determination of melt flow index for different materials.
7. Extrusion of strands / film and Pelletization.
8. To study Compression moulding.
9. To synthesis polymer using Bulk, solution, suspension & emulsion polymerization method.

Major Equipment

Extruder, compression molding machine, etc.

List of Open Source Software/learning website:

Reference to NPTEL lectures can be made for a better understanding

Literature available on Polymer technology.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160512
Semester – VI
Subject Name: Biochemical Engineering

Type of course: Professional elective

Prerequisite: Basic Concepts of chemistry and unit operations.

Rationale: This course is intended to familiarize the students of chemical engineering with the key aspects associated with biochemical processes. Students will be exposed to the concepts which constitute biochemical engineering including its scope, applications and advantages over conventional processes. Students will also learn the principles and practice of cell culture including sterilization techniques, bioreactor design, and some of the common unit processes of the downstream processing of biological products.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs
1	Biochemical engineering as an interdisciplinary course, comparison of chemical and biochemical processes, Integrated bioprocess systems, Unit Operations in Bioprocess, microbiology fundamentals, Prokaryotic and Eukaryotic cells and their comparison; important features.	6
2	Chemicals of life: carbohydrates- types and functions, proteins- functions, elemental composition and types of proteins, basic idea about primary, secondary and tertiary structure of proteins, protein denaturation. Lipids- classifications and functions.	7
3	Properties of enzymatic reactions, Various models for enzyme-substrate complex formation, factors affecting enzyme activity, Michaelis-Menten equation: derivation and graphical evaluation of kinetic parameters, Enzyme inhibition, Enzyme immobilization, different methods of immobilization, Industrial enzymes and their applications.	7
4	Sterilization and media preparation, different types of solid media, cell death kinetics, Air sterilization, steam sterilization, batch and continuous sterilization. Stoichiometry of microbial growth and product formation, elemental balances, degree of reduction, yield coefficient, respiratory quotients. Oxygen uptake rate, Biomass production in cell cultures, phases of microbial growth, measurement of microbial growth by various methods, Monod growth kinetics, Evaluation of kinetic parameters, substrate and product	7

	inhibition, maintenance energy, environmental factors affecting microbial growth.	
5	Growth of organisms in batch reactor, continuous culture of organism, comparison between batch and continuous biomass culture, Stirred tank reactor in series and stirred tank reactor with recycle of biomass. Fed batch reactor, plug flow reactor.	**6**
6.	Design of Fermentor, Basic Functions, Body construction, Maintenance of aseptic conditions, Control of parameters, Valves and steam traps, Variants of fermentation vessels, Oxygen requirement in fermentations, Aeration and Agitation, Determination of K_La values, Fluid rheology, Factors affecting K_La values	**6**
7.	Product recovery operations, applications of filtration, cell disruption, centrifugation, liquid-liquid extraction, micro and ultrafiltration, chromatography, electrophoresis, isoelectric focusing in downstream processing.	**6**

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
14	26	23	7		

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Bioprocess Engineering: Basic concepts, 2nd Edition, by Michael L Shuler & Fikret Kargi, PHI, New Delhi.
2. Introduction to Biochemical Engineering by D. G. Rao, Tata McGraw-Hill Education, 2005.
3. Biochemical Engineering Fundamentals by James Bailey & David F Oillis, Second Edition, McGraw Hill Publications.
4. Principles of Fermentation Technology, by Whitaker, Peter F Stanbury, S. Hall and A. Whitaker, Publisher: Butterworth-Heinemann; 2nd edition
5. Biochemical Engineering, Harvey W Blanch and Douglas S Clark, CRC Press

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

Sr. No.	CO statement	Marks % weightage
CO-1	To understand basic features of a biochemical reaction and its stoichiometry	15

CO-2	To develop an elementary idea of the basic features of common microorganisms and their growth and functions of selected biochemical.	20
CO-3	To identify and explain the basic design features of bioreactors	25
CO-4	To understand the principles of the various downstream processing of bio-products	20
CO-5	To understand the basics of enzyme kinetics and features of enzymes with few applications	20

List of Open Source Software/learning website:

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

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

1. Preparation of aqueous culture medium for microbial growth and steam sterilization of the medium in autoclave.
2. Preparation of solid medium (on agar): Slant, stab, petridish and inoculation of microbial culture in laminar hood cabinet.
3. Analytical Estimation of Glucose from aqueous solution by DNS method using spectrophotometer.
4. Estimation of total sugar, reducing and non-reducing sugar from jaggery sample by Cole's Method.
5. Estimation of Protein by Folin-Lowry method
6. To study the Growth kinetic of any microorganism by using Monod Equation
7. Determination of dissolved oxygen concentration from a sample of water.
8. Determination of oxygen transfer rate and $K_l a$ value
9. Determination of iodine value of the given sample of vegetable oil.
10. Determination of free CO_2 in a given sample of tap-water.
11. Determination of BOD-5 for a given sample of waste water
12. To perform column chromatography
13. To perform drying operation on any biomass/biological materials and construct the drying rate plot.

List of Open Source Software/learning website: Software:

Students can refer to video lectures available on the websites including NPTEL, Students can refer to the CDs which are available with some reference books for the solution of problems using software.

Students can develop their own programs for the solutions of problems.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160513
Semester – VI
Subject Name: Wastewater Engineering

Type of course: Open elective course

Prerequisite: None

Rationale:
To provide an idea on the challenges in the field of water management with a perspective on wastewater management. Students will learn about the problems and its solution perspective on waste water treatment methods, sewage and sludge disposal. Different types of primary, secondary and advances treatment methods should be known by the student. This subject will guide students in the same direction. The objectives of this course are to help the students develop the ability to apply the basic understanding of physical, chemical and biological phenomena for successful design, operation and maintenance of sewage treatment plants.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs	% weightage
1	**Characterization and treatment of wastewater** Introduction: Wastewater flow and its characteristics, Wastewater collection systems, Estimation and variation of wastewater flows. Problems of industrial wastewaters, sampling protocol, equalization, neutralization, proportioning processes, volume and strength reduction. Preliminary, primary, secondary and tertiary wastewater treatment processes. Theory and design of screens, grit chambers, sedimentation, coagulation, flocculation	**07**	**15**
2	**Activated sludge treatment for wastewater** Physico-chemical and biological treatment strategies and their evaluation, Theory of activated sludge process (ASP), extended aeration systems, trickling filters (TF), aerated lagoons, stabilization ponds, oxidation ditches, sequential batch reactor, rotating biological contactor, etc., Mass balancing in ASP and TF and their design.	**10**	**25**
3	**Anaerobic treatment of wastewater** Anaerobic treatment process, Effects of pH, temperature and other parameters on anaerobic treatment, Concept of anaerobic contact process, anaerobic filter, anaerobic fixed film reactor, fluidized bed and expanded bed reactors and up flow anaerobic sludge blanket (UASB) reactor.	**08**	**15**

4	**Planning for wastewater treatment and its reclamation** Indian standards for disposal of treated wastewaters on land and in natural streams, Agricultural irrigation, Ground water recharge, Treated wastewater reclamation and reuse, Introduction to duckweed pond, vermiculture and root zone technology for wastewater treatment, Special treatments, Recent technologies of treatment.	**10**	**20**
5	**Industrial wastewater treatment** Study on wastewater generation points, wastewater characteristics, process flow sheets, wastewater treatment scheme for sugar, textile, steel, paper/ pulp, oil refinery, pharmaceutical, dyes and intermediates industries.	**10**	**25**

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
30	**15**	**15**	**5**	**5**	**0**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference:

Text Books

1. Economics of Water Resources Planning, James L.D. and Lee R.R., McGraw-Hill, Newyork, 1971.
2. Water Resources Handbook, Mays L.W., McGraw-Hill 1996.
3. Design of Water-Resource Systems, Maass A., Hufschmidt M.M., Dorfman R., Jr. Thomas H.A., Marglin, S.A., Fair G.M., Harvard University Press, 1962.
4. Environmental Engineering (Vol. I) Water Supply Engineering, Garg S.K., Khanna Publishers, 1977.
5. Water Supply and Wastewater Engineering, Raju B.S.N., Tata McGraw-Hill, New Delhi, 1995.
6. Water Supply and Sanitary Engineering, Birdie G.S. and Birdie J.S. Dhanpat Rai Publishing Company Private Ltd. New Delhi, 2014.
7. Wastewater Engineering: Treatment Disposal Reuse, Metcalf & Eddy, McGraw-Hill, 1979
8. Water & Wastewater Engineering Volume II, Fair G.M., Geyer J.C., Okun D.A., John Wiley& Sons Ltd. Newyork, 1968.

Other References:

1. Water Resources Systems Planning and Management, Chaturvedi M.C., Tata McGraw-Hill, India, 1992.
2. Introduction to Hydrology, Viessman W., Thomas Y. Crowell, Harper and Row, NY, 1972.

3. Handbook of Applied Hydrology, Chow V.T., McGraw Hill Book Company, New York, 1964.
4. Engineering Hydrology, Subramanya K., Tata McGraw Hill Company Ltd., New Delhi, 1994.
5. Hydrology and Water Resources Engineering, Patra. K.C., Narosa Publising House, New Delhi, 2008.

List of Open Source Software/learning website: www.nptel.iitm.ac.in/courses/

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To understand the basic knowledge about the wastewater and its treatment processes	15
CO-2	To understand the activated sludge process for the treatment of wastewater	20
CO-3	To understand the anaerobic process for the treatment of wastewater	15
CO4	To understand the standards for wastewater treatment, disposal and its reclamation	15
CO-5	To study the wastewater treatment scheme for various industries	20

List of Tutorials: Students can select any type of wastewater treatment. Each group of students are expected to create a way to utilize wastewater treatment method and sludge disposal process in innovative way and prepare report of project assigned to his/her group. In addition, each group is expected to give a power point presentation during the semester. The presenter will be selected randomly just prior to the presentation.

List of Open Source Software/learning website: Students can refer to video lectures available on various websites including NPTEL. Students can refer to the CDs which are available with some reference books for the solutions of problems using softwares. Students can develop their own programs for the solutions using excel, ChemCAD and other simulation softwares.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160514
Semester – VI
Subject Name: Green Technology and Sustainable Development

Type of course: Open elective course

Prerequisite: None

Rationale:
To provide an idea on Green Technology with an approach towards the design, manufacturing and use of chemical products to reduce or eliminate the chemical hazards intentionally. Green Technology is a new and rapidly emerging branch of chemistry. The goal of Green Technology is to create better and safe chemicals while choosing the safest and the most efficient ways to synthesize them. The main goal of Green Technology is to eliminate hazards right at the design stage. The principles of Green Technology demonstrate how chemical production could be achieved without posing hazard to human health and environment.

Students will learn the concept of sustainable development including different perspectives, consequences of societal resource use and strategies for changing this concept towards a sustainable direction.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs	%weightage
1	**Principles of Green Technology and Green Engineering:** To learn to modify the processes and products to make them green safe and economically acceptable to the society, Concepts of green chemistry and Process intensification.	07	15
2	**Green Synthesis and Catalysis:** Green oxidation and photochemical reactions, Microwave and Ultrasound assisted reactions, Synthesis of Green Reagents, Green solvents, Green nanotechnology and Ionic liquids.	07	20
3	**Green Industrial Processes:** Pollution statistics from various industries like polymer, textile, pharmaceutical, dyes, pesticides and wastewater treatment. A greener approach towards all these industries.	07	15
4	**Meaning of Sustainable Development:** Understand the Sustainable Development, three principal dimensions: the ecological, the economic and the social dimension, including intergenerational justice; use a systems perspective, to describe sustainability challenges and possibilities for major technical systems and for their transformation to meet sustainability requirements	07	15
5	**Concepts of Cleaner Technologies:** Cleaner Production (CP), Definition, methodology, Role of CP in Achieving Sustainability, Benefits, Role of Industry, Government and Institutions, Environmental Management	10	20

	Hierarchy, Relation of CP and EMS. CP case studies: Ammonical nitrogen recovery from wastewater, Fluoride removal from wastewater, Reuse of water from sewage treatment plant, Gas quenching process: replacement of oil with nitrogen and Reduction of hydrogen cyanide from process stack. Reuse of liquid industrial waste from several industries.		
6	**Challenges and Practical Implementation:** Responsibilities and potentials of companies for action. Green Productivity and emerging technologies. Implementation of the practical applications of Green emerging technologies and sustainable development. Case studies in Green Technology. Green laws compliance.	**07**	**15**

Reference:

1. Chemistry for Environmental Engineering and Science, Sawyer C.N, McCarty P.L and Parkin G.F. 5th ed. McGraw-Hill Professional, 2003.
2. Environmental Chemistry with Green Chemistry, Das A. K. Books and Allied (P) Ltd., Kolkata, India, 2012.
3. Green Chemistry: Environmentally Benign Reactions, Ahluwalia, V.K. Ane Books India, New Delhi, India, 2006.
4. Green Chemistry: An Introductory Text, Lancaster M. Royal Society of Chemistry, Cambridge, 2002.

Text Books

1. Introduction to Green Chemistry, Matlack A.S. Publisher: Marcel Dekker, Newyork, 2001.
2. Green Chemistry: Theory and Practice, Anastas P.T. and Warner J.C. Oxford University Press, 1998.
3. Pollution Prevention: Fundamentals and Practice, Bishop P. L. McGraw-Hill, Boston, 2000.
4. Cleaner Production Audit Environmental System Reviews, Modak P., Visvanathan C. and Parasnis M. Asian Institute of Technology, Bangkok, 1995.
5. Handbook of Green Chemistry and Technology, Clark J.H. and Macquarrie D.J. Wiley-Blackwell Publishers, 2002

Other references

List of Open Source Software/learning website: www.nptel.iitm.ac.in/courses/

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
30	**15**	**15**	**5**	**5**	**0**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160514

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To understand the principles of green chemistry and engineering	15
CO-2	To understand the field of Green Technology and its approach towards the new discovery and innovation	20
CO-3	To gain knowledge on Green industrial processes	15
CO4	To understand the concept of sustainable development and its importance	15
CO-5	Ability to describe Cleaner Production measures applicable to different industries	20
CO-6	Understand and select the different principles of green chemistry and sustainable development for various applications.	15

List of Tutorials: Students can select any type of green technology and sustainable development method. Each group of students is expected to create a way to utilize green technology and sustainable development process of industry in an innovative way and prepare report of project assigned to his/her group. In addition, each group is expected to give a power point presentation during the semester. The presenter will be selected randomly just prior to the presentation.

List of Open Source Software/learning website: Students can refer to video lectures available on various websites including NPTEL. Students can refer to the CDs which are available with some reference books for the solutions of problems using software's. Students can develop their own programs for the solutions using excel, ChemCAD and other simulation software's.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160515
Semester – VI
Subject Name: Solid Waste Management

Type of course: Open elective course

Prerequisite: None

Rationale:
To provide an idea on Solid Waste Management is a pressing issue. The course on Solid Waste Management gives the student an overview of municipal solid waste management including collection, transfer, transport and disposal. To make the students conversant with different aspects of the types, sources, generation, storage, collection, transport, processing and disposal of municipal solid waste.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs	% weightage
1	**Introducing Municipal Solid Waste Management its Generation and Characteristics of Waste:** Sources, Types, composition, quantity, sampling and characteristics of waste, factors affecting generation of solid wastes. Overview: problems and issues of solid waste management-Need for solid waste management-Functional elements such as waste generation, storage, collection, transfer and transport, processing, recovery and disposal in the management of solid waste.	08	15
2	**Types of Solid Waste:** Waste products during manufacturing and packing, operation of pollution control facilities, generation and minimization at source, recycling, disposal, Bio medical waste-generation and management system, E-waste-generation and management system.	10	20
3	**Disposal of Solid Waste:** Segregation, volume reduction at source, recovery and recycle; dumping of solid waste-sanitary, landfills-site selection-design and operation of sanitary landfill-leachate, landfill gas management-landfill closure and environmental monitoring-landfill remediation; Municipal solid waste in Indian conditions, legal aspects of solid waste disposal, plastic waste disposal and necessary equipments.	10	20
4	**Waste Collection, Storage and Transport:** Collection: Collection of solid waste–collection services–collection system, equipments–time and frequency of collection–labour requirement–factors affecting	10	20

	collection–analysis of collection system–collection routes–preparation of master schedules. Transfer and Transport: Need for transfer operation–transfer stations–types –transport means and methods–location of transport stations–Manpower requirement–collection routes: Transfer stations–selection of location, types and design requirements, operation and maintenance.		
5	**Risk Assessment and Environmental Legislation** Characterization and site assessment, Waste minimization and resource recovery, Laws for solid waste management	**07**	**15**

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
30	**15**	**15**	**5**	**5**	**0**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference:

Text Books

1. Integrated solid waste management: Engineering Principles and Management Issues, Tchobanoglous G., Theisen H., Vigil S.A. McGraw-Hill, New York, 1993.
2. Unit Operations in Resource Recovery Engineering, Vesilind P.A. and Rimer A.E., Prentice Hall, 1981.
3. Waste Treatment and Disposal, Willams P. T. John Wiley and Sons, Ltd. 2005.
4. Waste Management, Bilitewski B., Härdtle G., Marek K. Springer-Verlag Berlin Heidelberg, 1997.

Other references

1. Manual on Municipal Solid Waste Management, CPHEEO, Ministry of Housing and Urban Affairs, Government of India, New Delhi, 2000.
2. Solid Waste Management: Collection Processing and Disposal, Bhide A.D. and Sundaresan, B.B. NEERI, Nagpur, 2001.
3. Practical Handbook of Processing and Recycling Municipal Waste, Manser A.G.R. and Keeling A.A. Lewis Publishers, CRC Press, 1996.
4. Waste Management Practices: Municipal, Hazardous, and Industrial, Pichtel J. CRC Press, 2014.
5. Hazardous Waste Management, LaGrega M.D., Buckingham P.L., Evans J.C. McGraw-Hill, New York, 1994.
6. Hazardous Wastes: Sources, Pathways, Receptors, Watts R.J. John Wiley and Sons, New York, 1998.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160515

List of Open Source Software/learning website: www.nptel.iitm.ac.in/courses/

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO1	An understanding of the nature and characteristics of municipal solid wastes	**15**
CO2	Execute an action plan for types of solid waste	**20**
CO3	Select the appropriate method for solid waste disposal	**15**
CO4	Ability to plan waste minimization and design storage, collection, transport, processing and disposal of municipal solid waste	**20**
CO5	To implement risk assessment and laws related to solid waste management	**15**

List of Tutorials: Students can select any type of solid waste management techniques. Each group of students is expected to create a way to utilize industrial methods of waste minimization techniques in innovative way and prepare report of project assigned to his/her group. In addition, each group is expected to give a power point presentation during the semester. The presenter will be selected randomly just prior to the presentation.

List of Open Source Software/learning website: Students can refer to video lectures available on various websites including NPTEL. Students can refer to the CDs which are available with some reference books for the solutions of problems using softwares. Students can develop their own programs for the solutions using excel, ChemCAD and other simulation softwares.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170001
Semester –VII
Subject Name: Summer Internship

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
0	0	0	2	0	0	80	20	100

The duration of internship will be two weeks. It will be after completion of 6th Semester and before the commencement of Semester VII.

Following five options can be opted by the students:

1. Offline internship in industry - Internship in industry subjected to permissions from Government and concern Industry subject to the conditions of following the SOP issued by Government and written consent of the student and parents. Student is supposed to produce joining letter and relieving letter once the internship is over in case of Offline internship in any industry.
2. Online internship in industry / other agencies
3. Seminar by student under mentorship of a faculty. The topic shall be as per UG Syllabus topics
4. Preparation of consolidated report on survey of materials used in the respective branch of the student. The work should include the study of catalogues, price list specifications, properties, usage notes and other technical details and drawings etc, Work shall be carried out under the guidance of faculty. A detailed report shall be submitted. It shall be done by only one student. It is to be completed individually.
5. A Mini Project- on some suitable topic related to respective branch. It can be small fabrication / experimental results/ simulations / Programmes/ application development etc depending on the branch of the student. Preferably a single student should do it.

Other guidelines:

- Student has to prepare detailed report and submit to his/her college. A copy of report can be kept in the departments for record.
- Each student must be assigned a faculty as a mentor from the college and an Industry expert as co-mentor.
- The evaluation of the work done by students will be carried out after 2 weeks by the internal and external examiner.
- External examiner will evaluate for 80 marks and internal examiner will evaluate for 20 marks.
- The presentation by student in the presence of all student is desirable.

Student should produce successful completion certificate in case of offline / online internship in industry.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170001

Course Outcomes:

Upon completion of this course students should be able to:

1. Will expose Technical students to the industrial environment, which cannot be simulated in the classroom and hence creating competent professionals for the industry.
2. Provide possible opportunities to learn, understand and sharpen the real time technical / managerial skills required at the job.s
3. Gain experience in writing Technical reports/projects.
4. Expose students to the engineer's responsibilities and ethics.
5. Understand the social, economic and administrative considerations that influence the working environment of industrial organizations

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170501
Semester – VII
Subject Name: Chemical Reactions Engineering II

Type of course: Professional core

Prerequisite:
Chemical reaction engineering- 1.

Rationale:
The course is intended to familiarize the students with concepts of gas-solid catalytic and non-catalytic reactors and gas-liquid reactors, concepts of catalysis kinetics and mechanistic aspects of catalysts, design and rating of catalytic reactors and design aspects of Gas-Liquid Reactors

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs
1	Heterogeneous Reactions: Introduction: Rate steps involved in heterogeneous systems, Overall rate expression for linear and non linear process, contacting patterns for two-phase systems.	7
2	Fluid-Fluid systems: Rate equation, rate equation for straight mass transfer, kinetic regimes of mass transfer and chemical reaction, rate equation for mass transfer and chemical reactions, film conversion parameter, fluid-fluid reactor design.	7
3	Fluid-Particle systems: Fluid partial reaction kinetics, selection of a model, Shrinking Core Model for unchanging and changing size spherical partials, Diffusion through gas film and through ash layer controlling, Chemical reaction controlling, Shrinking core model, its limitations, Determination of rate controlling step.	7
4	Introduction to Catalysis, Catalysts, Physical properties of catalyst, surface area, void volume, solid density, pore volume distribution, Classification and preparation of catalyst, catalyst promoters. Catalyst inhibitors, Catalyst poisons, Nature and Mechanism of Catalytic reactions.	7
5	Solid-Catalyzed reactions: Kinetics: Adsorption isotherms and rates of adsorption and desorption. Kinetic regimes, rate equations for surface kinetics, Pore diffusion, determining rate controlling step, experimental methods for finding rates, product distribution in multiple reactions.	7

6	Catalytic reactions, introduction to LHHW (Langmuir-Hinshelwood-Hougen-Watson) kinetic model. Introduction to Catalytic Reactors: Packed bed catalytic reactors, fluidized bed reactors, trickle beds, slurry reactors. Design concepts, Mass transfer correlations for various reactors, Isothermal and non-isothermal interphase effectiveness factor	**10**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
14	26	23	7	0	**0**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. H. Scott Fogler, Elements of Chemical Reaction Engineering, 4th Edition, Prentice Hall of India Pvt. Ltd
2. Froment, G.B., and K.B. Bischoff, 1990, Chemical Reactor Analysis and Design, 2nd Ed., Wiley, New York
3. O. Levenspiel, Chemical Reaction Engineering, 3rd Edn, Wiley & Sons (1999).
4. Carberry, J.J., 1976, Chemical and Catalytic Reaction Engineering, McGraw-Hill, New York.

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

Sr. No.	CO statement	Marks % weightage
CO-1	To understand the nature and mechanism of catalytic reactions.	25
CO-2	To identify regions of mass transfer control and reaction rate control and calculate conversion	25
CO-3	To predict the rate controlling step for the fluid - particle reactions	25
CO-4	To develop conceptual framework for designing catalytic reactors.	25

List of Open Source Software/learning website:

Preparation of power-point slides, which include videos, animations, Pictures, graphics for better understanding theory – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus of Chemical Reaction engineering -1 is covered.

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

The analysis will include various experiments with the objective of sample preparation, measurement of concentration, prediction of kinetics and modeling of kinetics data. Along with prediction of errors in experimentation and compare experimental data with models

1	Determination of properties of solids (pertaining to catalyst development and application)
2	Experiment on the Adsorption of oxalic acid (or any other suitable organic compound) on activated Carbon.
3	Study the effect of surface area on adsorption.
4	To conduct any experiment involving heterogeneous catalysis in the fixed bed reactor
5	Synthesize detailed reaction networks for catalytic reactions on solid catalyst surfaces, such as zeolites or TiO_2
6	Experiment on determining the mass transfer zone and an absorber's mass balance and efficiency
7	Experiment on predicting breakthrough curves in adsorption of any selected system with environmental application
8	Experiment on detection of the influencing factors contact time, temperature and mode of operation.
9	Experiment on fluidized bed catalytic reactor.
10	Kinetic modeling study of heterogeneously catalyzed chemical synthesis reactions.
11	Catalytic oxidation experiment to demonstrate the principles of i) reaction rate determination, ii) reactor design, iii) heterogeneous catalysis, etc

List of Open Source Software/learning website: Software:

Students can refer to video lectures available on the websites including NPTEL, Students can refer to the CDs which are available with some reference books for the solution of problems using software. Students can develop their own programs for the solutions of problems.

Open Ended Projects:

1. In the beginning of the academic term, faculties will have to allot their students at least one Open-ended Project / Study Report / Latest outcome in technology.
2. Literature survey including patents and research papers of fundamental process

- Design based small project **or**
- Study report based on latest scientific development or
- Technology study report/ modeling/ simulation/collection report **or**

- Computer based simulation/ web based application/ analysis presentations of basic concept field which may help them in chemical engineering.

3. These can be done in a group containing maximum **three** students in each.
4. Faculties should cultivate problem based project to enhance the basic mental and technical level of students.
5. Evaluation should be done on approach of the student on his/her efforts (not on completion) to study the design module of given task.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170502
Semester – VII
Subject Name: Process Equipment Design

Type of course: Professional Core Course

Prerequisite: The student should have basic understanding of Unit Operations of Chemical Engineering.

Rationale: Equipment design involves determination of all linear dimensions of equipment like diameter, length, etc. It also includes determination of thickness and weight of different parts of equipment. Readymade software's are available for the design of equipments. However, to use these soft wares effectively and correctly fundamental knowledge of this subject is required. With rapid rate of increase in the advancement of knowledge, it is important that the students should know also about the latest development in the design of equipments. Students who like to work as Design Engineer, Process Engineer or as Process Development Engineer, knowledge of this subject is essential. It is also useful for Production Engineer working in process plant for trouble shooting of problem related to operation of equipment.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
4	0	2	5	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Process design of Piping and Pumps:** Introduction, Process design of piping, $NPSH_A$ & $NPSH_R$, Power required by pump, Power required in Fan, Blower and adiabatic compressor, flow meters, Process design of Orifice meter, Rotameter etc	10
2	**Process design of Heat Exchangers:** Shell & Tube heat exchangers, Functions of various parts of shell & Tube Heat exchanger, General design method of shell & tube heat exchanger, Criteria of selection among Fixed Tube sheet, U Tube & Floating Head heat exchanger, Process design of without phase change heat exchanger, Process design of condenser, Criteria of selection for Horizontal and vertical condenser, Process design of Kettle type & Thermosyphon Reboilers and vaporizes, Tinker's flow model.	12

3	**Process design of Distillation Column:** Introduction, Criteria of selection, Selection of equipment for distillation, Distillation column design, Selection of key components for multi- component distillation, Determination of operating pressure for distillation column, Advantages & disadvantages of vacuum distillation, Determination of nos. of theoretical stages for binary distillation by McCabe Thiele method Determination of nos. of theoretical stages for multi-component distillation by Fenskey- Underwood-Gilliland's method, Selection of trays, Calculations for tower diameter & pressure drop of sieve tray tower, Checking of conditions for weeping, down comer flooding, liquid entrainment, etc, tray efficiency, Jet Flooding & down comer Flooding, Different types of weirs & down comers of tray tower, their selection criteria.	12
4	**Process design of Absorbers**: Introduction, Criteria for selection among different types of absorption equipment, Process Design of packed tower type absorber: Determination of actual amount of solvent, Selection of packing, Determination of tower diameter & pressure drop, Determination of *NtoG*, *HtoG* & height of packing, Process design & selection criteria of liquid distributors, redistributors & packing support, Process design of Spray chamber or spray tower type absorber, Venturi Scrubber.	12
5	**Mechanical design of Pressure Vessel:** Selection of material of construction, Concept of internal & external design pressure, design stress & design temperature, Different types of equipments, Static & rotary equipments, Different types of static equipments, Different types of welding joints, Joint efficiency, Radiography. Mechanical design of shell, head, Jacket, coil, agitator, nozzle, etc.,	14

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
0	**10**	**25**	**30**	**20**	**15**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Introduction to Process Engineering and Design by S B Thakore and B I Bhatt, McGraw Hill, 2nd Edition, 2015.
2. Ray Sinnott, Gavin Towler, Chemical Engineering Design - Principles, Practice and

Economics of Plant and Process Design, Butterworth - Heinemann, 2008.
3. Brownell and Young, Process Vessel Design, Wiley Eastern, 1977.
4. M. S. Peters and K. D. Timmerhaus, Plant Design and Economics for Chemical Engineers, 4th ed., McGraw - Hill, New York, 1991.
5. Ludwig, E. E., Applied process design for chemical and petrochemical plants , volume 1,2 & 3, Third Edition, Butterworth- Heinemam,1997
6. TEMA Standards.
7. Don W. Green, Robert H. Perry, Perry's Chemical Engineers' Handbook, 8th Edn., McGraw -Hill, New York, 2008
8. James R. Couper, James R. Fair & W. Roy Penney, Chemical Process Equipment - Selection and Design, 2 ndEdn., Butterworth - Heinemann, 2010.

Course Outcomes:

After learning, the course the students should be able to:

Sr. No.	CO statement	Marks % weightage
CO-1	Design process equipment and modify the design of existing equipment to new process conditions or new required capacity.	30
CO-2	Build a bridge between theoretical and practical concepts used for designing the equipment in any process industry.	30
CO-3	Create understanding of equipment design.	20
CO-4	Review the importance of design concepts in process industry.	20

List of Experiments:

1. Prediction of Physical properties
2. Process design of shell and tube heat exchanger
3. Process design of packed tower type absorber
4. Process design of tray tower type distillation column
5. Process design of packed tower type distillation column
6. Mechanical design of pressure vessel

List of Open Source Software/learning website:

- Open source software like DWSIM, COCO, 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 refer to the CDs available with some reference books for the solution of problems using software/spreadsheets. Students can develop their own programs/spreadsheets for the solution of problems.
- MIT Open course lecture on Equipment design.
- Literature available for Process design of equipment in plant / industry.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170507
Semester – VII
Subject Name: Computer Aided Process Synthesis

Type of course:

Prerequisite: Basics of heat transfer, mass transfer and reaction engineering

Rationale: The design-synthesis activities focuses on the practical application of the fundamentals and integrates the considerations of numerous options to form a complete manufacturing system. The design engineer need to know the basics of fluids, heat transfer, separations, and reactor engineering for selection of the steps as individual operations and their integration to form an efficient process synthesis. Energy integration is the most important component of process synthesis for design optimization. Heat Integration, reactor network, separation trains, batch scheduling are the focus areas for effective process synthesis. The study of this course will help students to take their understanding of basic subjects to a new and higher level.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs
1	**The Design Process:** Objectives, Design Opportunities, Steps in Product Process Design, Environmental, Protection, Safety Considerations, Engineering Ethics, Role of Computers	3
2	**Reactor Design and Reactor Network Synthesis:** Objectives, Reactor Models, Reactor Design for complex configurations, Reactor Network Design using the Attainable Region	5
3	**Synthesis of Separation Trains:** Objectives, Introduction, Phase Separation of Reactor Effluent, Criteria for Selection of Separation Methods, Selection of Equipment, Sequencing of Ordinary Distillation for the Separation of Nearly Ideal Fluid Mixtures, Heuristics for Determining Favourable Sequences, Marginal Vapour Rate Method, Complex and thermally coupled distillation, Sequencing of Ordinary Distillation for the Separation of nearly Non-Ideal fluid mixtures	8

4	**Synthesis of Heat Exchanger Networks:** Objectives, Basic Heat Exchanger Network Synthesis (HENS), Minimum Utility Targets, Temperature Interval Method, Hohmann / Lochart Composite Curves (HCC), Grand Composite Curves (GCC), Pinch Design Approach to Inventing a Network, Networks for Maximum Energy Recovery, Minimum Number of Exchangers, Stream Splitting, Threshold and Optimum Approach Temperature, Derivation of Network Superstructures for Minimization of Annual Costs, Multiple Utility Design Problems	**16**
5	**Energy Integrated Distillation Processes:** Heat Integrated Distillation Trains, Impact of Pressure, Multi Effect Distillation, Heat Pumping, Vapour Recompression and Reboiler Flashing, Positioning of Heat Engines and Heat Pumps	**6**
6	**Design and Scheduling of Batch Processes:** Objectives, Introduction, Design of Batch Process Units, Design of Reactor-Separator Processes, Design of Single Product Processing Sequences, Design of Multi-Product Processing Sequencing	**7**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
5	10	25	15	10	5

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Lorens T. Biegler, E. Ignacio grossmann, Arthur W. Westerberg, Systematic Methods of Chemical Process Design, Prentice Hall International.
2. Warren D. Seider, J. D. Seader, Daniel R. Lewin, Product and Process Design Principles: Synthesis, Analysis, and Evaluation, 2nd Edition, Wiley.
3. Robin Smith, Chemical Process: Design and Integration, Wiley.
4. James M. Douglas, Conceptual Design of Chemical Processes, McGraw Hill International, 1988.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170507

Course Outcomes:

After successful completion of the course, student will be able to

Sr. No.	CO statement	Marks % weightage
CO-1	identify minimum hot and cold utilities and develop heat exchanger networks using pinch design approach.	30
CO-2	develop reactor network synthesis using attainable region	10
CO-3	analyze various alternatives for heat integration of distillation columns	20
CO-4	design batch processes using cycle time for a single/multi product plants	15
CO-5	develop HENs using various tools	25

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

Practical based on the syllabus topics to be planned. The list may include following experiments:

1. Minimum utility target and pinch point using temperature interval method
2. Minimum utility target and pinch point using HCC & GCC method in MS Excel
3. Minimum utility target and pinch point using HINT software
4. Minimum utility target and pinch point using LP in MS Excel
5. Minimum utility target and pinch point using LP in GAMS
6. Design of heat exchanger network using HINT Software
7. Application of GAMS to solve MILP model for HENS with minimum number of heat exchangers for minimum utility targets using expanded transhipment model
8. Attainable region for PFR & CSTR for Van De Vusse reaction system
9. Reactor network synthesis for manufacture of maleic anhydride
10. Design and scheduling of batch process
11. Sequencing of multiple distillation columns

List of Open Source Software/learning website:

- Students can refer to video lectures available on the websites including NPTEL lecture series.
- Students can refer to the CDs available with some reference books for the solution of problems using software/spreadsheets.
- Heat Exchanger Network synthesis, design and analysis can be performed in HINT open source software. Student can use spreadsheet software for most calculations. Students can develop their own programs/spreadsheets. Student can use DWSIM, COCO, ChemSep open source software also.
- Students can use Scilab/GAMS software for the solution of LP, NLP, MILP optimization problems

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170509
Semester – VII
Subject Name: Nanoscience and Technology

Type of course: Professional elective course

Prerequisite: None

Rationale:
To provide an idea on the fundamentals of nanotechnology with a approach towards the synthesis, characterization and applications of nanomaterials. Nanotechnology is a new and rapidly emerging branch. It is a field of research and originality related to creation of new materials and devices. Students will learn the concept of nanotechnology, different techniques for synthesizing nanomaterials, characterization of nanomaterials and its applications in different fields.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs	%weightage
1	**Introduction to Nanotechnology:** Introduction, definition, history, effects of nanoscience and nanotechnology in different fields.	03	**10**
2	**Properties of nanomaterials:** Size and shape and based properties, colour, melting point, density of states, band gap and magnetism.	07	**15**
3	**Nanoparticles synthesis:** Top down and bottom-up approach, colloids, emulsions, micelles, polymers, mechanical attrition and high energy ball milling.	07	**15**
4	**Nanomaterials characterization:** Scanning electron microscopy, Transmission electron microscopy, Fourier transform infrared spectroscopy, Energy dispersive spectroscopy, Atomic force microscopy, X-ray diffraction, Dynamic light scattering, UV-Vis spectrophotometer.	10	**20**
5	**Fabrication:** Lithography, chemical vapor deposition, physical vapor deposition, sol-gel synthesis, molecular self-assembly, crystal growth, epitaxy, etching, masking.	10	**20**
6	**Applications of nanotechnology in chemical industry:** Catalysis, fuel cells, drug delivery and diagnostics, coatings, nanocomposite polymers, fluid inks, dyes, block copolymers, dendrimers, carbon nanotubes applications.	08	**20**

Text Books:

1. Nanoscale materials in Chemistry, K.J. Klabunde, Wiley, 2001.
2. Introduction to Nanotechnology, C.P. Poole Jr. and F.J.Owens, Wiley, 2003.

3. Nanotechnology, M. A. Ratner and D. Ratner, Pearson, 2003.
4. The Chemistry of Nanomaterials: Synthesis, Properties and Applications, C.N.R Rao, Achim Müller, A. K. Cheetham, Wiley, 2004.

References:

1. Hand book of Nanostructured Materials and Nanotechnology, H. Nalwa, Vol. 1 to 5, Academic Press, 1999.
2. Hand book of Nanotechnology, B. Bhusan, Springer, 2004.
3. Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers and Architects, D. Schodek, P. Ferreira, M.F. Ashby, 2009.

Other references

List of Open Source Software/learning website: https://nptel.ac.in/courses/118/104/118104008/

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
30	**15**	**15**	**5**	**5**	**0**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To understand the principles of nanotechnology	**10**
CO-2	To understand the properties of nanomaterials	**15**
CO-3	To gain the knowledge of nanoparticles synthesis by different methods	**15**
CO-4	To understand the characterization of nanomaterials by various techniques	**20**
CO-5	To acquire the knowledge on the nanotechnology fabrication methods	**20**
CO-6	To study the applications of nanotechnology in chemical industry:	**20**

List of Open Source Software/learning website: Students can refer to video lectures available on various websites including NPTEL.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170510
Semester – VII

Subject Name: Process Intensification

Type of course: Professional Elective Course

Prerequisite: Basics of heat transfer, mass transfer and reaction engineering

Rationale: Process intensification is the paths for development of more sustainable chemical processes. Process intensification leads to a substantially smaller, cleaner, safer, and more energy efficient technology. Process intensification concerns engineering methods and equipment only; development of a new chemical route or a change in composition of a catalyst is not covered under process intensification. Process intensification consists of the development of novel apparatuses and techniques to bring improvements in manufacturing and processing, substantially decreasing equipment size/production-capacity ratio, energy consumption, or waste production; ultimately resulting better sustainable technologies. Process intensifying equipment covers novel reactors, intensive mixers, and heat-transfer and mass-transfer devices. Process intensifying methods covers new or hybrid separations, integration of reactions and separations, heat exchange, phase transition and/or new process-control methods such as intentional unsteady-state operations.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs
1	**Introduction to process Intensification** History of Process Intensification, Definitions and Interpretations of Process Intensification, Fundamentals of Process Intensification – Principles, Approaches, Domains, and Scales, Techniques of Process Intensification (PI) Applications, The philosophy and opportunities of Process Intensification, Main benefits from process intensification, Process Intensifying Equipment, Process intensification toolbox, Techniques for PI application.	5
2	**Novel Reactors:** Introduction to spinning disc reactor, Rotor stator reactors: the STT reactor, Taylor–Couette reactor, Rotating packed-bed reactors, Oscillatory baffled reactors (OBRs), Micro-reactors (The catalytic plate reactor (CPR), HEX-reactors), Hydrodynamic	8

	Cavitation Reactors	
3	**Intensive mixers:** Introduction to special types of mixers, Ultrasound mixers, Mixing in intensified equipment, Chemical Processing in High-Gravity Fields Atomizer, Ultrasound Atomization, Nebulizers, High intensity inline mixers reactors; Static mixers, Ejectors, Tee mixers, Impinging jets, Rotor stator mixers	**6**
4	**Structured Catalysts and Reactors:** Introduction to catalyst, Overview of structured reactors, Monolithic Catalysts and Reactors, Gauzes, Structured Packings, Foams, Three-Levels-of-Porosity (TLP) Reactors, Membrane-Enclosed Catalytic Reactor (MECR), Environmental Catalysis, Hydrodynamics and Mass Transfer in Monoliths	**7**
5	**Hybrid Separation :** Distillation – dividing wall columns, Short path distillation, Membrane distillation, Extractive distillation, Adsorptive distillation, Membrane absorption/stripping, Adsorptive membranes (membrane chromatography), Membrane extraction, Supercritical separation, Barriers and future prospects	**6**
6	**Integration of reaction and separation:** Heat Integrated Distillation Trains, Reactive distillation, Reactive extraction, Reactive absorption, Fundamentals of process modeling in integrated systems, Case studied such as Absorption of NOx, Coke Gas Purification, Methyl Acetate Synthesis, Synthesis of Methyl Tertiary Butyl Ether	**7**
7	**New Heat Exchangers:** Plate heat exchangers, Graphite plate heat exchangers, Spiral heat exchangers, Printed circuit heat exchangers, The Chart-flow heat exchanger, Flat tube-and-fin heat exchangers, Microchannel heat exchangers, Polymer film heat exchanger, Foam heat exchangers, Mesh heat exchangers, Selection of heat exchanger technology, Integrated heat exchangers in separation processes	**6**

Plasma

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
5	10	25	15	10	5

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170510

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Process Intensification Engineering for Efficiency, Sustainability and Flexibility by David Reay, Colin Ramshaw, Adam Harvey. Elsevier Science, 2013
2. Reengineering the Chemical Process Plants, Process Intensification by Stankiewicz, A., Moulijn, (Eds.), Marcel Dekker, 2003.
3. Process Intensification for Green Chemistry, Engineering Solutions for Sustainable Chemical Processing by Kamelia Boodhoo, Adam Harvey, Willey 2013

Course Outcomes:

After successful completion of the course, student will be able to

Sr. No.	CO statement	Marks % weightage
CO-1	identify process intensification for the enhancement of chemical processes	15
CO-2	apply intensified reactors and/or separators in process industries	35
CO-3	analyze scale up issues in the process industries.	25
CO-4	solve process challenges using intensification technologies	25

List of Open Source Software/learning website:

- Students can refer to video lectures available on the websites including NPTEL lecture series.
- Students can refer to the CDs available with some reference books for the solution of problems using software/spreadsheets.
- Heat Exchanger Network synthesis, design and analysis can be performed in HINT open source software. Student can use DWSIM, COCO, ChemSep open source software also.
- Students can use recent research articles published in Chemical Engineering and Processing: Process Intensification, Elsevier.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170511
Semester – VII
Subject Name: Transport Phenomena

Type of course: Professional Elective Course

Prerequisite: Concepts of Fluid Flow Operations, Process Heat Transfer and Mass Transfer Operations.

Rationale: This course will highlight coupling between three transport phenomena with applications in various disciplines in engineering and science, and will demonstrate to the students the common mathematical structure of transport problems.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs
1.	**Introduction to Transport Phenomena:** Classification of Transport Processes, Conservation Laws, Vector and Tensor Calculus	3
2.	**Momentum Transport:** Newton's Law of Viscosity and viscosity estimation, Shell Momentum Balance, Application of Shell Momentum Balance for Flow of Falling Film, Flow Through Circular Pipe, Flow Through annulus, Flow Over Moving Plate, Flow of adjacent immiscible fluids, Equation of Changes: Continuity Equation, Equation Motion, Navier-Stokes Equation.	14
3.	**Steady State Heat Transport:** Fourier's Law of heat conduction and estimation of thermal conductivity, Shell Energy Balance, Applications of Shell Energy Balance for Heat Conduction with Electrical Source, Heat conduction with Nuclear heat source, Heat conduction Viscus heat source, Heat Conduction with Chemical Heat Source, Heat Conduction in a Cooling Fin, Forced Convection, The energy equation.	14
4.	**Mass Transport:** Fick's law of binary diffusion and estimation of diffusivity, Mass and Molar Concentrations, Mass Average and Molar Average Velocity, Mass and Molar Fluxes, Convective Mass and Molar Fluxes, Shell mass balance, Applications of Shell mass balance for Diffusion Through a Stagnant Gas Film, Diffusion with Heterogeneous Chemical Reaction, Diffusion With Homogeneous Chemical Reaction, Diffusion Into a Falling Liquid Film (Gas Absorption, Forced Convection Mass Transfer). The Equations of Continuity For a Multicomponent Mixture.	14

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170511

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
0	14	42	7	7	0

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. R. B. Bird, W. E. Stewart, E. N. Lightfoot. "Transport Phenomena", 2nd Edition, John Wiley & Sons (Asia) pvt. Ltd. 2002.
2. C. J. Geankoplis, "Transport Processes and Separation Process Principles", 4th Edition, PHI Learning Private Limited., New Delhi
3. W. J. Thomson, "Introduction to Transport Phenomena", Prentice Hall, 2000.

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

Sr. No.	CO statement	Marks % weightage
CO-1	Analyze transport equations using vector and tensor calculus.	10
CO-2	Estimate transport properties such as viscosity, conductivity and diffusivity.	10
CO-3	Solve transport problems using shell balance methods.	35
CO-4	Develop equation of changes from conservation laws for momentum, energy and mass transport.	25
CO-5	Compare the mechanisms of transport processes	20

List of Open Source Software/learning website:

- SWAYAM and NPTEL courses available on Transport Phenomena
- MIT Open course lecture on Transport Phenomena
- OpenFOAM, SimFlow etc. softwares

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170512
Semester – VII
Subject Name: Introduction to Computational Fluid Dynamics

Type of course: Professional Elective Course

Prerequisite: Fluid flow operation, Numerical methods in Chemical Engineering

Rationale: The course deals with the numerical solution of equations governing fluid flow in chemical engineering applications. In all these fields, one needs to deal extensively with fluid flow related phenomena and one needs to resolve flow-related features of the processes and equipment. Although the equations governing fluid flow have been formulated, it is only in recent years that these are being solved in the practical applications in which the flow occurs. The course deals with the basic techniques that enable the numerical solution of these equations.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs
1	**Introduction:** Illustration of the CFD approach, CFD as an engineering analysis tool, Review of governing equations, Modeling in engineering, Partial differential equations- Parabolic, Hyperbolic and Elliptic equation, CFD application in Chemical Engineering, CFD software packages and tools.	5
2	**The Governing Equations of Fluid Dynamics:** Introduction, Models of the Flow, The Substantial Derivative (Time Rate of Change Following a Moving Fluid Element), The Divergence of the Velocity, The Continuity Equation, The Momentum Equation, The Energy Equation, Physical Boundary Conditions	10
3	**Mathematical Behavior of Partial Differential Equations:** Introduction, Classification of Quasi-Linear Partial Differential Equations, A General Method of Determining the Classification of Some Simple CFD Techniques: A Beginning Partial Differential Equations: The Eigenvalue Method, General Behavior of the Different Classes of Partial Differential Equations: Impact on Physical Computational Fluid Dynamics.	10

4	**Basic Aspects of Discretization:** Introduction, Introduction to Finite Differences, Difference Equations, Explicit and Implicit Approaches: Definitions and Contrasts, Errors and an Analysis of Stability	**08**
5	**Application of CFD in design:** practical applications and case study of reactor (PFR and CSTR) design, agitator design, coils and jacket design, design of insulation system, dryer design, furnace design, design of mass transfer contactors, thin-film evaporator, design and simulation of mixing, fluidized bed reactor and combustion chamber.	**12**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**20**	**25**	**20**	**15**	**10**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Anderson J.D. (1995) Computational Fluid Dynamics: The Basics with Applications,McGraw-Hill, Inc.
2. .Ferziger J.H. & Peric M. (1999) Computational Methods for Fluid Dynamics, Springer, Berlin, Germany.
3. Hirsch C. (1988) Numerical Computation of Internal and External Flows, John Wiley & Sons, New York, USA.
4. Patankar S.V. (1980) Numerical Heat Transfer and Fluid Flow, Hemisphere, Washington D.C., USA.
5. Versteeg H.K. & Malalsekera W. (1995) An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Longman Scientific & Technical, Harlow, Essex, UK.

Course Outcomes:

After successful completion of the course, student will be able to

Sr. No.	CO statement	Marks % weightage
CO-1	relate importance of CFD in design	15
CO-2	to implement numerical solutions for heat, mass and momentum transport equations	35
CO-3	evaluate discretization methods and solution methodology	20

CO-4	apply CFD simulation for design of equipments and operations	30

List of Open Source Software/learning website:

- Students can refer to video lectures available on the websites including NPTEL lecture series.
- Students can refer to the CDs available with some reference books for the solution of problems using software/spreadsheets.
- Student can take MIT Open course lecture on Computational Fluid Dynamics
- Students can use OpenFOAM (open source software) or ANSYS FLUENT or other CFD software.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170513

Semester – VII

Subject Name: Process Modelling, Simulation and Optimization

Type of course: Professional Elective Course

Prerequisite: Basics kknowledge of unit operations, fundamental of process engineering, engineering mathematics and numerical computations.

Rationale: The Process Modelling, Simulation and Optimization of chemical engineering processes is a subject of major importance for the knowledge of transport processes; improved design process and its kinetics. The subject comprises of three parts: modelling, simulation and optimization. Modelling and simulation emphasize on the concept of modelling of chemical engineering processes, parameter estimations, decomposition of networks, application of numerical methods, data regression, convergence promotion, specific-purpose simulation, dynamic simulation, etc. Optimization includes the concept; i.e., how one develops mathematical statements for the objective function (usually economic model) to be minimized or maximized and the equality and inequality constraints (the process model) and selection of optimization technique, which is best suited to the problem characteristics.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs
1	**Introduction :** Definition of Modelling, Simulation and Optimization, importance of modelling for simulation and optimization, comparison of design and simulation, scope and applications of modelling, simulation and optimization	3
2	**Modelling Aspects:** Definition of model, process model, deterministic and stochastic process, physical and mathematical modelling, classification of models, process to build a model, degrees of freedom analysis for model, empirical model, selecting functions to fit empirical data, Black-box model	4
3	**Mathematical Modelling of Chemical Engineering Systems:** Introduction, uses of mathematical models, scope of coverage, principles of	3

	formulation, fundamental laws, continuity equations, energy equations, equation of motion, transport equation, equation of state, equilibrium, kinetics.	
4	**Examples of Mathematical Models of Chemical Engineering systems:** flow tank, mixing tank, two heated tanks, PFR, CSTR, series of isothermal constant-hold up CSTR, CSTR with variable holds up, gas-phase pressurized CSTR, non-isothermal CSTR, single-component vaporizer, batch reactor, reactor with mass transfer, ideal binary distillation column, batch distillation with holdup, Solvent Extraction, gas adsorption	**6**
5	**Chemical Process Plant Simulation :** Steady state vs dynamic simulation, lumped system-partitioning equation, tearing equation, simultaneous equation, modular approaches & equation solving approaches, decomposition of networks, partition and tearing applied to process flow sheeting, reachability matrix, selection of property perdition method for simulation, Introduction to Various Professional Simulators and Equation Solver Software	**5**
6	**Basic Concepts of Optimization:** Scope and hierarchy of optimization, examples of applications of optimization, the essential features of optimization problems, general procedure for solving optimization problems, obstacles to optimization, continuity of function, convexity and its applications, interpretation of the objective function in terms of its quadratic approximation, necessary and sufficient conditions for an extremum of an unconstrained function.	**4**
7	**Optimization of Unconstrained Functions:** One dimensional search numerical methods for optimizing a function of one variable, scanning and bracketing procedures, Newton and Quasi-Newton methods of unidimensional search, polynomial approximation methods, how one-dimensional search is applied in a multidimensional problem, evaluation of unidimensional search methods, methods using function values only : Simplex search, Hooke-Jeees and Powell's method; methods that use first derivatives : Newton's method, Marquardt's method, Quasi-Newton methods.	**6**
8	**Linear Programming (LP) and Applications**: Formulation of linear programming models, LP in standard form, principles of simplex method, applications	**5**
9	**Constrained Optimization :** Lagrange's multiplier, Kuhn-Tucker conditions, transformation methods : penalty function, constrained direct search method: complex method, Quadratic approximation methods	**4**
10	**Application of Optimizations:** Examples and case studies of optimization in chemical processes like optimizing recovery of waste heat, optimal shell and tube heat exchanger design, optimal design and operation of binary distillation column, chemical reactor design and operation, optimal location of coal-blending plant, optimization of Glycol-Ethylene Oxide process	**5**

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170513

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
5	10	25	15	10	5

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. B Wayne Bequette, Process Dynamics: Modeling, Analysis and Simulation, Prentice Hall International Inc.
2. B V Babu, Process Plant Simulations, Gulf Publications.
3. William L. Luyben, Process Modeling, Simulation and Control for Chemical Engineers, McGraw Hill International Editions.
4. R Turton, R C Bailie, W B Whiting and J A Shaeiwitz, Analysis, Synthesis and Design of Chemical Processes, Prentice Hall International In.
5. W D Seider, J D Seader and D R Lewin, Product and Process Design Principles-Synthesis, Analysis, and Evaluation, 2nd ed., John Wiley and Sons Inc.
6. W. F. Ramirez, Computational Methods for Process Simulation, Second Edition, Butterworth Heinemann.
7. Edger, Himmelblau, Lasdon, Optimization of Chemical Processes, McGraw-Hill International Edition.
8. Gordon S. G. Beveridge and Rober S. Schechter, Optimization: Theory and Practice, McGrawHill Book Company.
9. M C Joshi and K M Moudgalya, Optimization: Theory and Practice, Narosa Publishing
10. S. S. Rao, Engineering Optimization: Theory and Practice, Third Edition, Wiley Eastern Ltd.
11. A. Ravindran, K.M. Ragsdell and G.V. Reklaitis, Engineering Optimization: Methods and Applications, Second Edition, Wiley

Course Outcomes:

After successful completion of the course, student will be able to

Sr. No.	CO statement	Marks % weightage
CO-1	Illustrate use of fundamental laws to develop model for Chemical engineering processes.	10

CO-2	Outline the scope of process optimization and its applications to chemical processes.	20
CO-3	Apply mathematical principles and techniques to solve the models for simulation.	20
CO-4	Analyse process plant simulation results using professional simulators.	25
CO-5	Formulate optimization problems and evaluate the solutions.	25

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

Practical based on the syllabus topics to be planned. The list may include following experiments:

1. Familiarization to tools used for laboratory like Excel Spreadsheet, COCO/DWSIM (open source simulator and MATLAB/SCILAB (computation platform)
2. Solve single and multi-variable optimization problems in Excel Spreadsheet using solver
3. Solve Linear Programming problems in Excel Spreadsheet using solver
4. Estimate kinetic parameters of the reaction using batch reactor data
5. Plot ideal and non-ideal vapour liquid equilibrium (VLE) plots computing data using (i) ideal mixture assumption and (ii) using Van-Laar activity coefficient model
6. Determine composition of vapour and liquid streams in a flash distillation still using VLE data
7. Simulate continuous binary distillation column developing material and enthalpy balance in the column. Compute ideal number of places using optimal reflux ratio.
8. Simulate multicomponent distillation with reboiler and condenser.
9. Develop material and energy balance for adiabatic combustion of methane and simulate the effect of excess air on performance of combustion.
10. Develop simulation of shell and tube heat exchange and evaluate Rating / Design.
11. Develop design and optimization of single and multiple effect evaporator
12. Develop simulation of fed batch reactor to evaluate effect of initial volume and feed recipe on productivity and yield

List of Open Source Software/learning website:

- Students can refer to video lectures available on the websites including NPTEL lecture series.
- Students can refer to the CDs available with some reference books for the solution of problems using software/spreadsheets.
- Student can use DWSIM, COCO, ChemSep open source software for simulation study.
- Students can use Matlab, Scilab or GAMS software for the solution optimization problems.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170514
Semester – VII
Subject Name: Mechanical Design of Process equipments

Type of course: Open Elective

Prerequisite: The student should have basic understanding of Unit Operations of Chemical Engineering and mechanical properties associated with the material.

Rationale:
Equipment design involves modifications and additions to existing plants or creating design layouts of plant/equipments. With rapid rate of increase in the advancement of knowledge, it is important that the students should know the relevant application for equipment design. It has been observed conclusively that practice in using the reference literature and software has helped the students to secure jobs and also to perform better in profession.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Contents	Total Hrs
1	**Introduction:** Design pressure and temperature, design and allowable stress, Static and rotary equipments, Different types of welding joints, joint efficiency and methods of fabrication of equipment, Radiography, Codes, standard and specification for pressure vessel, Mechanical properties of material.	04
2	**Design of Pressure vessel:** Mechanical design of shell and head subjected to internal and external pressure, Graphical & analytical method for shell and head subjected to external pressure, Shell design for external pressure with & without stiffening ring, Different types of Nozzles and design of reinforcement pad for nozzle by area for area method, Different types of flanges, flange facings, gaskets and their selection criteria, Design of bracket support.	08
3	**Design of Reaction Vessel:** Mechanical design of shell, head, Jacket, coil, agitator, nozzle, etc., Different types of agitators & their selection criteria, Determination of power required for agitation, shaft diameter, blade thickness, etc., Different types of jackets & their selection criteria, Selection between coil & jacket.	05

4	**Design of Storage Tank:** Types of storage tanks, Capacity of storage tank, its diameter & height, Design of fixed roof storage tank, Design of structural supported conical roof as per API 620, Vent sizing for atmospheric and low pressure tanks.	**05**
5	**Design of Shell & Tube Heat Exchangers**: Function of various parts of shell & tube heat exchanger, Mechanical design of Shell, tube, tube sheet, head, channel shell, etc. of shell & tube heat exchanger, Mechanical design of saddle support.	**04**
6	**Design of Distillation and Absorption Column:** Mechanical design of shell, head, tray support for Vertical tall tower, Determination of shell thicknesses at various heights for tray tower & packed tower in case of internal & external pressure, Different types of tray support, Mechanical design of skirt support.	**06**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
07	21	21	07	14	--

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Brownell L.E., Young E.H., "Process Equipment Design", Wiley Eastern, Delhi, 1977.
2. Thakore S.B., Shah D.A., "Illustrated Process Equipment Design", 4th Edition, Atul Prakashan, Ahmedabad, 2018.
3. Bhattacharyya B.C., "Introduction to Chemical Equipment Design: Mechanical Aspects", 5th Edition, CBS Publishers, New Delhi, 2008.
4. Perry R.H., "Chemical Engineers' Handbook", McGraw-Hill, 2009.
5. Joshi M.V., Mahajani V.V., "Process Equipment Design", 3rd Edition, MacMillan, Delhi, 1996.
6. Coulson J.M, Richardson J.F and Sinnott, R.K., "Coulson and Richardson's Chemical Engineering", Vol. 6, 4th Edition, Elesevier, New Delhi, 2006.
7. Dawande S.D., "Process Design of Equipments",Vol 1 & 2, Denett Publications, Nagpur, 2007.
8. Kern D.Q., "Process Heat Transfer", McGraw-Hill, New York, 1965.
9. Ludwig E., Chemical Process Equipment Design, 3rd Edition, Gulf Publications, 2002.

Course Outcomes: After learning the course the students should be able to:

Sr. No.	CO statement	Marks % weightage
CO-1	Design process equipment and modify the design of existing equipment to new process conditions or new required capacity.	20
CO-2	Build a bridge between theoretical and practical concepts used for designing the equipment in any process industry.	35
CO-3	Create understanding of equipment design with mechanical concept.	20
CO-4	Review the importance of design concepts in process industry.	25

List of Open Source Software/learning website:

- Students can refer to the video lectures available on the websites including NPTEL lecture series.
- Students can refer to the CDs available with some reference books for the solution of problems using software/spreadsheets. Students can develop their own programs/spreadsheets for the solution of problems.
- MIT Open course lecture on Equipment design.
- Literature available for Process design of equipment in plant / industry.

Suggested List of Design Problems for practical/tutorials: (8 to 10 practicals are to be given)

- Prediction/Estimation of various physical properties such as density, viscosity, surface tension, specific heat, thermal conductivity etc.
- Finding suitable material of construction for handling various chemicals.
- Design of shell for pressure vessel subjected to internal and external pressure.
- Design of heads for pressure vessel subjected to internal and external pressure.
- Design of nozzle for pressure vessel.
- Design of fixed roof and conical roof storage tank.
- Design of storage tank to store different acids and organic chemicals.
- Design of batch reaction vessel provided with agitator.
- Design of plain, channel and half coil jacket for reaction vessel.
- Design of shell and tube heat exchanger.
- Design of shell for distillation/absorption column under internal and external pressure.
- Design of tray support for the distillation column.
- Design of bracket and skirt support for vertical cylindrical vessel.
- Design of saddle support for horizontal cylindrical vessel.
- Sketches of equipment such as batch reaction vessel, tray column, packed tower, storage tank and shell and tube heat exchanger to be made in drawing sheet.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170515
Semester – VII
Subject Name: Piping Design

Type of course: Open Elective

Prerequisite: The student should have basic understanding of fluid mechanics, engineering and mechanical properties associated with the material.

Rationale:
Piping design and engineering is a key area in various streams of engineering. Piping and accessories constitute over 25% of the total capital investment in the chemical process industry, petroleum and petrochemical industry, pharmaceutical industry, power plants, and so on. The present course is intended to familiarize undergraduate students about the fundamental design aspects of piping components and their applications in process industries.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Contents	Total Hrs
1	**Fundamentals of piping:** Classification of pipe, Codes and standards, Pipe Fabrication, vibration, its prevention and control in piping systems, Mechanical Properties of material, schedule number, Piping materials and selection	04
2	**Design calculations for piping:** Determination of pipe size, Calculation of pressure drop in pipe, Equivalent length of pipe line for fittings and valves, Energy losses in pipe line, Different types of pumps and their selection criteria, NPSHA & NPSHR, Power required by pump, Calculation of flow measurement in pipe line.	06
3	**Piping component and Flow through pipe line:** Types of Fitting, Different types of flange and gasket, their selection criteria and applications, Different types of valves, their selection criteria and applications, Determination of valve size, Steam separators and steam traps, Calculation of pressure drop for two phase flow through pipe line by using Lockhart and Martinelli correlations, Piping drainage and water hammer in process plant, Calculations for water hammer in pipe line.	07
4	**Mechanical design of piping:** Operating pressure and temperature, Design Pressure & Design Temperature for Piping Systems, Design equation for longitudinal, hoop and allowable stresses, Determinations of thickness required by steel pipe for withstanding	06

	internal and external pressure, Determinations of thickness required by jacketed steel pipe for withstanding external pressure.	
5	**Pipe supports and P & I diagram:** Functions of Supports and selection, Types of loads, Different types of piping support, Determination of support location, Maximum span between the supports suggested by ASME B 31.1, Thermal expansion in pipe line, Different types of expansion joints and their applications, Difference between a PFD and P&ID, Typical P&I diagrams for pumps, distillation column, Reactors and Shell and tube heat exchanger.	**07**

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
07	21	21	07	14	--

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Perry R.H., "Chemical Engineers' Handbook", McGraw-Hill, 2009.
2. Thakore S.B., Bhatt B.I., "Introduction to Process Engineering and Design", 2nd Edition, Tata McGraw Hill Publication, 2017.
3. Nayyar M.L., "Piping Handbook", 7th Edition, Tata McGraw Hill Publication, 2000.
4. Coulson J.M, Richardson J.F and Sinnott, R.K., "Coulson and Richardson's Chemical Engineering", Vol. 6, 4th Edition, Elesevier, New Delhi, 2006.
5. McCabe W.L, Smith J.C, Harriott P., "Unit Operations of Chemical Engineering", Mc Graw Hill Publication
6. Ludwig E., Chemical Process Equipment Design, 3rd Edition, Gulf Publications, 2002.
7. Kellogg, M. W Company., "Design of Piping Systems", Pullman Power Products, New York, 1976.

Course Outcomes: After learning the course the students should be able to:

Sr. No.	CO statement	Marks % weightage
CO-1	To understand the safety and practical engineering aspects of piping systems.	20
CO-2	To understand the design and principles used in piping system.	35
CO-3	To know the terminology, concepts, equipment, and process used piping network	20

CO-4	To get an idea of pipe support with other accessories and P& I diagram	25

List of Open Source Software/learning website:

- Students can refer to the video lectures available on the websites including NPTEL lecture series.
- Students can refer to the CDs available with some reference books for the solution of problems using software/spreadsheets. Students can develop their own programs/spreadsheets for the solution of problems.
- MIT Open course lecture on Equipment design.
- Literature available for Process design of equipment in plant / industry.

Suggested List of Design Problems for practical/tutorials: (8 to 10 practicals are to be given)

- Prediction/Estimation of various physical properties such as density, viscosity, surface tension, specific heat, thermal conductivity etc.
- Finding suitable material of construction for handling various chemicals.
- Determination of pipe size and pressure drop for various fittings in the pipe line.
- Determination of Power required by centrifugal pump.
- Design of pipe flow measurement devices.
- Determination of valve size for pipe line.
- Determination of pressure drop for two phase flow through pipe line.
- Determination of water hammer in pipe line.
- Design of pipe subjected to internal and external pressure.
- Design of jacketed steel pipe under external pressure.
- Design of piping support.
- P&I diagrams for pumps, distillation column, Reactors, Shell and tube heat exchanger.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170516
Semester – VII
Subject Name: Process Auxiliaries and utilities

Type of course: Open Elective

Rationale:

Process auxiliaries and utilities involve the understanding of designing the process plants or creating design layouts of plant. It also includes the fundamentals of chemical engineering viz. development of flow diagrams, importance of various design consideration, various utility systems, and key selection considerations during the development and design of any process. This subject is intended to familiarize students with the basics as well as advanced understanding of various process auxiliaries and utilities used in chemical plant and how they integrate with the process facilities and overall operation.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Contents	Total Hrs
1	Process Auxiliaries: Basic considerations and flow diagrams in chemical engineering plant design. Piping design: Selection of material, pipe sizes, working pressure, basic principles of piping design, piping drawings, pipe installations, overhead installations, Process steam piping, selection and determination of steam – pipe size, Piping insulation, application of piping insulation, weather proof and fire resisting pipe insulation jackets, piping fittings, pipe joints	**07**
2	Valves: Types of valves, selection criteria of valves for various systems. Pumps: Types of pumps, NPSH requirement, pump location, pump piping, pump piping support.	**07**
3	Process Utilities: Process Water: Sources of water, hard and soft water, Requisites of industrial water and its uses, Methods of water treatment, Chemical softening, Demineralization, Resins used for water softening, Water for boiler use, cooling purposes, cooling towers, drinking and process water treatment, reuse and conservation of water, waste water treatment and disposal.	**06**
4	Process heating systems using steam, hot oil, glycol and water, Steam generation and its application in chemical process plants, distribution and utilization, boilers, design of efficient steam heating systems, steam economy, condensate utilization, steam traps, their characteristics, selection and application, waste heat utilization. Process cooling systems, process drains-open and closed. Non-steam heating system: Thermic fluid heater, Down	**06**

	therm heater, Temperature range, Principle, construction & working.	
5	Air: Air compressors, Vacuum pumps, Air receivers, Distribution systems, Different types of ejectors, Air dryers	**06**
6	Compressors and Vacuum Pumps: Types of compressors and vacuum pumps and their performance characteristics, Methods of vacuum development and their limitations, materials handling under vacuum, lubrication and oil removal in compressors and pumps, instrument air.	**07**
7	Refrigeration and Chilling systems. Oil heating systems, Nitrogen systems, utilities energy consideration and utilities management issues.	**06**

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

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
07	21	21	07	14	--

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Steam generators and waste heat boilers for process and plant engineers, V Ganapathy, CRC Press, Taylor & Francis Group.
2. Process Utility Systems: Introduction to Design, Operation, and Maintenance, Jack Broughton, IChemE, UK
3. Plant design and Economics for Chemical Engineers, Max S Peters, Klaus D Timmerhaus, Ronald E West. Mc Graw Hill 5th Edition.
4. Process plant layout and piping design, Ed Bausbacher & Roger Hunt, PTR Prentice Hall, UK
5. Efficient Use of Steam, Oilver Lyle Prentice Hall 1963

Course Outcomes: After learning the course the students should be able to:

Sr. No.	CO statement	Marks % weightage
CO-1	To understand the importance of process auxiliaries and utilities in a	20

	chemical industry.	
CO-2	To acquire an overview of key selection considerations of plant utilities	35
CO-3	To understand how the utilities could be integrated with the process facilities and overall operation.	20
CO-4	To understand basic calculation involved in the steam generation, psychometric operation and refrigeration	25

List of Open Source Software/learning website:

- Students can refer to the video lectures available on the websites including NPTEL lecture series.
- Students can refer to the CDs available with some reference books for the solution of problems using software/spreadsheets. Students can develop their own programs/spreadsheets for the solution of problems.
- MIT Open course lecture on Equipment design.
- Literature available for Process design of equipment in plant / industry.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3180501
Branch Name: Chemical Engineering
Semester – VIII
Subject Name: In-Plant Training

Type of course: Professional core course

Prerequisite: Material & Energy Balance, Fluid Flow Operations, Heat Transfer, Chemical Engineering Thermodynamics, Instrumentation & Process Control, Mass Transfer, Chemical Reaction Engineering, Process Equipment Designing

Rationale: To enhance employability skills of the students In-plant Training is required. It provides practical exposure in a field of Chemical Engineering and help to reinforce theoretical knowledge gained in different courses to solve real life challenges. The students are given exposure to explore the new technology and developments, which can lead them to self-employment or even employment generation.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks					Total Marks
				Theory Marks			Practical Marks		
L	T	P	C	ESE (E)	PA (M)		ESE (V)	PA (I)	
					PA	ALA			
0	0	24	12	0	0	0	100	100	200

The following guidelines are required to be followed for the in-plant training …

General Guidelines for In-plant Training

Content:

During 8th semester of Chemical Engineering, every student of chemical engineering branch will have to undergo in-plant training. The in-plant training would be of 12 credits.

The in-plant training would be assigned to the students with the approval of head, chemical engineering department.

The total duration of the in-plant training would be for a period equal to the 12 calendar weeks. The duration will be divided into 2 phases of equal duration (6 weeks / phase).

A student can complete the entire 12 weeks duration in a single organization or can take in two different organizations for each of the phase.

The in-plant training could be of the following forms:

1. In-plant training in a company (Within state or out state) involved in R&D / Process design / manufacturing (QA / QC / Plant engineering / Production / Consultancy / Technical services / Engineering Projects)

2. At the end of 1st phase and 2nd Phase of in-plant training, each student needs to submit written report based on the work carried out during in-plant training with weekly diary. The report and weekly diary will be counter signed by the supervisor / in charge of company.

3. During 1st & 2nd phase of in-plan training, faculty from the institute need to visit the specific organization / industry to have the update regarding the progress of the student from the industry representative as well as to have interaction with the industry representative.

4. The performance of the student will be assessed based on the written report, weekly diary & a presentation to the committee consisting of two expert faculty members assigned from the University.

5. Generalized points need to be taken care by the students during the report preparation of in-plant training are:

   - Company Profile, List of Raw Materials/Products, etc. of the industry & production capacity
   - P & I Diagram, Process Flow Diagram
   - Chemical Reactions involved, Unit Operation & Processes Involved
   - Energy & Material Balance Calculations
   - Process & Mechanical design of at least one equipment (Reactor / Storage Tank / Heat Exchanging Devices / Distillation Column / Absorber / stripper / Cooling Tower, etc.)
   - Treatment & handling of various waste materials which may include liquid effluent handling, air pollution control measures and solid waste handling and disposal.
   - Safety measures of the plant site: Process safety, PPEs, color coding & Symbols, types of permits, Fire Extinguishers, etc.

6. Students will be assigned a grade based on the written report, weekly diary & a presentation evaluated by the committee of the expert faculty members.

Distribution of Marks					
R Level	U Level	A Level	N Level	E Level	C Level
5	10	30	30	10	15

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

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3180501

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
	At the end of this course, student will be able to	
CO-1	identify unit process and unit operations, their correlation and implementation for the manufacturing unit.	20%
CO-2	Evaluate the P & I diagram; control system implemented and use it for trouble shooting purpose.	30%
CO-3	design a process equipment and propose appropriate modification/better control action/optimized operational methods including flow sequences to enhance the economic output.	30%
CO-4	determine the best waste minimization, enhance process safety, personal safety, health and hygiene.	20%

Reference:

- AICTE Model curriculum
- AICTE Internship Policy:

  https://www.aicte-india.org/sites/default/files/AICTE%20Internship%20Policy.pdf

TEACHING SCHEME / DETAIL SYALLBUS

Course: BE Branch: 05 Sem/Year : 3

*L=lectures,T=tutorial,P=Practical,E=TheoryExternal,M=TheoryInternal,I=Practical Internal,V=Practical External,On Job Training(OJT) is equivalent to Practical

					Credit				Marks				
	subcode	SubjectName	Category	Sem/Year	L.	T.	P.	Total	E	M	I	V	Total
	3130004	Effective Technical Communication	Humanities and Social Science	3	2	0	2	3	70	30	30	20	150
	3130007	Indian Constitution	Mandatory Subject	3	2	0	0	0	70	30	0	0	100
	3130502	Fluid Flow Operations	Professional Core Course	3	4	0	2	5	70	30	30	20	150
	3130506	Applied Chemistry	Basic Science	3	3	0	4	5	70	30	30	20	150
	3130507	Chemical Engineering Thermodynamics I	Engineering Science	3	3	1	0	4	70	30	0	0	100
	3130508	Material & Energy Balance Computation	Professional Core Course	3	4	1	0	5	70	30	0	0	100

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TEACHING SCHEME / DETAIL SYALLBUS

BE | 05 - CHEMICAL ENGINEERING | 1

2018-19 | Subject Code | Enter Subject Name | Search

*L=lectures,T=tutorial,P=Practical,E=TheoryExternal,M=TheoryInternal,I=Practical Internal,V=Practical External,On Job Training(OJT) is equivalent to Practical

						Hours			Credit	Max Marks				
Exp.	Subcode	Branch code	Eff_from	SubjectName	Category	Sem /Year	L.	T.	P.	Total	E	M	I	V	Total
	3110001	05	2018-19	Chemistry	Basic Science	1	3	0	2	4	70	30	20	30	150
	3110002	05	2018-19	English	Humanities and Social Science	1	2	0	2	3	70	30	20	30	150
	3110003	05	2018-19	Programming for Problem Solving	Engineering Science	1	3	0	2	4	70	30	20	30	150
	3110004	05	2018-19	Basic Civil Engineering	Engineering Science	1	3	0	2	4	70	30	20	30	150
	3110005	05	2018-19	Basic Electrical Engineering	Engineering Science	1	3	0	2	4	70	30	20	30	150
	3110006	05	2018-19	Basic Mechanical Engineering	Engineering Science	1	3	0	2	4	70	30	20	30	150
	3110007	05	2018-19	Environmental Sciences	Mandatory	1	2	2	0	0	70	30	0	0	100
	3110012	05	2018-19	Workshop/ Manufacturing Practices	Engineering Science	1	0	0	4	2	0	0	20	80	100
	3110013	05	2018-19	Engineering Graphics & Design	Engineering Science	1	2	0	4	4	70	30	20	30	150
	3110014	05	2018-19	Mathematics - 1	Basic Science	1	3	2	0	5	70	30	0	0	100
	3110015	05	2018-19	Mathematics - 2	Basic Science	1	3	2	0	5	70	30	0	0	100
	3110017	05	2018-19	Induction Program	Mandatory	1	0	0	0	0	0	0	0	0	0

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						Hours			Credit	Max Marks				
Exp.	Subcode	Branch code	Eff_from	SubjectName	Category	Sem /Year	L.	T.	P.	Total	E	M	I	V	Total
	3150001	05	June 2020	Design Engineering - II A	Design Engineering	5	0	0	2	1	0	0	20	80	100
	3150004	05	June 2020	Contributor Personality Development Program	Personality development Elective	5	2	0	0	2	70	30	20	30	150
	3150005	05	June 2020	Integrated Personality Development Course	Personality development Elective	5	2	0	0	2	70	30	20	30	150
	3150501	05	June 2020	Mass Transfer Operations I	Professional Core Course	5	4	0	2	5	70	30	20	30	150
	3150502	05	June 2020	Mechanical Operations	Professional Elective Course 1	5	3	0	2	4	70	30	20	30	150
	3150504	05	June 2020	Instrumentation and Process Control	Professional Core Course	5	4	0	2	5	70	30	20	30	150
	3150505	05	June 2020	Particle and Fluid Particle Processing	Professional Elective Course 1	5	3	0	2	4	70	30	20	30	150
	3150506	05	June 2020	Chemical Process Plant Design & Economics	Humanities and Social Science	5	3	0	0	3	70	30	0	0	100
	3150507	05	June 2020	Energy Technology	Open elective-1	5	3	0	0	3	70	30	0	0	100
	3150508	05	June 2020	Material Science and Engineering	Open elective-1	5	3	0	0	3	70	30	0	0	100
	3150509	05	June 2020	Fuels and Combustion	Open elective-1	5	3	0	0	3	70	30	0	0	100

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						Hours			Credit	Max Marks				
Exp.	Subcode	Branch code	Eff_from	SubjectName	Category	Sem /Year	L.	T.	P.	Total	E	M	I	V	Total
	3160001	05	Dec-2020	Design Engineering II B	Project Work	6	0	0	2	1	0	0	20	80	100
	3160002	05	Dec-2020	Contributor Personality Development Program	Personality development Elective	6	2	0	0	2	70	30	20	30	150
	3160003	05	Dec-2020	Integrated Personality Development Course	Personality development Elective	6	2	0	0	2	70	30	20	30	150
	3160501	05	Dec-2020	Mass Transfer Operations II	Professional Core	6	4	0	2	5	70	30	20	30	150
	3160506	05	Dec-2020	Chemical Reactions Engineering I	Professional Core	6	3	0	2	4	70	30	20	30	150
	3160507	05	Dec-2020	Advanced Separation Processes	Professional Elective - III	6	3	0	2	4	70	30	20	30	150
	3160510	05	Dec-2020	Petroleum Refining and Petrochemicals	Professional Elective - II	6	3	0	2	4	70	30	20	30	150
	3160511	05	Dec-2020	Polymer Science and Technology	Professional Elective - II	6	3	0	2	4	70	30	20	30	150
	3160512	05	Dec-2020	Biochemical Engineering	Professional Elective - III	6	3	0	2	4	70	30	20	30	150
	3160513	05	Dec-2020	Waste Water Engineering	Open elective - II	6	3	0	0	3	70	30	0	0	100
	3160514	05	Dec-2020	Green Technology and sustainable Development	Open elective - II	6	3	0	0	3	70	30	0	0	100
	3160515	05	Dec-2020	Solid waste Management	Open elective - II	6	3	0	0	3	70	30	0	0	100

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						Hours			Credit	Max Marks				
Exp.	Subcode	Branch code	Eff_from	SubjectName	Category	Sem /Year	L.	T.	P.	Total	E	M	I	V	Total
	3170001	05	June 2021	Summer Internship	Project	7	0	0	0	2	0	0	20	80	100
	3170501	05	June 2021	Chemical Reactions Engineering II	Professional Core	7	3	0	2	4	70	30	20	30	150
	3170502	05	June 2021	Process Equipment Design	Professional Core	7	4	0	2	5	70	30	20	30	150
	3170507	05	June 2021	Computer Aided Process Synthesis	Professional Elective - VI	7	3	0	2	4	70	30	20	30	150
	3170509	05	June 2021	Nanoscience and Technology	Professional Elective - IV	7	3	0	0	3	70	30	0	0	100
	3170510	05	June 2021	Process Intensification	Professional Elective - IV	7	3	0	0	3	70	30	0	0	100
	3170511	05	June 2021	Transport Phenomena	Professional Elective - V	7	3	0	0	3	70	30	0	0	100
	3170512	05	June 2021	Introduction to Computational Fluid Dynamics	Professional Elective - V	7	3	0	0	3	70	30	0	0	100
	3170513	05	June 2021	Process Modelling, Simulation and Optimization	Professional Elective - VI	7	3	0	2	4	70	30	20	30	150
	3170514	05	June 2021	Mechanical Design of Process equipments	Open Elective - III	7	2	0	2	3	70	30	20	30	150
	3170515	05	June 2021	Piping Design	Open Elective - III	7	2	0	2	3	70	30	20	30	150
	3170516	05	June 2021	Process Auxiliaries and utilities	Open Elective - III	7	3	0	0	3	70	30	0	0	100

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							Hours			Credit	Max Marks				
Exp.	Subcode	Branch code	Eff_from	SubjectName	Category	Sem /Year	L.	T.	P.	Total	E	M	I	V	Total
	3140005	05	2018-19	Design Engineering 1 B	Project Work	4	0	0	2	1	0	0	20	80	100
	3140503	05	2018-19	Heat Transfer	Professional Core Course	4	4	0	2	5	70	30	20	30	150
	3140507	05	2018-19	Chemical Engineering Thermodynamics II	Professional Core Course	4	3	1	0	4	70	30	0	0	100
	3140508	05	2018-19	Unit Processes & Chemical Technology	Basic Science	4	4	0	2	5	70	30	20	30	150
	3140509	05	2018-19	Pollution control & safety Management	Humanities and Social Science	4	3	0	2	4	70	30	20	30	150
	3140510	05	2018-19	Numerical Methods in Chemical Engineering	Professional Core Course	4	3	1	0	4	70	30	0	0	100

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							Hours			Credit	Max Marks				
Exp.	Subcode	Branch code	Eff_from	SubjectName	Category	Sem /Year	L.	T.	P.	Total	E	M	I	V	Total
	3180501	05	Dec 2021	Internship/Project	Project Work	8	0	0	24	12	0	0	100	100	200

GUJARAT TECHNOLOGICAL UNIVERSITY

CHEMICAL ENGINEERING - 30

Advanced Chemical Engineering Thermodynamics (Elective – II)

SUBJECT CODE: 3713019

M.E. Semester: I

Type of course: Program specific Elective-II

Prerequisite: Introductory Chemical Engineering Thermodynamics (CET-I and CET-II)

Rationale:

Efficient separation operations and many other chemical processes depend on a thorough understanding of the properties of gaseous and liquid mixtures. This course is advanced, building upon prior courses in thermodynamics covered at graduate level. The goal of this course is to interpret, correlate, and predict thermodynamic properties used in mixture related phase-equilibrium and reaction equilibrium calculations. Solving phase equilibria problems involves general computational techniques that have widespread applications in chemical engineering.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs	%Weightage
1	**Review of Chemical Engineering Thermodynamics** Introduction to Molecular Thermodynamics of Fluid Phase Equilibria, Basic Differences among Classical, Statistical and Molecular Thermodynamics, Fundamental Concepts of Statistical Thermodynamics, Classical Thermodynamics of Phase Equilibrium, Gibbs-Duhem Equation, Chemical Potential, Fugacity and Activity, Estimation of Physical Properties, Estimation Methods for Vapour-Liquid Critical Properties Tc, Pc and Vc	6	11
2	**Thermodynamics Properties from Volumetric Data** Fugacity of a Component in a Mixture at Moderate Pressures, Fugacity of a Pure Liquid or Solid, Thermodynamics Properties With Independent Variables V and T, Fugacity of a Component in a Mixture According to Van der Waals' Equation	6	11
3	**Fugacities in Gas Mixtures** The Virial Equation of State, Extension to Mixtures, Fugacities from the Virial Equation, Calculation of Second and Third Virial Coefficients	6	11
4	**Fugacities in Liquid Mixtures: Excess Functions** The Ideal Solution, Fundamental Relations of Excess Functions, Temperature and Pressure dependency of Activity Coefficients, Activity Coefficients from Excess Functions in Binary Mixtures, Testing Equilibrium Data for the Thermodynamic Consistency, Wohl's Expansion for the Gibbs Energy, Wilson NRTL and UNIQUAC Equations, Excess Functions and Partial Miscibility, Upper and Lower Consolute	21	39

	Temperatures, Excess Functions for Multicomponent Mixtures, Wilson, NRTL, and UNIQUAC Equations for Multicomponent Mixtures		
5	**Chemical reaction Equilibria** Review of Reaction Equilibrium Principle, Equilibrium Conversion, Calculation and Construction of Equilibrium Conversion Charts, Algorithmic Calculation of Equilibrium Conversion, Homogeneous and Heterogeneous reaction Systems, Phase Rule for Reacting Systems, Chemical Reaction Equilibria for Complex and Multiple Reactions, Lagrange's Undetermined Multiplier's Methods, Various Methods Computation of Equilibrium Composition of Complex Multiphase Systems	**15**	**28**

Reference Books:

1. J. M. Prausnitz, R. N. Litchtenthaler, E. G. de Azevedo, Molecular Thermodynamics of Fluid Phase Equilibria, 3rd Edition, Prentice Hall.
2. S. M. Walas, Phase Equilibria in Chemical Engineering, Butterworth .
3. J. M. Smith, H. C. VanNess, M. M. Abbott, Introduction to Chemical Engineering Thermodynamics, 7th Edition, McGraw-Hill.
4. Bruce E. Poling, John M. Prausnitz, John P. O'Connell, The Properties of Gases and Liquids, 5th Edition, McGraw-Hill.

Course Outcome:

After learning the course the students should be able to:

- Apply chemical engineering thermodynamics to a variety of systems and problems, including phase and reaction equilibrium.
- Use theoretical concepts to describe and interpret solution properties.
- Know how to qualitatively calculate the equilibrium properties of real liquid mixtures.
- Solve phase equilibria problems; this includes the ability to determine which of a variety of models best describes a given set of data, and to calculate the model parameters.

List of Open Source Software/learning website:

- Students can refer to video lectures available on the websites including NPTEL lecture series.
- Students can refer to the CDs available with some reference books for the solution of problems using softwares/spreadsheets. Students can develop their own programs/spreadsheets for the solution of problems.

GUJARAT TECHNOLOGICAL UNIVERSITY
CHEMICAL ENGINEERING (30)
APPLICATION OF NANOTECHNOLGY IN CHEMICAL ENGINEERING
SUBJECT CODE: 3713018
SEMESTER: I

Type of course: Chemical Engineering (ELECTIVE -II)
Prerequisite: None

Rationale:
This course is intended to familiarize students about the concepts of nanoscience and nano-technology in the design and manufacture devices and systems that exploit the unique properties of nanoscale materials to create entirely new functionality and capabilities. It would also focus on underlying scientific, technical, and engineering challenges for advancing nanotechnology in the controlled synthesis of nanostructured materials, especially for industrially important, energy, and environmentally related technologies. The curriculum is built to address the educational needs of this new engineering field.

Teaching and Examination Scheme:

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

SR. No	Topic	Teaching hours	Module weightage
1	Concept of nanoscale; historical applications of nanotechnology, examples of reduced dimensionality system: 1D, 2D, 3D confinements, Effect of nanometer length scale on different physico-chemical properties of matter.	10	16
2	Synthesis of nanomaterials, top down and bottom up approach: Milling, Equal Channel Angular Pressing, High Pressure torsion, Lithography, Chemical and Physical Vapor Deposition, Sputtering, Laser Method, Spray Pyrolysis, Thermo Chemical /Flame Decomposition of metal organic Precursors methods	7	13
3	Synthesis of nanoparticles, homogeneous nucleation, microemulsion based methods, synthesis of carbon fullerene, synthesis of nanowires, nanorods and nanotubes, Deposition of thin film, synthesis of microporous and mesoporous materials.	7	13
4	Oxide nanoparticles, Routes for the Preparation of Isolated Oxide Nanoparticles Hydrolysis, oxidation, thermolysis, methathesis, solvothermal methods, oxidation and hydrolysis	6	10
5	Reactive methods in high boiling point solvents 20, hydrothermal and solvothermal methods, gas-phase synthesis of semiconductor nanoparticles, synthesis in a structured medium, the suitability of such methods for scaling	7	13

6	Tools to characterize nanomaterials: X-Ray Diffraction (XRD), Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy,UV/Visible Spectroscopy, Scanning Tunneling Microscopy, Filed Ion Microscopy, Three dimensional atom probe, Nanoindentation	5	9
7	Applications of nanomaterials: Cosmetics and Consumer Goods, Nano Sensor, Nano catalysts, Water Treatment and the Environment, Paints, Food and Agriculture Industry. Nano-medical Applications, Textiles, Paints	7	13
8	Concerns and Challenges of nanotechnology: Environmental, ecological and health hazards of nanoparticles, Nanotoxicology and its effect	7	13

Reference Books:

1. Nanostructures and Nanomaterials: Synthesis, Properties and Applications by G. Cao, Imperial College Press, 2004.
2. Engines of creation: The coming era of Nanotechnology by Drekler, K. E., Anchor Books, New York, 1986.
3. Nanomaterials: Synthesis, Properties & Applications, by Edelstein, A. S & R C Cammarata (Eds.), Taylor & Francis, New York, 1996.
4. The Chemistry of Nanomaterials: Synthesis, Properties and Applications by C. N. R. Rao, A. Muller, A. K. Cheetham, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, ISBN: 3-527-30686-2.
5. The self made Tapestry: Pattern formation in nature, Oxford Press, Oxford, 2001.
6. Textbook of Nanoscience and Nanotechnology, B.S. Muty, P. Shankar, Baldev Raj, B.B Rath and James Murday, University Press, IIM (ISBN-978 81 7371 738 3).
7. Introduction to Nanotechnology by Charles P. Poole Jr and. Frank J. Owens, Wiley-Inter science, 2003.

Course outcome:

Following learning outcomes are anticipated

- To prepare students for nanotechnology by providing them with a sound grounding in multidisciplinary areas of nanoscience and nanoengineering
- To increase students' understanding of materials and their properties at the atomic and nanometer level,
- To develop understanding of the intimate relationship between material scale (nanostructure) and the properties/functionality of materials
- To know the processing of Nanoparticles and Nanomaterials along with their major applications.
- Prepare students to conduct research and development of economically feasible and innovative applications of nanodevices

List of tutorials

- To explain and identify the physical and instrumental principles of techniques used for the characterization of nanostructures including molecular and continuum (macroscopic) scale characterization of organic and inorganic materials and their application to specific questions.
- Read and understand a scientific paper: Identify the goal, method, result and conclusion of the research. Explain the content to a fellow student

List of Open Source Software/learning website

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

GUJARAT TECHNOLOGICAL UNIVERSITY
CHEMICAL ENGINEERING (30)
Elective II
INDUSTRIAL POLLUTION CONTROL
SUBJECT CODE:3713017
M.E. Semester-I

Type of course: Program Specific Elective - II

Prerequisite: None

Rationale:

The Course focuses on principles of various types of industrial pollution control and its abatement. It explain the students with different treatment technologies and thereby management of various wastes in industries.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Hrs	% Weightage
1	**Industries & Environment** Industrial scenario in India - Industrial activity and Environment - Uses of Water by industry -Sources and types of industrial wastewater - Industrial wastewater and environmental impacts - Regulatory requirements for treatment of industrial wastewater - Industrial waste survey – Industrial wastewater generation rates, characterization and variables - Population equivalent - Toxicity of industrial effluents and Bioassay tests.	11	21
2	**Industrial Noise pollution** Sources of noise pollution, characterization of noise pollution prevention& control of noise pollution, Factories Act 1948 for regulatory aspects of noise pollution.	7	12
3	**Air Pollutant Abatement** Air pollutants scales of concentration, lapse rate and stability, plume behavior, dispersion of air pollutants, atmospheric dispersion equation and its solutions, Gaussian plume models. Air pollution control methods, Source correction methods, Design concepts for pollution abatement systems for particulates and gases. Such as gravity chambers, cyclone separators, filters, electrostatic precipitators, condensation, adsorption and absorption, thermal oxidation and biological processes.	12	22
4	**Waste water treatment processes** Design concepts for primary treatment, grid chambers and primary sedimentation basins, selection of treatment process flow diagram, elements of conceptual process design, design of thickener, biological treatment Bacterial population dynamics, kinetics of biological growth and its applications to biological treatment, process design relationships and	12	23

	analysis, determination of kinetic coefficients, activated sludge process. Design, trickling filter design considerations, advanced treatment processes, Study of environment pollution from process industries and their abatement: Fertilizer, paper and pulp, inorganic acids, petroleum and petrochemicals, recovery of materials from process effluents.		
5	**Solid waste and Hazardous waste management** Sources and classification, properties, public health aspects, Sanitary land fill design, Hazardous waste classification and rules, management strategies, Nuclear waste disposal Treatment methods – component separation, chemical and biological treatment, incineration, solidification and stabilization, and disposal methods, Latest Trends in solid waste management.	12	22

Reference Books:

1. Rao C.S., "Environmental Pollution Control Engineering", 2nd edition
2. Mahajan S.P., "Pollution Control in Process Industries".
3. Nemerow N.L., "Liquid waste of industry- theories, Practices and Treatment", Addison Wesley, New York, 1971
4. Weber W.J., "Physico-Chemical Processes for water quality control", Wiley Interscience New York, 1969
5. Strauss W., "Industrial Gas Cleaning", Pergamon, London, 1975
6. Stern A.C., "Air pollution", Volumes I to VI, academic Press, New York, 1968
7. Peterson and Gross .E Jr., "Hand Book of Noise Measurement", 7th Edn, 2003.
8. Antony Milne, "Noise Pollution: Impact and Counter Measures", David & Charles PLC, 2009.

Course Outcome:

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

1. Recognize the causes and effects of environmental pollution
2. Analyze the mechanism of proliferation of pollution
3. Develop methods for pollution abatement and waste minimization
4. Design treatment methods for gas, liquid and solid wastes

List of Open Source Software/learning website:

- Softwares: Pollution Control Systems & Air Pollution Simulation - ANSYS, Anti-pollution software - Down To Earth
- Students can refer to video lectures available on the websites including NPTEL.
- Students can refer to the CDs which are available with some reference books for the solution of problems using softwares. Students can develop their own programs for the solutions of problems.

GUJARAT TECHNOLOGICAL UNIVERSITY

CHEMICAL ENGINEERING (30)

FLUIDIZATION ENGINEERING
SUBJECT CODE:3713016

SEMESTER: I

Type of course: Chemical Engineering (Elective-I (c))

Rationale:
Fluidization finds extensive application today in Process Industry and also in combustion. Objective of this course is to make the student aware of fundamentals of Fluidization and understand the design aspects of fluidized bed systems.

Teaching and Examination Scheme:

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

Contents:

Sr. No.	Content	Hrs	% weightage
1	**Introduction to fluidization and applications** Phenomenon of fluidization, behavior of fluidized bed, contacting modes, advantages and disadvantages of fluidization, fluidization quality, selection of contacting mode, Beds for Industrial applications, coal gasification, synthesis reactions, physical operations, cracking of hydrocarbons	6	10
2	**Mapping of fluidization regimes** characterization of particles, mechanics of flow around single particles, minimum fluidization velocity, pressure drop versus velocity diagram, The Geldart classification of solids, fluidization with carryover of particles, terminal velocity of particles, distributor types, gas entry region of bed, pressure drop requirements, design of gas distributor, power consumption	8	15
3	**Bubbling fluidized beds** Davidson model for bubble in a fluidized bed, and its implications, the wake region and movement of solids at bubbles, coalescence and splitting of bubbles, bubble formation above a distributor, slug flow, Turbulent and fast fluidization - mechanics, flow regimes and design equations, Emulsion movement, estimation of bed properties, bubble	10	25

	rise velocity, scale up aspects, flow models, two phase model, K-L model		
4	**Solids movement and Gas dispersion** Vertical and horizontal movement of solids, Dispersion model, large solids in beds of smaller particles, staging of fluidized beds Gas dispersion in beds, gas interchange between bubble and emulsion, estimation of gas interchange coefficient, Heat and mass transfer in fluidized systems, Mixing in fluidized systems - measurements and models.	12	25
5	**Fluidized bed reactors** Entrainment and elutriation, Freeboard behavior, gas outlet, entrainment from tall vessel, freeboard entrainment model, high velocity fluidization, pressure drop in turbulent and fast fluidization, Slugging, Spouted beds, Circulating Fluidized Beds. Mathematical model of a homogeneous fluidized bed, Design of catalytic reactors, pilot plant reactors, information for design, bench scale reactors, design decisions, deactivating catalysts, Design of noncatalytic reactors, kinetic models for conversion of solids, models for shrinking particles, conversion of solids of unchanging size	16	25

List of Practicals:

1. Determination of minimum fluidization velocity in circular bed
2. Determination of minimum fluidization velocity in rectangular bed
3. Calculation of entrainment in fluidized bed
4. Classification of particles as per the Geldart classification scheme.
5. Estimation of gas interchange coefficient in fluidized bed
6. Performance evaluation of fluidized bed using K-L model
7. Performance evaluation of fluidized bed using Davidson model
8. Modelling and simulation of Fluidized Catalytic Cracker
9. Design study of iron-coke smelting furnace
10. Design study of fluidized bed drying using FBD model.
11. Application study of fluidized bed in pharmaceuticals industries
12. Fluidization performance study using various fluids to fluidize sand particles.

References:

1. Levenspiel O. and Kunnii D., "Fluidization Engineering", John Wiley, 1972
2. Liang-Shih Fan, "Gas-Liquid-Solid Fluidization Engineering", Butterworths, 1989

Course Outcomes:

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

1. Performing and understanding the behavior fluidization in fluidized bed
2. Evaluate the characterization of particles and power consumption in fluidization regimes
3. Understanding the applicability of the fluidized beds in chemical industries

GUJARAT TECHNOLOGICAL UNIVERSITY

CHEMICAL ENGINEERING (30)
CHEMICAL REACTOR ANALYSIS
SUBJECT CODE: 3713015
SEMESTER: I

Type of course: Chemical Engineering (Elective-I (b))

Course Outcomes:
At the end of the course, the student will be able to:
1. Evaluate heterogeneous reactor performance considering mass transfer limitations
2. Perform the energy balance and obtain concentration profiles in multiphase reactors.
3. Estimate the performance of multiphase reactors under non-isothermal conditions

Teaching and Examination Scheme:

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

Contents:

Sr. No.	Content	Hrs	% weightage
1	**Unit-I:** Chemical factor affecting the choice of the reactor, fundamental mass, energy and momentum balance, Model for a semi-batch reactor, optimum operation policies and control strategies, optimal batch operation time, optimal temperature policies, stability of operation and transient behavior for mixed flow reactor. Transient CSTR analysis, Hot spot equation; Optimization using Lagrange multiplier, Pontryagin's maximum principle.	6	15
2	**Unit-II:** Fixed bed catalytic reactor: The importance and scale of fixed bed catalytic processes, factors in preliminary design, modeling of fixed bed reactor. Pseudo-homogeneous model, the multibed adiabatic reactor, auto-thermal operation, non-steady-state model with axial mixing, two dimensional pseudo-homogeneous models, heterogeneous models, global and intrinsic rates, Mechanism of catalytic reactions, Engineering properties of catalysts - BET surface area, pore volume, pore size, pore size distribution, one dimensional and two dimensional model equation.	8	15
3	**Unit-III:**	8	20

	Multiphase flow reactor: Types of multiphase flow reactors, packed columns, plate columns, empty columns, stirred vessel reactors.Development of rate equations for solid catalyzed fluid phase reactions; Estimation of kinetic parameters. External mass and heat transfer in catalyst particles. Stability and selectivity, Packed bed reactor, slurry reactor; Trickle bed reactor and fluidized bed reactor. Intra-particle heat and mass transfer - Wheelers parallel pore model, random pore model of Wakao and Smith. deactivation of catalyst, Ideal and non-ideal flow in reactors.		
4	**Unit-IV:** Design model for multiphase flow reactors, gas and liquid phase in completely mixed and plug flow, gas phase in plug flow and liquid phase in completely mixed flow, effective diffusion model, two zone model, specific design aspects, packed absorber, two-phase fixed bed reactor, plate column, spray tower, bubble reactor, stirred vessel reactor.Computer - aided reactor design.	14	20
5	**Unit-V:** Temperature effects in reactor: Introduction, well mixed system with steady feed, the stability and start-up of CSTR, limit cycles and oscillatory reactions, the plug flow reactors, tubular reactor, diffusion control, prorogation of reaction zone.	16	30

List of Practicals:

1. Differential and integral method of analysis for kinetics in CSTR
2. Study of saponification reaction in batch reactor to find the kinetic rate constant.
3. Performance study of CSTR
4. Performance study of PFR and location of hot-spot
5. Modeling and simulation of Batch, PFR, and CSTR using CFD software
6. Modeling and simulation of packed bed reactor using CFD software
7. Modeling and simulation of multi-phase reactor using CFD software
8. Transient CSTR analysis for finding kinetics of reaction.
9. Study of temperature effects in hydrodealkylation process plant
10. Evaluation of kinetics of aromatic reaction in micro-reactor
11. Study of light-off behaviour in vehicular exhaust using PFR model
12. Modelling of Platforming reactions/Oxidative coupling of methane

References:

1. Froment G. F. and K.B.Bischoff, " Chemical Reactor Analysis and Design", John Wiley & Sons
2. Denbigh K. G. and J.C. Turner, " Chemical Reactor and Theory – an Introduction", 3rd edition Cambridge University Press.
3. Bruce Nauman, " Chemical Reactor Design", John Wiley & Sons
4. Elements of Chemical Reaction Engineering by H. Scott Fogler
5. Chemical Engineering Kinetics by J. M. Smith.
6. Chemical Reactor Design and Operation by K. R. Westerterp, W. P. M. Van Swaaij and A. A. C.M. Beenackers
7. Chemical Reactor Analysis and Design by G. F. Froment and K. B. Bischoff

GUJARAT TECHNOLOGICAL UNIVERSITY

CHEMICAL (COMPUTER AIDED PROCESS DESIGN) (16)

Process Design and Synthesis

SUBJECT CODE: 3713014

SEMESTER: I

Type of course: Core - I

Prerequisite:

Rationale:

Teaching and Examination Scheme:

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

Content

Sl. No.	Topic	Teaching Hours	Module Weightage (%)
1.	**Unit 1: Introduction** Introduction to fundamental concepts and principles of process synthesis and design and use of flow sheet simulators to assist process design. Process Flow sheet Models: An Introduction to Design, Chemical process synthesis, analysis and optimization. Introduction to commercial process design software such as HYSYS, Aspen plus etc., Chemical Process (reactor, heat exchanger, distillation etc) analysis using commercial software		
2.	**Unit 2: Product design and developments** Process engineering economics and project evaluation Life Cycle Assessments of process: From design to product development, Engineering Economic Analysis of Chemical Processes, Project costing and performance analysis, Environmental concerns, Green engineering, Engineering ethics, Health and safety		
3.	**Unit 3: Reactor Networks** Geometry of mixing and basic reactor types, The Attainable Region (AR) approach, AR in higher dimensions & for other processes, Reactive Separation processes, Fundamental behavior and problems, Separation through reactions. Reactive Residue Curve Maps		
4.	**Unit 4: Synthesis of Separation Trains** Criteria for selection of separation methods, select ion of equipment**:** Absorption, Liquid-liquid extraction Membrane separation, adsorption, leaching, drying, crystallization, Ideal distillation -		

	Column and sequence fundamentals, Sharp splits & sequencing Phase diagrams for 2, 3 and 4 components, Feasibility and vapor flow rates for single columns, Residue curve basics, Non-ideal Distillation - Azeotropic systems; detecting binary azeotropes, Residue curve maps for azeotropic systems, Topological analysis, Feasibility for single azeotropic columns ,Binary VLLE and pressureswing separation, Non-ideal distillation synthesis. Equipment sequencing: VLE + VLLE, Detailed Residue Curve Maps, Residue curve maps: Interior structure		
5.	**Unit 5: Heat Exchanger Network Synthesis** Minimum heating and cooling requirements, Minimum Energy Heat Exchanger Network, Loops and Paths, Reducing Number of Exchangers, HENS basics & graphics, The pinch point approach, Stream Splitting, Performance targets, trade-off & utilities, Heat & power integration, HENS as mathematical programming		
6	**Unit 6: Mass Integration:** Introduction, Minimum Mass Separating Agent (MSA), Mass Exchanger Networks Minimum External MSA, Minimum Number of Mass Exchangers		

References books:

- Douglas, J. "Conceptual Design of Chemical Processes",New York, NY: McGraw-Hill Science / Engineering / Math, 1988. ISBN: 0070177627.
- Seider, W. D., J. D. Seader, and D. R. Lewin. "Product and Process Design Principles: Synthesis, Analysis, and Evaluation",. 2nd ed. New York, NY: Wiley, 2004. ISBN: 0471216631.
- Richard Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz., "Analysis, Synthesis, and Design of Chemical Processes", 2nd Edition, 2002, Prentice Hall ISBN-10: 0-13-064792-6
- Biegler L.T., Grossmann I.E. and Westerberg A.W., "Systematic Methods of Chemical Process Design", Prentice Hall, 1997

Course Outcome:

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

1. Analyze alternative processes and equipment
2. Synthesize a chemical process flow sheet that would approximate the real process
3. Design best process flow sheet for a given product
4. Perform economic analysis related to process design and evaluate project profitability

List of Laboratory Experiments

1 Determine minimum utility requirements for the given process stream information.
2 Calculate pinch point and utility requirements for given process data.
3 Solution of linear programming model for determination of pinch point using tools like GAMS / MATLAB / SCILAB / Excel.
4 Solution of MILP model for determination of pinch point using tools like GAMS / MATLAB / SCILAB / Excel.

5 Analyze optimum approach temperature and parameters influencing it for the heat exchanger network synthesis using given stream information.
6 Estimate the area and cost of heat exchangers required for the given process plant data.
7 Optimize utilities, number of heat exchangers and average area of heat exchangers in a heat exchange network design assignment using sequential optimization.
8 Optimize utilities, number of heat exchangers and average area of heat exchangers in a heat exchange network design assignment using simultaneous optimization.
9 Plotting of Attainable Region for reactor networks.
10 Pinch point and utility requirement calculation for mass exchanger network synthesis.
11 Determine the best sequence of distillation column for multi-component system.
12 Course project by each student with analysis of HENS for industrial case study.

GUJARAT TECHNOLOGICAL UNIVERSITY

CHEMICAL ENGINEERING (30)

ADVANCED SEPARATION PROCESSES

Subject Code: 3713013

SEMESTER: I

Type of course: Core

Prerequisite: Mass Transfer fundamentals

Rationale: The aim of this subject is to impart comprehensive understanding to the students regarding various novel and advanced separation techniques and its advancement which have profound significance in Industrial and Research arenas.

Content

Sr. No	Topic	Teaching hours	Module% weightage
1	**Multi Component Distillation** Selection of operating pressure, Equilibrium for Multi component System, Methods for Multi Component Distillation, Design of Batch Distillation for Multi component with Rectification, with constant reflux and constant over head component, Continuous distillation of multi component system, Energy Conservation in Distillation column, Advanced topics in distillation, Short path distillation	**12**	**22**
2	Types and choice of membranes, Plate and frame, tubular, spiral wound and hollow fiber membrane reactors and their relative merits, Commercial, pilot plant and laboratory membranes permeators involving dialysis, reverse osmosis, Nanofiltration, ultrafiltration, Microfiltration, Gas separation by membranes, Membrane Distillationj	**10**	18
3	**Advances in Absorption** Criteria for selection of packed tower, tray tower, Spray chamber, Venturi Scrubber etc. Design of Falling Film Absorption, Design of Spray Chamber , Design of Venturi Scrubber, Advantage of Falling Film Absorber	**9**	17
4	**Separation By Adsorption Techniques**: Mechanism, Types and choice of adsorbents, Normal adsorption techniques, Affinity chromatography and immuno chromatography. Types of equipment and commercial processes, Recent advances and process economics.	**9**	16
5	**Ionic Separations**: Controlling factors, Applications, Types of equipment employed for electrophoresis, Di-electrophoresis, Ion exchange chromatography and electro dialysis, Commercial Processes.	**8**	14
6	**Other Techniques:** Separations involving Iyophilisation, Pervaporation and permeation techniques for solids, liquids and gases. Industrial viability and examples, Zone melting, Adductive crystallization, Other separation process, Supercritical fluid extraction, Oil spill Management, Industrial effluent treatment by modern techniques.	**7**	13

References:

1. Equilibrium-stage separation operation in chemical engineering by Ernest J. Henley and J.D. Seader.
2. Chemical Engineering Handbook 7 th edition by R.H.Perry & Green D.
3. Mass Transfer Operation 3 rd Edition by R.E.Treybal.
4. Industrial Processing with Membranes by Lacey, R.E. and S.Loaeb - Wiley -Inter Science, New York, 1972.
5. New Chemical Engineering Separation Techniques by Schoew, H.M. - Interscience Publishers, 1972.
6. Ronald W.Roussel - "Handbook of Separation Process Technology ", John Wiley, New York, 1987.

Course Outcome:

1. To familiarize students with various advanced aspects of separation processes and the selection of separation processes.
2. To enable students to understand the principles and processes of adsorption, membrane separation and chromatography
3. To introduce them to new trends used in the separation technologies.
4. To identify the types of experimental data needed for the calculation of membrane parameters.
5. Apply advanced separation techniques to identify and study environmental as well as chemical industries problems.

List of Experiments:

1. Study of membrane modules and their parts for pressure activated Membrane separation Process such¬ as Reverse Osmosis, Nano Filtration, Ultra Filtration, Micro Filtration
2. Practical on Gas Absorption
3. Practical related to Bubble Cap Distillation Column (Continuous Distillation)
4. Experimental determination of permeate flux, permeate rejection and permeate characteristics in RO, NF, UF and MF membranes.
5. The above experiment should be repeated with different membranes and fluxes may be compared Determination of Membrane Permeability using different membranes.
6. Swelling characteristics of membrane used in separation of aqueous-organic mixture

Major Equipments: Bubble Cap Dist Distillation Column¬ Gas Absorption apparatus¬ Membrane modules etc.¬

List of Open Source Software/learning website: Students can refer to video lectures available on various websites including NPTEL.¬ Students can refer to the CDs which are available with some reference books for the solution of¬ problems using softwares. Students can develop their own programs for the solutions of problems using excel, Chemcad and other simulation softwares.

GUJARAT TECHNOLOGICAL UNIVERSITY

CHEMICAL (COMPUTER AIDED PROCESS DESIGN) (16)

Numerical Methods in Chemical Engineering

SUBJECT CODE: 3713007

SEMESTER: I

Type of course: Core - I

Prerequisite:

Rationale:

Teaching and Examination Scheme:

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

Content

Sl. No.	Topic	Teaching Hours	Module Weightage (%)
1.	**Unit-1: Equation Forms in Process Modelling:** Introduction and motivation, linear and nonlinear algebraic equation, optimization based formulations, Ordinary Differential Equations (ODE) - Initial Value Problems (IVPs) and Differential Algebraic Equations (DAEs), ODE - Initial Value Problems (IVPs) and Partial Differential Equations (PDEs), abstract model forms, fundamentals of vector spaces, generalized concepts of vector space, sub-space, linear dependence, concept of basis, dimension, norms defined on general vector spaces, norms defined on different vector spaces, Cauchy sequence and convergence, Cauchy-Schwartz inequality and orthogonal sets, Gram-Schmidt process and generation of orthogonal basis, orthogonal basis matrix norms, classification of problems in numerical analysis, polynomial approximations, Taylor series approximation, Necessary and sufficient conditions for unconstrained multivariate optimization, transformations and unified view of problems through the concept of transformations		
2.	**Unit-2: Interpolation & Curve Fitting**: Least square approximations, Formulation and derivation of weighted linear least square estimation, Geormtraic interpretation of least squares Projections and least square solution, Function approximations and normal equation in any inner product space, Model Parameter Estimation using linear least squares method, Generic equation forms in transformed problems. Linear and Polynomial Regression, Introduction to polynomial		

	interpolation, Polynomial and function interpolations, Lagrange Interpolating Polynomials, Spline Interpolation, Cubic Spline		
3.	**Unit-3:** Linear Algebraic Equations : System of linear algebraic equations, conditions for existence of solution - geometric interpretations (row picture and column picture), review of concepts of rank and fundamental theorem of linear algebra, Classification of solution approaches as direct and iterative, review of Gaussian elimination, Introduction to methods for solving sparse linear systems: Thomas algorithm for tridiagonal and block tridiagonal matrices, Block-diagonal, triangular and block-triangular systems, solution by matrix decomposition, Iterative methods: Derivation of Jacobi, Gauss-Siedel and successive over-relaxation methods, Convergence of iterative solution schemes: analysis of asymptotic behavior of linear difference equations using Eigen values, convergence of iterative solution schemes, Optimization based solution of linear algebraic equations, matrix conditioning, examples of well conditioned and ill-conditioned linear systems.		
4.	**Unit-4**: Nonlinear Algebraic Equations: Method of successive substitutions, derivative free iterative solution approaches, Secant method, Regulafalsi method and Wegsteine iterations, Modified Newton's method and Qausi-Newton method with Broyden's update, Optimization based formulations and Leverberg-Marquardt method, contraction mapping principle and introduction to convergence analysis.		
5.	**Unit-5:** Ordinary Differential Equations - Initial Value Problems (ODE-IVPs) :Introduction, Analytical Solutions of Linear ODE-IVPs, basic concepts in Numerical solutions of ODE-IVP: step size and marching, concept of implicit and explicit methods, Taylor series based and Runge-Kutta methods, Multi-step (predictor-corrector) approaches, Stability of ODE-IVP solvers, choice of step size and stability envelopes, stiffness and variable step size implementation, Introduction to solution methods for differential algebraic equations (DAEs),		
6	**Unit-6:** Ordinary Differential Equations – Boundary Value Problems (ODE-BVPs) : Method of least squares for solving ODE-BVP, Gelarkin's method and generic equation forms arising in problem discretization, Errors in Discretization, Discretization using approximation theory, finite difference method for solving ODE-BVPs with examples, finite difference method for solving PDEs with examples, , Orthogonal Collocations method for solving ODE-BVPs with examples, Orthogonal Collocations method for solving PDEs with examples, Single shooting method for solving ODE-BVPs		

References books:

- Gilbert Strang, Linear Algebra and Its Applications (4th Ed.), Wellesley Cambridge Press (2009).
- Philips, G. M.,Taylor, P. J. ; Theory and Applications of Numerical Analysis (2nd Ed.), Academic Press, 1996.

- Gourdin, A. and M Boumhrat; Applied Numerical Methods. Prentice Hall India, New Delhi, (2000).
- Gupta, S. K.; Numerical Methods for Engineers. Wiley Eastern, New Delhi, 1995.
- Linz, P.; Theoretical Numerical Analysis, Dover, New York, (1979).
- Gilbert Strang , Introduction to Applied Mathematics, Wellesley Cambridge Press (2009)

Course Outcome:

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

1. Students should be able to solve system of linear algebraic equations.
2. Students should be able to do numerical integrations of functions.
3. Students should be able to fit relationship between two data sets using linear, non-linear regression.
4. Students should be able to calculate maxima/minima and functions.
5. Student should be able to design, simulate and optimise chemical engineering operations and processes.

List of Laboratory Experiments

1. Introduction to computation platform to be used for laboratory (C/C++/ MATLAB /SCILAB)
2. Applications of data Analysis tools and Plotting
3. Fitting experimental data to model
4. Solution of Linear Algebraic Equations using inbuilt solvers.
5. Implementation of algorithm for solution of Linear Algebraic Equations
6. Solution of non-Linear Algebraic Equations using inbuilt solvers.
7. Implementation of algorithm for solution of non-Linear Algebraic Equations
8. Application to solution of multi-component distillation.
9. Solution of ODE-IVP with inbuilt solvers for chemical engineering application.
10. Solution of ODE-BVP with inbuilt solvers for chemical engineering application.
11. Solution of PDE with inbuilt solvers for chemical engineering application.
12. Individual Coues project by each student implementing numerical solution of any chemical engineering process.

GUJARAT TECHNOLOGICAL UNIVERSITY

RESEARCH AND IPR

M.E. SEMESTER: I

Rationale:

To the Student:

The purpose of this subject is to orient the students to the scientific methodology of research and presenting their thesis. Research constitutes primarily of literature review, giving critical comments on the literature reviewed and identifying the gap, problem formulation, modeling in either an analytical or experimental set up, validating the model and solving the problem you set for yourself.

At the end, student should be able to present and defend the solution he/she has found, in a simple and easy manner. Communicating the research outcomes, is an art wherein, you do not want to either undermine or over emphasise the content, within the short time limit given for such presentations. The balance of critical technicality and overall outcomes is the key to an effective presentation. The language, content and articulation should be such as to convey in a unified manner, the gist of your work.

To the Teacher:

It is envisaged that the teacher will discuss actual case studies to make the student understand the concepts of demonstration of examples during theory. Theory classes will be used to explain each of the concepts in Module 1 and 2. This syllabus is based on the model AICTE course prescribed in May2018.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE(E)	PA (M)	PA (V)	PA (I)	
1	0	2	2	0	0	80	20	100

Content:

	Module 1 Starting Research	**Teaching Hrs**
1.1	**Find what is expected of you**	
	Identify specific requirements for evaluation/review and what constitutes completion of your work	
	Find where the source is available	
	Establish proper methods for finding the relevant material from the source.	
1.2	**Analyse the question**	
	Identify key areas in your field	
	Determine the nature and extension of papers that you should read	
1.3	**Identify the gaps**	

	Learn to Critique existing knowledge and how to find the gap	
1.4	**Formulate the Problem Statement**	
	Understand what should be the key aspects of your problem statement	
	Examples of effective and ineffective Titles	
1.5	**Validation**	
	Identify problem and experimental/theoretical data for comparison with your model	
	Learn how to extrapolate/scale data for validation	
	Find what is acceptable level of error and justification thereof	
	Module 2 Finding Good Literature	
2.1	**Decide which sources you will need**	
	Differentiate between journals, conferences, books, magazines and their quality	
	Understand how to establish their quality and authenticity	
2.2	**Finding Information**	
	How to conduct effective searches	
	How to find relevant papers related to your area of research	
	How to capture critical information	
2.3	**Identify main ideas in scholarly literature**	
	Understand and identify the bias, theoretical position and evidence produced	
2.4	**Write notes to organize your ideas**	
	Compare ideas and concepts from different papers	
	Module 3 Writing and Presenting your Work	
3.1	**Effective technical writing**	
	How to write Report, Paper, Developing a Research Proposal, Format of research proposal	
3.2	**Build your argument**	
	Recognise the importance of emphasizing your point	
	Distinguish between your point and the evidence available	
	Acknowledge the evidence	
3.3	**Review and finalize your work**	
	Know and follow the Process of reviewing and proof reading your work	
	Use feedback to improve your work	
3.4	**Check the logistics of your presentation**	
	Identify the key message of your presentation	
	Understand the expectations and what will be the key review points	
3.5	**Develop the structure of your presentation**	
	Understand the key components of an oral presentation	
	Know the usual structure of a good presentation	
3.6	**Prepare for delivery of your Oral presentation**	
	Rehearse and time your presentation	
	Prepare to answer questions from the audience: Fundamental concepts should be spoken from memory as reviewer will be looking for evidence of your thorough understanding.	
	Read more than the content you are presenting; keep sources ready on hand for reference;	
	Module 4 Intellectual Property	
4.1	**Patents, Designs, Trade and Copyright.,**	
	Process of Patenting and Development: Technological research innovation, patenting, development.	

4.2	**International Scenario:**	
	International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.	
4.3	**Patent Rights**	
	Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications	
4.4	**New Developments in IPR**	
	Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies	

Reference Books:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students"
2. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
3. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
4. Mayall, "Industrial Design", McGraw Hill, 1992.
5. Niebel, "Product Design", McGraw Hill, 1974.
6. Asimov, "Introduction to Design", Prentice Hall, 1962.
7. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Propertyin New Technological Age", 2016.
8. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

Course Outcome:

At the end of the course the students should be able to:

1. Conduct a quality literature review and find the research gap.
2. Identify an original and relevant problem and identify methods to find its solution
3. Validate the model
4. Present and defend the solution obtained in an effective manner in written or spoken form.
5. Follow research ethics
6. Understand IPR protection for further research and better products

GUJARAT TECHNOLOGICAL UNIVERSITY

Stress Management by Yoga
SUBJECT CODE: 3700007
SEMESTER: I/II

Type of course: Audit course

Prerequisite: -

Rationale: -

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE(E)	PA (M)	PA (V)	PA (I)	
0	0	4	0	0	0	0	50	50

Content

Sl. No.	Topic	Teaching Hours	Module Weightage (%)
1.	Definitions of Eight parts of yog. (Ashtanga)	8	33
2.	Yam and Niyam Do`s and Don't's in life Ahinsa, satya, astheya, bramhacharya and aparigraha Shaucha, santosh, tapa, swadhyay, ishwarpranidhan	8	34
3.	Asan and Pranayam Various yog poses and their benefits for mind & body Regularization of breathing techniques and its effects-Types of pranayama	8	33

Reference Books:

1. Yogic Asanas for Group Tarining-Part-I" :Janardan Swami Yogabhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, AdvaitaAshrama (Publication Department), Kolkata

Course Outcome:

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

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

GUJARAT TECHNOLOGICAL UNIVERSITY

English for Research Paper Writing
SUBJECT CODE: 3700001
SEMESTER: I/II

Type of course: Audit course

Prerequisite: -

Rationale: -

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE(E)	PA (M)	PA (V)	PA (I)	
2	0	0	0	50	0	0	0	50

Content

Sl. No.	Topic	Teaching Hours	Module Weightage (%)
1.	Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness	4	17
2.	Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction	4	17
3.	Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check	4	17
4.	key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature	4	17
5.	skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions	4	16
6	useful phrases, how to ensure paper is as good as it could possibly be the first- time submission	4	16

Reference Books:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

Course Outcome:

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

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title
4. Ensure the good quality of paper at very first-time submission

GUJARAT TECHNOLOGICAL UNIVERSITY
Master of Engineering
Subject Code - 3723024
Semester II
Subject Name: Advanced Reaction Engineering

Type of course: Core Course – IV

Prerequisite: Knowledge of Reaction engineering at undergraduate Level

Rationale: This subject deals with the heterogeneous reactions and non-ideal flow systems including performance of various types of reactors. The non-isothermal systems are introduced with its application. The catalyst systems are also be covered in this.

Teaching and Examination Scheme:

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

Syllabus Content:

Sr. No.	Content	Total Hrs
1	Overview of Reaction Engineering & challenges, Stoichiometric Table & gas law, Reactor Design Equations for ideal Vessels, Effect of Pressure Drop on performance of Plug Flow vessels, Plug Flow Recycle Reactors design equation, Advantages of plug flow recycle reactor, Effect of Condensing gas on Reactor design	7
2	Multiple Reactions, finding number of independent reactions and independent set, Polymerization reaction in a CSTR, Energy Balance for stirred vessels, Semi batch reactor operation, Stability of Steady States in CSTR, Plotting Liapunov Contours, Understanding Multiple steady states in a CSTR	8
3	Heat Effects in reversible exothermic reactions, Need for Multi-staging, Optimal Design of Reactors for Reversible exothermic reactions, One Dimensional & Two-dimensional models for PFR, Design of Packed Tubular Reactors	7
4	Non-ideal Flow, Residence Time Distribution of ideal vessels, Deriving RTD from velocity field, Modelling Non-ideal Flow (Dispersion, Tanks in series, Recycle reactor)	9
5	Gas Solid Non-Catalytic Reactions, The shrinking Core Model, Case of Pseudo steady state hypothesis & ash diffusion control, Gas Solid reactions in Rotary Kiln - tracking gas and solid composition changes for reversible reactions, Gas Liquid Reactions, Reaction Regimes	9
6	Introduction to population balance modelling, Deriving RTD from PBE, Deriving particle size distribution for continuous fluid beds via PBE, Deriving design equations for gas solid reactions via PBE, Deriving property distributions in reactor regenerator systems,	7

	Applications of PBE modelling to real life problems, Reaction Engineering and mitigation of Global warming, CO_2 absorption in high pressure water	
7	Catalyst deactivation, Design for deactivating catalyst, Flow and Reaction through porous media, Acid Leaching of Rocks, Fluidized bed reactor modelling	**4**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
5	**25**	**15**	**10**	**10**	**5**

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1) K.G. Denbigh: Chemical Reactor Theory, Cambridge University Press, Second Edition, 1971
2) J.M. Smith: Chemical Engineering Kinetics, Mcgraw Hill, Third Edition, 1981
3) Levenspiel O., Chemical Reaction Engineering, Wiley, 1998
4) Foggler,H.S., Elements of Chemical Reaction Engineering, Prentice Hall of India, 2008
5) Fromment G.F. and Bischoff K.B., Chemical Reactor Analysis and Design, John Wiley, 2010

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Evaluate heterogeneous reactions and reactor performance.	10
CO-2	Perform the energy balance and obtain concentration profiles in multiphase reactors.	10
CO-3	Estimate the performance of multiphase reactors under non-isothermal conditions.	20
CO-4	Understand non-ideal flow and reactor models.	20
CO-5	Understand catalysts deactivation and application of catalysts.	10

List of Experiments:

- To study RTD in PFR, CSTR and CSTR in series.
- To compare conversion in CSTR and PFR.
- To Compare catalytic and non-catalytic reaction conversion.
- To study the performance of fluidized bed reactor.

Major Equipment:

- Plug flow reactor
- CSTR in series
- CSTR
- Fluidized bed reactor

List of Open Source Software/learning website:

NPTEL open source

www.academia.edu/.../A_NOVEL_DESIGN_OF_HETEROGENEOUS_C

GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering
Subject Code: 3723023
Semester – II
Subject Name: Cleaner Production

Type of course: Chemical Engineering

Prerequisite: Basics of Chemical Engineering & Environmental Science

Rationale: One of the major causes of pollution is industrial production, which is increasing day by day and hence cleaner production techniques have become necessary. The aim of this course is to introduce students about 'Cleaner Production Techniques' and its application leading to minimize pollution. Students will acquire knowledge about environmental, economic and technological aspects of Cleaner Production Methods. The student will be exposed to methodology of cleaner production projects, methods of their implementing into industrial establishment and process of pollution prevention and reduction along with operating costs reduction and increase in safety of operation with the help of various case studies. Thus this course deals with an emerging area and hence important for engineers.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs
1	**Introduction to Cleaner production (CP):** Concept & Theory of cleaner production, Applications to industries, Benefits of CP, Internal and external motivators and drivers of CP, Barriers for CP	6
2	**CP Tools:** Source Reduction, Good house keeping, Process Technology Innovations, Equipment Modification, Reuse and recycle, Product modification, Life Cycle Assessment and its elements, CP Tools for different sectors: Food industries, Chemical sector, Electroplating and dairy sector	12
3	**Cleaner Production Methodology:** Six steps methodology for CP, Designation of cleaner production team, Analyze process steps, generating cleaner production opportunities, selecting cleaner production solutions, Implementation, maintaining cleaner production, CP and Environmental Management System viz different ISO used under CP	12
4	**Energy Audit Methodology:** Introduction , primary energy Audit, Detailed energy audit, Energy conservation, Energy conservation via Cleaner Technology	7
5	**CP and Sustainable Development:** Cleaner Production & Cleaner Technology: As a remedial measure for mitigating Climate change, Ozone layer depletion, Current practices in Cleaner Production & Cleaner Technology viz Rio Declaration and agenda 21 etc, CP network.	9
6	Case studies for various industries and financial analysis.	8

Reference Books:

1. "Cleaner Production: Environmental and Economic Perspectives", Misra Krishna B, ISBN: 978-3-642-79940-2, Springer Publication.
2. "Environmental Management Systems and Cleaner Production, Dr. Ruth Hilary, ISBN: 978-0-471-96662-3, Wiley Publication.
3. Cleaner Production : Greening of Industries for Sustainable Development, Rajiv K Sinha and Sunil Herat, ISBN -10:8171324010.
4. "Cleaner Production & Energy Conservation for Sustainable Development", Jurgis Staniskis, Lithuania C. Jayaraman, ISBN: 9789351301936, Daya Publishing House.

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Ability to explain the concept and principles of cleaner production	10
CO-2	Ability to suggest different unit operations in industrial production process to minimize pollutions.	15
CO-3	Ability to describe cleaner production measures applicable to different industries	20
CO-4	Ability to conduct energy and material balances for processes as part of a cleaner production assessment	30
CO-5	Ability to evaluate environmental management strategies and its relation to the concept of sustainable development	10
CO-6	Ability to suggest cleaner production methods for a given situation which will also lead to cost reduction in long run.	15

List of Experiments:

1. Application of Cleaner production in different industrial sector.
2. Use of Heat Exchangers as cleaner production devices.
3. Energy Audit for Campus.
4. CP application in campus.

List of Open Source Software/learning website:

1. www.scew.gov.au/.../anzecc-ppr-towards-sustainability-achieving-cleane
2. www.unep.org/Pdf/Capacity_building.pdf
3. www.iisd.ca/consume/unep.html
4. www.gcpc.org.in

In the beginning of the session, subject faculty will allot an OEP / DP to the students. Students will be free to choose a topic of their choice which will be relevant to the syllabus and they will either prepare a working model/ report / presentation / poster on their topic.

GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering
Subject Code: 3723022
Semester – II
Subject Name: Advances in Petroleum Refining and Petrochemicals

Type of course: Program Elective

Prerequisite: Basics of Organic Chemistry and General Chemical Technology fundamentals

Rationale: Crude Oil Refinery is the largest process industry in the Chemical sector in term of Quantum and eminence as it includes all the processes and equipment in the Chemical Industry. Some of the most difficult and tedious Unit Operations and processes is an inmate of Refinery section. The study of this subject will lead the students to gain specialized knowledge about a unique field in Chemical Engineering.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs
1	Typical composition of petroleum regulations related to transportation and storage of petroleum. Petroleum products- their important properties, specification and testing methods. TBP and other distillations.	11
2	Crude assay analysis, inter-conversion of distillation data, Nelson's Method, Mid percentage curve, Yield curve, Edmisters method and product blending	10
3	Process Design of Atmospheric Distillation Unit (ADU), heat and mass balance calculations for ADU and VDU, types of equipment used: columns, pumps tube still heaters etc	10
4	Treatment of petroleum products, hydrodesulphurisation, hydrotreating, lube oil processing, deasphalting, dewaxing etc	7
5	Catalytic reforming, CCR (Continuous Catalytic Regeneration) Platforming	7
6	Advances in Fluidized Catalytic Cracking (FCC), feedstock properties of FCC, Thermodynamics, FCC Configuration, Material and Energy balance, Reactor-Regenerator FCC dynamic model	9

Master of Engineering
Subject Code: 3723022

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

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

Reference Books:

1. Nelson, W. L. Petroleum Refinery Engineering, Tata McGraw Hill publishing company, 1985
2. James H, Gary & Glenn E. Handwerk, 'Petroleum Refining, Technology & Economics', 5th Edition, Marcel Dekker, Inc, 2001.
3. Speight, J. G., The Chemistry and technology of Petroleum, 5 th Edition, M. Dekker, 1991.
4. Watkins, R. N., Petroleum Refinery Distillation, 2nd Edn., Gulf Pub. Co., Houston, Tex, 1979. 5. Fundamentals of Petroleum Refining, Taher A. Al- Sahhaf, Amal Sayed Elkilani, B. V. Elsevier, 2010.
5. Fundamentals of Petroleum Refining, Taher A. Al- Sahhaf, Amal Sayed Elkilani, B. V. Elsevier, 2010.
6. The Petroleum Act, 1934. Professional Book Publishers, New Delhi.

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Outline composition and transportation law	15
CO-2	Estimate crude assay analysis by different distillation methods	20
CO-3	Apply process design of vacuum distillation, atmospheric distillation on crude assay	25
CO-4	Apply different treatment methods on crude	15
CO-5	Design catalytic Cracking unit for residuum	15
CO-6	Estimate fluid catalytic cracking considering all parameters	10

List of Experiments:

List of Experiments (Any Five):
1. To carry out ASTM distillation of Petrol/ Gasoline & convert those distillation data into TBP and Equilibrium Flash Vaporization (EFV).
2. To carry out ASTM distillation of Diesel & convert those distillation data to TBP and EFV.
3. Mathematical modeling of FCC Reactor-Regenerator model.

4. To find out important test properties of Gasoline/blends and compare it with actual data.
5. To find out important test properties of Naphtha and compare it with actual data.
6. To find out important test properties of Diesel and compare it with actual data.
7. To find out important test properties of Kerosene and compare it with actual data.
8. To find out important test properties of Lube oil and compare it with actual data.
9. To find out important test properties of Cycle stock/ Fuel oil and compare it with actual data.

Major Equipment:

Laboratory Distillation Columns

Equipment for testing of petroleum products

ASTM distillation apparatus

GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering
Subject Code: 3723021
Semester – II
Subject Name: Advanced Analytical Techniques

Type of course: Elective

Prerequisite: Basic Concepts of physical, inorganic and organic chemistry.

Rationale: This course is intended to familiarize students with various traditional and modern physicochemical methods of analysis and the development of the students ability to the interpretation of the results obtained by various techniques.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs
1	Theory of errors: Sources and classification of errors. Statistical treatment of analytical data & presentation of result. Sampling of solids, liquids and gases. Evaluation and validation of analytical methods. Good laboratory practices.	
2	Chromatographic methods: Introduction & classification of chromatography. Theory, instrumentation & applications of the following chromatographic techniques: (i) Column chromatography (ii) TLC (iii) Paper chromatography (iv) GC (v) HPLC	
3	UV-Visible Spectroscopy: Introduction, Theory of UV-Visible Spectroscopy & colourimetry, Beer Lambert law, Deviation from Beer Lambert law. Infrared Spectroscopy: Introduction, Infrared radiation & its interaction with organic molecules, vibrational mode of bonds, instrumentation & applications, interpretation of IR spectra. Mass spectrometry: Basic principles & brief outline of instrumentation. Ion formation, molecular ion, meta stable ion, fragmentation process in relation to molecular structure & functional groups.	
4	Potentiometry, ion selective electrodes. Voltammetric methods, Conductometry and conductometric titration, Coulometric methods applied to industrial analysis and air pollution observation.	
5	Thermogravimetric analysis, differential scanning calorimetry: principles and applications.	

6	X-ray Diffraction studies Principles and applications, Various Microscopic analysis sucah as SEM, TEM and AFM. Working principles, applications and sample preparations.	
7	Errors and Treatment of statistical data True value, Precision, accuracy, error, mean and median, spread, deviation, standard deviation, coefficient of variation, variance, significant figures, types of errors, statistical treatment of random errors ,evaluation of experimental results, comparison of results	

Reference Books:

1. Chemical Analysis, Modern Instrumentation Methods and Techniques, F. Rouessac, A. Rouessac, Jon Wiley & Sons Ltd, 2007.
2. Analytical Chemistry, Theoretical and Metrological Fundamentals, K. Danser, Springer, 2007.
3. Instrumental Methods of Analysis, B. K. Sharma, Goel Publishing house.
4. Elementary Organic Spectroscopy, Y.R. Sharma, S.Chand & company Ltd. New Delhi 2008
5. Spectroscopic identification of organic compounds, R.M. Silverstein, F.X. Webster, D.J. Kiemle,John Wiley & Sons Ltd, 2005

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

Sr. No.	CO statement	Marks % weightage
CO-1	Recognize fundamentals as well as recent developments in instrumental methods of analysis	20
CO-2	Understand the working of instruments as well as for the development of new technologies	35
CO-3	Select the best method of sample preparation required for a particular analytical technique.	20
CO-4	Spectroscopy and microscopy to identify molecular structures from their spectra and micrograph	25

List of Open Source Software/learning website:

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

GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering
Subject Code: 3723020
Semester – II
Subject Name: Bioprocess Engineering

Type of course: Elective

Prerequisite: Basic Concepts of Transport Phenomena, Mass transfer and Reaction kinetics

Rationale: This subject is an integration of chemical engineering with biological systems. It deals with kinetics of biological reactions, mass and heat transfer concepts and transport phenomena occurring within biological reactors.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs
1	**Kinetics of Enzyme Catalyzed Reaction** The Enzyme Substrate Complex and Enzyme Action, Simple Enzyme kinetics with one and two substrates, Determination of Elementary Step Rate Constants, Other patterns of substrate concentration dependence, Modulation and Regulation of Enzymatic Activity, Other Influences on enzyme activity, Enzyme deactivation, Enzyme reactions in Heterogeneous systems	
2	Kinetics of Substrate Utilization, Product Formation, Biomass Production in Cell Cultures Ideal Reactors for kinetics measurements, Stoichiometry and kinetics of Balanced Growth, Transient growth kinetics, structured kinetic models, product formation kinetics, Segregated kinetic models of Growth and Product Formation, Thermal Death kinetics of Cells and Spores.	
3	Transport Phenomena in Bioprocess Systems Gas Liquid Mass transfer in cellular systems, determination of oxygen transfer rates, mass transfer for freely rising or falling bodies, forced convection mass transfer, overall K_La estimates and power requirements for sparged and agitated vessels, Mass transfer across free surfaces, other factors affecting Kla, Scaling of Mass transfer equipment, Heat Transfer, Sterilization of Gases and liquids	
4	**Design and Analysis of Biological Reactors:** Ideal reactors, reactor dynamics, reactors with non-ideal mixing, sterilization reactors, immobilized biocatalysts, multiple	

	bioreactors, Fermentation Technology, animal and plant cell reactor technology	
5	**Product Recovery Operations** Recovery of particulates – cells and solid particles by Filtration, Centrifugation, Flocculation, Cell Disruption, Production isolation by Liquid Liquid extraction, Precipitation, Chromatography and Fixed Bed Adsorption, Dialysis, Membrane Separation, Electrophoresis, Crystallization and Drying	

Reference Books:

1. Bioprocess Engineering- Basic Concepts; M.L. Shuler and F. Kargi, second edition, PHI Pvt. Ltd.
2. Bioprocess Engineering Principles by - Doran P.M., Elsevier Science and Technology Publishers, 1995.
3. Biochemical Engineering Fundamentals by James E. Bailey, David F. Ollis, Publisher: McGraw-Hill Inc.,US, 2nd Edition.
4. Principles of Fermentation Technology, by Whitaker, Peter F Stanbury, S. Hall and A. Whitaker, Publisher: Butterworth-Heinemann; 2nd edition

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

Sr. No.	CO statement	Marks % weightage
CO-1	Understand the different cells and their use in biochemical processes	20
CO-2	Understand the role of enzymes in kinetic analysis of biochemical reaction	35
CO-3	Analyze bioreactors, upstream and downstream processes in production of bioproducts	20
CO-4	Apply the concepts of various unit operations in downstream processes of biological products	25

List of Open Source Software/learning website:

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

GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering in CHEMICAL ENGINEERING (30)
Subject Code: 2733007
Semester – III
Subject Name: Computational Fluid Dynamics

Type of course: [Elective – III] (c)

Prerequisite: Numerical Methods

Rationale:

1. To be able to model and simulate all the mass, momentum, and energy transport processes in chemical engineering using the generalized conservation equations.
2. To make students understand the governing equations of fluid dynamics and their derivation from laws of conservation
3. To develop a good understanding in computational skills, including discretisation, accuracy and stability.
4. To acquaint the students with a process of developing a mathematical and geometrical model of flow, applying appropriate boundary conditions and solving system of equations.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs	% Weightа
1	Introduction to Fluid Dynamics Concepts of Fluid Flow, Pressure distribution in fluids, Reynolds transport theorem, Integral form of conservation equations, Differential form of conservation equations, Different Types of Flows, Euler and Navier Stokes equations, Properties of supersonic and subsonic flows, Flow characteristics over various bodies. Philosophy of CFD, Governing equations of fluid dynamics and there physical meaning, Mathematical behavior of governing equations and the impact on CFD simulations, Simple CFD techniques and CFL condition. Numerical Methods in CFD:Finite Difference, Finite Volume, and Finite Element, Upwind and downwind schemes, Simple and Simpler schemes, Higher order methods, Implicit and explicit methods, Study and transient solutions	14	27%

2	Grid Generation Basic theory of structured grid generation, Surface grid generation, Mono block, multi block, hierarchical multi block, Moving and sliding multiblock, Grid clustering and grid enhancement. Basic theory of unstructured grid generation, advancing front, Delaunay triangulation and various point insertion methods, Unstructured quad and hex generation, grid based methods, various elements in unstructured grids, Surface mesh generation, Surface mesh repair, Volume grid generation, Volume mesh improvement, mesh smoothing algorithms, grid clustering and quality checks for volume mesh. Adaptive, Moving and Hybrid Grids, Need for adaptive and, moving grids, Tet, pyramid, prism, and hex grids, using various elements in combination	14	27%
3	Turbulence and its Modelling Transition from laminar to turbulent flow, Effect of turbulence on time-averaged Navier-Stokes equations, Characteristics of simple turbulent flows, Free turbulent flows, Flat plate boundary layer and pipe flow, Turbulence models, Mixing length model,The k-e model, Reynolds stress equation models, Algebraic stress equation models	10	20%
4	Chemical Fluid Mixing Simulation Stirred tank modeling using the actual impeller geometry, Rotating frame model, The MRF Model Sliding mesh model, Snapshot model, Evaluating Mixing from Flow Field Results, Industrial Examples	8	15%
5	Post-Processing of CFD results Contour plots, vector plots, and scatter plots, Shaded and transparent surfaces, Particle trajectories and path line trajectories, Animations and movies, Exploration and analysis of data.	6	11%

Reference Books:

1. Anderson John D., “Computational Fluid Dynamics: The Basics with Applications”, McGraw Hill, 1995
2. Ranade V.V., “Computational Flow Modeling for Chemical Reactor Engineering”, Process Engineering Science, Volume 5, 2001
3. Knupp Patrick and Steinberg Stanly, “Fundamentals of Grid Generation”, CRC Press, 1994.
4. Wilcox D.C., “Turbulence Modelling for CFD”, 1993
5. Wesseling Pieter, “An Introduction to Multigrid Methods”, John Wiley & Sons, 1992
6. Thompson J.F., Warsi Z.U.A. and Mastin C.W., “Numerical Grid Generation: Foundations and Applications”, North Holland, 1985
7. Patankar S.V., “Numerical Heat Transfer and Fluid Flow”, McGraw-Hill,1981
8. Gatski Thomas B., Hussaini M. Yousuff and Lumley John L., “Simulation and Modelling of Turbulent Flows”, Oxford University Press, 1996
9. Laney, C. B., “Computational Gas Dynamics”, Cambridge Uni. Press, 1998.

GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering in CHEMICAL ENGINEERING (30)
Subject Code: 2733007

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Understand the basic principles of mathematics and numerical concepts of fluid dynamics	
CO-2	Develop governing equations for a given fluid flow system	
CO-3	Adapt finite difference techniques for fluid flow models	
CO-4	Apply finite difference method for heat transfer problems	
CO-5	Solve computational fluid flow problems using finite volume techniques	
CO-6	Get familiarized to modern CFD software used for the analysis of complex fluid-flow systems	

List of Experiments:

1. Evaluation of matrix format of conservation equation
2. Grid generation for Ideal CSTR and PFR reactors
3. Grid generation technique for fluidized bed
4. Application of grid refinement on PID of chemical plant
5. Simplification of momentum balance to derive bernoulli's equation
6. Comparison of solution methods for various CFD softwares
7. Evaluation of heat loss using CFD software
8. Evaluation of fluid dynamics in water hammer effect using OpenFOAM
9. Setting up the modelling equation for simultaneous heat, mass and momentum transfer application.

Major Equipment:

1. Concentric pipe with insulation
2. CSTR and PFR

List of Open Source Software/learning website:

1. OpenFOAM (https://www.openfoam.com/)
2. ANSYS/Fluent (https://www.ansys.com/en-in/products/fluids/ansys-fluent)
3. Star-CD (https://mdx.plm.automation.siemens.com/star-cd)
4. Star-CCM+ (https://mdx.plm.automation.siemens.com/star-ccm-plus)
5. COMSOL Multiphysics
6. CFDTool (https://www.cfdtool.com/)
7. MATLAB
8. C/C++/Python based tutorials

GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering
Subject Code: 3723017
Semester – II
Subject Name: Advanced Transport Phenomena

Type of course: Core Course III

Prerequisite: Basics of Fluid Mechanics, Heat Transfer and Mass Transfer Operations

Rationale: Momentum, Heat and Mass Transfer are three basic transport processes in chemical engineering. It is very important to understand mathematical modeling and analogical aspects of chemical process systems where these transport processes occur simultaneously. This course focuses such typical situations and thereby its complete understanding on axial as well as radial profiles.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs
1	**Analogies in Momentum, Heat and Mass Transfer:** Introduction, Reynolds analogy, Prandtl Taylor analogy, Van Karman analogy, Martinelli analogy, Chilton analogy.	09
2	**Principles of Momentum Transport:** Molecular and convective momentum transport, Molecular theory of viscosity in gases and liquids. Shell momentum balances and equation of changes: Navier-Stoke's equation and its applications, Velocity distributions in laminar flow, creeping flow around a sphere. Time dependent flow of laminar Newtonian fluids: Unsteady Laminar Flow between two parallel plates. Turbulent flow: Reynolds stress, Time-Smoothed Equations of Change for Incompressible Fluids and Velocity distributions, Boundary layer flow.	15
3	**Principles of Energy Transport:** Molecular and convective energy transport, Theory of thermal conductivity in solids, gases and liquids, Shell energy balances, Heat conduction with various heat sources, Equation of changes in non-isothermal systems and its applications to solve steady state forced and free convection and viscous heat generation problem, Unsteady state heat conduction, temperature distributions in laminar tube flow and laminar forced convection near heated flat plate. Temperature distributions in turbulent flow: time smoothened equation of changes and time smoothened temperature profile near wall. Temperature distribution in boundary layer.	15
4	**Principles of Mass Transport:** Molecular and convective mass transport, Theory of binary and multicomponent diffusion in gases and liquids, Shell mass balances and concentration distribution in laminar flow, diffusion in falling liquid film, diffusion in three component gas system, equation of changes for multicomponent systems, Use of the Equations of Changes to solve Simultaneous heat and mass transport and concentration profile in a tubular reactor principles of unsteady state diffusion.	15

Suggested Specification table with Marks (Theory):

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

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Bird R.B., Stewart W.E., Lightfoot E.N., Transport Phenomena, 2nd Edition, John Wiley & Sons, 2002
2. James Welty, Charles E. Wicks and Wilson, Gregory L Rorrer, "Fundamentals of Momentum, Heat and Mass transfer", 5th Edition, 2008.
3. Geankoplis C.J., Transport Processes and Separation Process Principles,4th Edition
4. Slattery J.C., Advanced Transport Phenomena, Cambridge University Press.

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

Sr. No.	CO statement	Marks % weightage
CO-1	Understand the mechanism of momentum, heat and mass transport for steady and unsteady flow.	**20**
CO-2	Perform momentum, energy and mass balances for a given system at macroscopic and microscopic scale.	**25**
CO-3	Solve the governing equations to obtain velocity, temperature and concentration profiles.	**25**
CO-4	Model the momentum, heat and mass transport under turbulent conditions.	**15**
CO-5	Develop analogies among momentum, energy and mass transport.	**15**

List of Experiments:

1. Hagen-Poisuille equation for calculation of viscosity and for capillary radii
2. Determination of diffusion coefficient for liquid phase mixture
3. Experiments on gas-liquid-solid contacting equipments
4. Cooling Towers
5. Fluidized beds
6. Bubble cap and sieve tray distillation columns
7. Bubble column and their modification etc.
8. Determination of thermal conductivity of metal rods.
9. Determination of Eflux time for various fluids.
10. Determination of kinematic viscosity of mixture using different viscometer

Major Equipments:

1. Hagen-Poisuille apparatus
2. Diffusion Co-efficient apparatus
3. Cooling tower
4. Bubble columns
5. Bubble cap, sieve tray distillation columns
6. Fluidized beds
7. Viscosity measurement (Efflux time) apparatus
8. Ostwald Viscometer
9. Multiphase flow

10. Thermal conductivity of metal rod

List of Open Source Software/learning website:

- NPTEL lecture series
- Literature available on momentum, heat and mass transfer
- MIT Open course lecture on Transport Processes

GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering
Subject Code: 3723009
Semester – II
Subject Name: Advanced Process Control

Type of course: Chemical Engineering

Prerequisite: Basics of Process Control at undergraduate level.

Rationale: Advanced process control is concerned with the usage of techniques for control of digital systems, systems operating under constraints, optimal control that takes into account control efforts and control of multivariate processes.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Topics	Teaching Hrs.
1	**Introduction:** Laplace Transforms. Review of dynamic behavior of linear systems. Linearization. Transportation lag. Control system design for linear closed loop systems. Studies on system stability.	4
2	**Analysis and Design of Advanced Control Systems:** Compensatory control system, Feedback control of systems with large dead time. Dead time compensation. Control system with inverse response. Multiple loop control systems- Cascade control, Selective control system, Split range control system. Feedforward control, Ratio control, Feedforward-Feedback control, Adaptive control, Inferential Control.	20
3	**Discrete- Time control systems**: Sampling and Z- transforms. Inversion of Z-Transform. Hold elements. Laplace transform of the impulse-modulated function. General conditions for stability. Open-Loop and Closed-Loop response, Stability analysis of discrete-time control systems.	10
4	**Multiple-Input, Multiple-Output (MIMO) Systems:** Introduction to MIMO systems, Design questions for MIMO control systems, Degrees of freedom and number of controlled and manipulated variables, Generation of alternative loop configurations, Extension to interacting systems.	8
5	**Analysis of Nonlinear Control Systems:** Examples of nonlinear Systems, Methods of Phase-Plane analysis.	7
6	**Design of control systems for complete plant:** Case Studies	5

Reference Books:

1. Chemical Process Control: George Stephanopoulos, Prentice Hall India Pvt. Ltd.
2. Process Systems Analysis and Control: Donald Coughanowr, McGraw-Hill, Inc.
3. Process Control and Instrumentation: Prof. R. P. Vyas, Central Techno Publications, Nagpur
4. Process Dynamics and Control: D. E. Seborg, T. F. Edgar, D. A. Mellichamp, Wiley.

5. Control System Design: Graham C. Goodwin, Stefan F. Graebe, Mario E. Salgado, Prentice Hall

Course Outcome:

Sr. No.	CO statement	Marks % weightage
CO-1	Analyze and design advanced control systems. Linear and non-linear systems	
CO-2	Understand industrial applications of control theory.	
CO-3	Learn the complex control techniques.	
CO-4	Identify, formulate and solve problems for control system design of complete chemical plant.	

List of Experiments:

1. Determination of response/behavior of linear control systems.
2. Dynamic behavior of a Pneumatic control valve
3. Temperature control using PID controller
4. Flow control using PID controller
5. Cascade control using PID controller
6. Level control using PID controller
7. Characterization of a control valve
8. Tuning of controller parameters
9. Dynamics of higher order systems
10. Minor course projects

Major Equipments:

1. Pneumatic Control Valve
2. PID controllers
3. Control trainers
4. MATLAB/SCILAB

List of Open Source Software/learning website:

1. NPTEL lecture series
2. Literature available on Process Control
3. MIT Open course lecture on Process Control

GUJARAT TECHNOLOGICAL UNIVERSITY
Master of Engineering
Subject Code - 3720001
Semester II
Subject Name: Mini Project with Seminar

Type of course: Core

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
0	0	4	2	0	0	0	100	100

Content:

A mini project requires comparatively less time than major projects. They are comparatively simpler and have shorter duration. Mini Project helps students to explore and strengthen the understanding of fundamentals through practical application of theoretical concepts. Mini Project can help them to boost their skills and widen their horizon of thinking. It will act like a beginners guide to undertake the major project/dissertation during the final year and will ensure preparedness of students to undertake major projects/dissertation. Students will be required to select the topic relevant to their specialization and that has value addition. Students will get an opportunity to work in actual industrial environment if they opt for internship. Based on the selected topic student will also prepare seminar report based on the literature survey

Mini Project will have mid semester presentation and end semester presentation. Mid semester presentation will include identification of the problem based on the literature review on the topic referring to latest literature available. End semester presentation should be done along with the report on identification of topic for the work and the methodology adopted involving scientific research, collection and analysis of data, determining solutions highlighting individuals' contribution. Continuous assessment of Mini Project at Mid Sem and End Sem will be monitored by the departmental committee.

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

1. Identify engineering problems reviewing available literature.
2. Study different techniques used to analyze complex systems.
3. Solve a live problem using software/analytical/computational tools and present solution by using his/her technique applying engineering principles.
4. Learn to write technical reports and develop skills to present and defend their work in front of technically qualified audience.

GUJARAT TECHNOLOGICAL UNIVERSITY

Stress Management by Yoga
SUBJECT CODE: 3700007
SEMESTER: I/II

Type of course: Audit course

Prerequisite: -

Rationale: -

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE(E)	PA (M)	PA (V)	PA (I)	
0	0	4	0	0	0	0	50	50

Content

Sl. No.	Topic	Teaching Hours	Module Weightage (%)
1.	Definitions of Eight parts of yog. (Ashtanga)	8	33
2.	Yam and Niyam Do`s and Don't's in life Ahinsa, satya, astheya, bramhacharya and aparigraha Shaucha, santosh, tapa, swadhyay, ishwarpranidhan	8	34
3.	Asan and Pranayam Various yog poses and their benefits for mind & body Regularization of breathing techniques and its effects-Types of pranayama	8	33

Reference Books:

1. Yogic Asanas for Group Tarining-Part-I" :Janardan Swami Yogabhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, AdvaitaAshrama (Publication Department), Kolkata

Course Outcome:

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

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

GUJARAT TECHNOLOGICAL UNIVERSITY

English for Research Paper Writing
SUBJECT CODE: 3700001
SEMESTER: I/II

Type of course: Audit course

Prerequisite: -

Rationale: -

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE(E)	PA (M)	PA (V)	PA (I)	
2	0	0	0	50	0	0	0	50

Content

Sl. No.	Topic	Teaching Hours	Module Weightage (%)
1.	Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness	4	17
2.	Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction	4	17
3.	Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check	4	17
4.	key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature	4	17
5.	skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions	4	16
6	useful phrases, how to ensure paper is as good as it could possibly be the first- time submission	4	16

Reference Books:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

Course Outcome:

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

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title
4. Ensure the good quality of paper at very first-time submission

GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering
Subject Code: 3733011
Semester – III
Subject Name: Process plant design and flow-sheeting

Type of course: Elective

Prerequisite: The student should have basic understanding of Chemical Engineering Economics and Plant design.

Rationale: Process plant design and flowsheeting involve the understanding of designing the process plants or creating design layouts of plant. It also involves the fundamentals of chemical engineering viz. development of flow diagrams, importance of various design consideration during the development and design of any process. This subject also deals with the basics as well as advanced understanding of various process auxiliaries and utilities used in chemical plant.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs
1	Introduction: Basic concepts, General Design Considerations, Process design development, layout of plant items, Economic aspects and optimum design, Practical considerations in design and engineering ethics, Network analysis, PERT/CPM	9
3	Analysis of cost estimation, Factors affecting investment and production costs, Estimation of capital Investment and total product cost, Interests, Time value of money, Taxes and Fixed Charges, Salvage value, Depreciation calculation	6
3	Flow-sheeting: Synthesis of flow sheet: Propositional logic and semantic equations, Deduction theorem, Algorithmic flow sheet generation using P-graph theory, Sequencing of operating units, Feasibility and optimization of flow sheet using various algorithms viz, Solution Structure Generation (SSG), Maximal Structure Generation (MSG), Simplex, Branch-and-bound etc. ,	10
4	Optimum Design and Design Strategy: Break-even analysis, Optimum production rates in plant operation, Optimum batch cycle time applied to evaporator and filter press, Economic pipe diameter, Optimum insulation thickness, Optimum cooling water flow rate and optimum distillation reflux ratio.	8

5	**Process Auxiliaries:** Basic considerations and flow diagrams in chemical engineering plant design. Piping design: Selection of material, pipe sizes, working pressure, Basic principles of piping design, piping drawings, pipe installations, overhead installations, Process steam piping, selection and determination of steam – pipe size, Piping insulation, application of piping insulation, weather proof and fire resisting pipe insulation jackets, piping fittings, pipe joints. Valves: Types of valves, selection criteria of valves for various systems. Pumps: Types of pumps	**12**

Reference Books:

1. M.S. Peters and Timmerhaus, Plant design and Economics for Chemical Engineers, Mc Graw Hill 4th Edition.
2. Anil Kumar, Chemical Process Synthesis and Engineering Design, Tata McGRaw Hill (1982)
3. F.C. Vibrandt and C.E. Dryden, Chemical Engineering Plant Design, McGraw Hill, 5th Edition.
4. Roger Hunt and Ed Bausbacher, Process Plant layout and Piping Design, PTR Prentice-Hall Inc.,
5. Jack Broughton; Process utility systems; Institution of Chem. Engineers, U.K.

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

Sr. No.	CO statement	Marks % weightage
CO-1	Analyze, synthesize, and design processes for manufacturing products commercially	20
CO-2	Recognize economic, construction, safety, operability and other design constraints	35
CO-3	Estimate fixed and working capitals and operating costs for process plants	20
CO-4	Use commercial flowsheeting software to simulate	25

GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering
Subject Code: 3733010
Semester – III
Subject Name: Computer Aided Design

Type of course: Program Elective 5

Prerequisite: The students should be having basic knowledge of computer and its use. The students must be aware of units and conversion, material and energy balance, thermodynamics for properties of components and mixtures, chemical engineering unit operation and processes.

Rationale: The objective of this course is to understand importance and applications of CAD in the field of chemical engineering. The student will become familiar to the basic structure and components of CAD software and importance of underlying thermodynamic and physical principles. They will get detailed insight into the approaches used in the simulation of flow sheets. They will be in position to relate flow charts, computer languages and numerical methods used for writing algorithms.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**Introduction :** Introduction to CAD, Scope and applications in chemical Engineering, Mathematical methods used in flow sheeting and simulation, Introduction to solution methods for linear and non-linear algebraic equations, solving one equation one unknown, solution methods for linear and nonlinear equations, general approach for solving sets of differential equations, solving sets of sparse non-linear equations.	6	10
2	**Properties Estimation :** Physical properties of compounds, Thermodynamic properties of gases and binary mixtures, Viscosity, Vapour pressure, Latent heat, Bubble point and drew point calculation, phase equilidria, Vapour-liquid equilibria, Liquid phase activity coefficients, K-values, Liquid phase activity coefficients, K-values, Liquid-Liquid equilidria, Gas solutions.	8	15
3	**Equipment Design :** Computer aided Design of Equipment: Design of Shell and Tube Heat exchangers; Design of Evaporators; Design of Distillation columns; Design of Reactors, Design of adsorption columns; Distillation columns (specific attention to multi components systems. Heat exchangers.	12	25

4	**Computer Aided Flow Sheet Synthesis :** Computerized physical property calculations, degrees of freedom in process design, degrees of freedom for a unit, degrees of freedom in a flow sheet, steady state flow sheeting and process design, approach to flow sheeting systems, introduction to sequential modular approach, simultaneous modular approach and equation solving approach, sequential modular approach to flow sheeting, examples. Tear streams, convergence of tear streams, partitioning and tearing of a flow sheet, partitioning and precedence ordering, tearing a group of units. Flow sheeting by equation solving methods based on tearing.	14	20
5	**Dynamic Simulation :** Dynamic simulation of stirred tanks system with heating Multi component system, Reactors, Absorption and distillation columns, Application of orthogonal collocation and weighted residuals techniques in heat and mass transfer systems, Introduction to special software for steady and dynamic simulation of Chemical engineering systems. Introduction to various commercial design software and optimization tools used in field of chemical engineering.	20	30

Reference Books:

1. Douglas James M., “Conceptual design of Chemical Processes", McGraw -Hill Book Company, New York, 1988.
2. Remirez, W.F. - " Computational methods for Process Simulations ", Butterworths, New York, 1989.
3. Sinnott R.K. "Chemical Engineering”, Volume 6, Pergamon Press, New York, 1989.
4. Westerberg A.W., et al, “Process Flow Sheeting”, Cambridge University Press.
5. Biegler Lorenz T, et al, “Systematic method of Chemical Process Design”, Prentice Hall.
6. Crowe C.M., et al, “Chemical Plant Simulation-An Introduction to Computer Aided Steady State Analysis”, Prentice Hall.
7. Anil Kumar, “Chemical Process Synthesis and Engineering Design”,TMH,1981.
8. Richard Turton et al., “ Analysis, Synthesis, and Design of Chemical Processes”, Pearson.

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

Sr. No.	CO statement	Marks % weightage
CO-1	Understand the computations for design simulation and optimization	15
CO-2	Estimate properties for chemical compounds and mixtures	20
CO-3	Design operations and processes equipment using computer aided design tools	25

CO-4	Model dynamic processes and validate simulation results	20
CO-5	Analyse simulation results and process plant data to identify optimal process conditions.	20

List of Experiments:

1. Thermodynamic property estimations using property estimation tools.
2. Analysis of VLE data for Non-ideal mixtures using property estimation tools.
3. Simulation studies of simple unit operations using process plant simulator.
4. Simulation of evaporators, heat exchangers, and distillation
5. Design verification for reactive distillation columns.
6. Apply sensitivity, design specification and case study tools
7. Dynamic simulation of Distillation Columns.
8. Simulation of Heat/Mass Transfer coefficient in 3 phase fluidized bed column
9. Modelling and Simulation of cyclone separator
10. Modelling and optimization of Spray Dryer
11. Design optimization for non-ideal reactors
12. Design and Simulation of adsorption for practical applications

Note: Software tools like DWSIM, HTRI, ASPEN PLUS, CHEMCAD may be used for laboratory experiments.

Major Equipment: Computer Lab

List of Open Source Software/learning website: DWSIM - an open source process plant simulator

GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering
Subject Code: 3733009
Semester – III
Subject Name: Design of experiments and parameter estimation

Type of course: Program Elective 5

Prerequisite: Fundamentals of statistics and mathematics

Rationale: This Subject is essential for Chemical engineering to know the effect of pressure and stress of fluid on different bodies. Further, it is useful for students to know the metering devices for different type of fluids.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs
1	Design of experiments. Basic concepts, Bias and confounding, controlling bias, causation, Examples. Random Variables: Introduction to discrete and continuous random variables, quantify spread and central tendencies of discrete and continuous random variables.	9
2	Exploratory Data Analysis Variable types, Displaying the distribution, mean variance and typical spread, quartiles and unusual spread, multivariate data: finding relations. Probability, Definition of a random variable, expectation, percentiles, common distributions such as the binomial, Poisson and normal distributions.	6
3	Linear Regression analysis: The linear regression model, Parameter estimation, accuracy of the coefficient estimates, checking the model, multiple linear regression, confidence and prediction intervals, potential issues, high leverage points, outliers. Matrix approach to linear regression.	10
4	Variance-Covariance matrix, ANOVA in regression analysis, quantifying regression fits of experimental data, Extra sum of squares approach, confidence intervals on regression coefficients, lack of fit analysis.	8
5	**Response Surface Methodology**: Method of steepest ascent, first and second order models, identification of optimal process conditions	12

Reference Books:

1. Hanneman, Robert A., Kposowa, Augustine J., Riddle, Mark D. (2012). Research Methods for the Social Sciences: Basic Statistics for Social Research. John Wiley & Sons.

2. Saunders, Mark, Brown, Reva Berman (2007). Dealing with Statistics: What You Need to Know. McGraw-Hill Education.
3. Cowles, Michael (2000). Statistics in Psychology: An Historical Perspective (2nd Edition). Lawrence Erlb

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Define design of experiments and relate it with random variables.	15
CO-2	Classify different types of variables and explain data analysis.	20
CO-3	Apply linear regression analysis for data analysis.	25
CO-4	Examine lack of fit by ANOVA using different errors calculations.	20
CO-5	Integrate data analysis approaches for optimal process conditions.	20

List of Experiments:

1. Plan experiments for a critical comparison of outputs.
2. Include statistical approach to propose hypothesis from experimental data.
3. Implement factorial and randomized sampling from experiments.
4. Estimate parameters by multi-dimensional optimization.

GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering (Chemical Engineering-30)
Subject Code: 3733008
Semester – III
Subject Name: Polymer science and Technology

Type of course: Elective V

Prerequisite: Basic knowledge of polymer chemistry at undergraduate level.

Rationale: The main theme of this course is to focus on understanding of polymer science, its technology, Polymer synthesis and its characterization. Knowledge of properties of polymers will enable their proper selection for applications in domestic as well as industrial appliances.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs
1	**Basic concepts of polymer:** Concepts of polymers, Classification of polymers based on: structures, configuration, application, tacticity crystalline etc.., mechanism and kinetics of polymerization, mode of formation, Poly dispersity and molecular weight distribution, Concept of Mn(Number average molecular weight), Mw((Weight average molecular weight), Mv(Viscosity average molecular weight) etc., measurement techniques, effect of molecular weight on polymer end use properties, Functionality principle, Theory of polymer solutions: solubility parameter, Mark-Houwink-Sakurda equation.	03
2	**Polymer Structure and Physical Properties:** The Crystalline Melting Point, The glass Transition, Properties Involving Large Deformation, Properties Involving small Deformation, Strength, Physical state of Polymers, Elastic property, Chemical resistance, Solubility, Intermolecular forces in monomers and polymers, Plastics- Elastomers & Fibers, Mechanical behavior of Polymers, Molecular weight & intermolecular forces, The amorphous state rheology, Stereochemistry, Crystallinity, Chemical Cross linking, Physical Cross linking, Polymer blends	10
3	**Chain growth polymerization:** Mechanism and kinetics of free radical, anionic, cationic and co-ordination polymerization, initiator efficiency, types of initiation reactions, auto acceleration chain transfer agents, inhibition and retardation reactions.	7

4	**Step growth polymerization:** Carothers's equation, kinetics of step growth polymerization, cross-linking and gelation, Comparison between addition and condensation polymerization, Co polymerization: Types of co polymers, monomer reactivity ratio, block and graft copolymers	6
5	**Polymer Degradation And Techniques of Polymerization:** Polymer degradation (chain and random), Methods of degradation of polymers such as mechanical, thermal, photo, oxidative and bio degradation, Bulk polymerization, Solution polymerization, Suspension polymerization, Emulsion polymerization and its kinetics, Comparison of bulk, solution, emulsion and suspension polymerization techniques.	10
6	**Polymerization Reaction Engineering :** Reactors for polymerization, analysis of polymerization reactions, Reactor design applied to polymer system, Average molecular weight of polymer in different reactor, Control of molecular weight, Reactors for Industrial polymerization Processes like manufacturing of PS, PBR SBR.	7
7	**Rheology of Polymeric System:** Unit operations in polymer industries. Polymer processing: moulding, calendaring, extrusion etc.	2

Suggested Specification table with Marks (Theory):

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

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Polymer science and technology, Joel R. Fried, Prentice Hall India Pvt. Ltd.
2. Textbook of Polymer Science, Fred W. Billmeyer, John Willy and Sons.
3. Rubber chemistry, Brydson, Elsevier Appl.
4. Principles of polymer system, Ferdinend &Rodrigues, Tata McGraw-Hill Pub.
5. Polymer Science, Gowariker, Eastern Wiley Pub.

GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering (Chemical Engineering-30)
Subject Code: 3733008

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Synthesize and characterize polymers based on their properties and applications.	25
CO-2	Understand the kinetics of polymers.	20
CO-3	Understand the basic concepts in design of a polymeric process.	20
CO-4	Understand and apply different techniques of polymerization.	15
CO-5	Discuss methodically the molding techniques.	10
CO-6	Apply the concepts learned to the different industrial applications.	10

List of Open Source Software/learning website:

- NPTEL lecture series.
- MIT Open course lecture on Polymer technology.

GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering
Subject Code: 3730009
Semester III
Waste to Energy

Type of Course:

Prerequisite:

Rationale:

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE Viva (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Sr. No.	Topics	Teaching Hours
1	Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors	
2	Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods – Yields and application – Manufacture of pyrolytic oils and gases, yields and applications	
3	Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation	
4	Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors	
5	Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion – Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India	

References:

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996

Course Outcomes:

After learning the course the students should be able to :

Sr. No.	CO statement	Marks % weightage
CO-1	Understand about Agriculture waste, Industrial waste and their conversion process	20
CO-2	Design construction and operation of Gasifiers	30
CO-3	Design construction and operation of Bio combustors	30
CO-4	Applications of Biomass	20

GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering
Subject Code:3730007
Semester III
Operation Research

Type of Course: Open Elective

Prerequisite: Nil

Rationale: Operation research techniques are useful for solving real life Industrial problem, Problems can be of Manufacturing, Service and supply related. Different techniques help for optimization of linear as well as non - linear type problem.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE Viva (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Sr. No.	Topics	Teaching Hours
1	**Linear Programming Problems:** Formulation of a LPP, - graphical solution, simplex method, duality in LPP, sensitivity analysis, Integer linear programming, revised simplex method, parametric linear programming, Dynamic programming under certainty, Dynamic programming approach for solving LPP.	12
2	**Project Management , Inventory Control and Decision Making:** CPM, PERT, Project time cost trade off, Resource allocation, Deterministic inventory control models, Probabilistic inventory control models, Decision making process, Decision making under uncertainty, Decision making under risk, Decision tree analysis, Theory of games, Pure strategies, Mix strategies, Solutions method games without saddle points.	10
3	**Classical Optimization Methods:** Single variable optimization, Constrained and unconstrained multi-variable optimization, Direct substitution method, Lagrange's method of multipliers, Kuhn-Tucker conditions	06
4	**Non-linear Programming:** **Constrained Optimization Techniques** Unimodal function, Unrestricted search, Exhaustive search, Dichotomous search, Interval halving method, Fibonacci method, Golden section method **Unconstrained Optimization Techniques** Direct Search Methods: Random search methods, Grid search method, Univariate method, **Constrained Optimization Techniques** Direct Methods: Random search method, Sequential linear programming.	10
5	**Evolutionary Algorithms** An overview of evolutionary algorithms, Simulated annealing algorithm, Genetic algorithm, Particle swarm optimization	04

Distribution of marks weightage for cognitive level

Bloom's Taxonomy for Cognitive Domain	Marks % weightage

Recall	10
Comprehension	10
Application	25
Analysis	25
Evaluate	20
Create	10

References:

1. J. K. Sharma, Operation Research, Theory and Application, Macmillan Publishers India Ltd,2013
2. H.A. Taha, Operations Research, An Introduction, PHI, 2008
3. S.S.Rao, Engineering Optimization Theory and Practice, New Age International (P) Ltd, Publishers.
4. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

Course Outcomes:
After learning the course:

Sr. No.	CO statement	Marks % weightage
CO-1	Students should able to apply the Liner programming techniques to solve problems of real life applications and carry out post optimality analysis.	30
CO-2	Students should able to apply the concepts of non-linear programming and apply them for real life problems.	30
CO-3	Students should able to obtain quantitative solutions in business decision making under conditions of certainty, risk and uncertainty.	20
CO-4	Students should able to implement various scientific tools and models that are available in the subject to take decisions in a complex environment.	20

Last Modified on 16-04-2019

GUJARAT TECHNOLOGICAL UNIVERSITY

Guidelines for the Preparation of M.E. Dissertation Thesis – 2018



GUJARAT TECHNOLOGICAL UNIVERSITY

Nr.Vishwakarma GovernmentEngineeringCollege
Nr.Visat Three Roads, Visat - Gandhinagar Highway
Chandkheda, Ahmedabad – 382424.

Phone: 079-23267508.

1. Introduction

1.1. The guidelines described in this document have been established so that thesis can be prepared in a form suitable for library cataloging. The document takes its place in the library as a product of original thinking and research, and it is, therefore, designed to appear in a form comparable to published work.

1.2. This document covers the general rules of quality, format and appearance. Students should consult their Project Guide for specific content requirements.

1.3. It is the student's responsibility to read and follow the requirements presented here. The final copies will not be accepted if they do not fulfill the criteria described below.

2. Originality

M.E. Thesis shall

2.1. Consist of the student's own account of his/her investigations;

2.2. Be either a record of original work or of an ordered and critical exposition of existing knowledge and shall provide evidence that the field has been surveyed thoroughly;

2.3. Be an integrated whole and present a coherent argument;

2.4. Give a critical assessment of the relevant literature, describe the method of research and its findings and include a discussion on those findings; and

2.5. Include a full bibliography and references.

2.6. Check originality of thesis with help of Turnitin anti-plagiarism which is provided to institute by GTU.

3. Components

A thesis should contain the following parts in the order shown:

3.1 Fly page (1 Blank Pages)

3.2 Title page (please see sample, Annexure I), containing:

3.2.1 the thesis title;

3.2.2 the full name of the Candidate, enrollment no. and Guide name;

3.2.3 the degree for which the thesis is submitted;

3.2.4 the name of the University, i.e. Gujarat Technological University

3.2.5 the month and year of submission

3.3 Declaration Page.

3.4 Thesis Certificate page (please see sample, Annexure II);

3.5 Originality Report Certificate

3.6 Thesis Approval Form

3.7 Abstract

3.8 Acknowledgments

3.9 Table of contents (please see sample, Annexure IV)

3.10 List of Symbols

3.11 List of Figures and Tables

3.12 List of Appendices

3.13 Abstract must be written on a separate page which should provide a concise summary of the thesis in maximum 300 words.

3.14 The thesis body (Chapters)

3.15 A thorough reference list

3.16 List of Publications

3.17 Appendices (List of abbreviation, etc.) and other addendum, if any.

4. Language, Style and Format

4.1. Language

Thesis should be written in English.

4.2. Final Version

The final version of the thesis must be free from spelling, grammatical and other errors when submitted.

4.3. Scripts and Page Format

Paper and print quality are vitally important for successful microfilming and legibility. Normally, international A4, not less than 75 gsm white paper should be used for the thesis which should be printed on single side of the paper. Exceptionally, paper other than international A4 size may be used when the nature of the thesis requires it.

4.4. A Times New Roman font, size 12-point, 10 to 12 characters per inch must be used with 1.5 line spacing.

4.5. Top and bottom margins should be 25 mm, right margin should be 20 mm and Left Margin should be 35 mm for both textual and non-textual (figures, tables, etc.) pages . Header footer should be 10 mm each. Exceptionally, margins of a different size may be used when the nature of the thesis requires it.

4.6. Figures and Illustrations: Figures, tables, etc., should be positioned according to the scientific publication conventions of the discipline.

4.7. Pagination:

Beginning with the first page of chapter 1 (Introduction) of the thesis, all pages shall be numbered consecutively using Arabic numerals in 12 point fonts. Page numbers of all the pages where a chapter begins shall appear at the center of the footer. Page numbers of all the pages, starting from the title page to the page before the chapter 1 starting page, shall be lower case Roman numerals (e.g. i, ii, iii etc.), placed at the center of footer. However, the page number on the title page shall not be printed.

4.8. Paragraph Format:

The paragraph of each section and subsection shall start without any indentation. A vertical space of around 12 points should be left between the section title line and the first paragraph of each section and subsections. All the paragraphs in the thesis shall be in single column format with full justification. A paragraph should normally comprise more than one line. A single line paragraph shall not be placed at the top or bottom of a page.

4.9. Chapter(s):

A chapter always begins on a fresh page. The capitalized word “CHAPTER” with a font size of 20 should begin with an additional top margin of 30 mm (total 55 mm) followed by chapter no. with center aligned. Next, place the chapter heading with 20 font size and leaving around 18 points vertical spaces and center justified. Leave around 36 points vertical space after chapter heading. In the chapter heading, capitalize the first letter all the words. Use boldface letters and numbers only.

4.10. Sections and Subsections:

A chapter is usually needed to be divided into sections, subsections, etc. So as to present concepts with different aspects separately. As mentioned above, a vertical space of around 36 point should be left between the chapter heading and the title of the first section of every chapter. For all subsequent sections/subsections, leave a vertical space of around 24 points before the section/subsection headings. A vertical space of

around 12 points should always be left between the first line and the title of every section/subsection. Sections and subsections shall be numbed chapter wise and consecutively. For example, say the first and second sections in chapter 5 shall be numbered as 5.1 and 5.2, respectively. Likewise, the third subsections of sections 1 and 2 in a chapter 4 shall be numbered as 4.1.3 and 4.2.3, respectively. Same style as in chapter heading but with font size of 14 and 12 for section and subsections, respectively, shall be followed for their titles, with a gap of around six characters between their numbers. Use boldface letters and numbers and the entire writable horizontal space to write their numbers and titles. Sub-subsection of a subsection should not be numbered. The title of such topic should all be boldface capitalized letter followed by a colon (:) the content of the same should start after the colon leaving a single character. Leave a space of around 12 points before a sub-subsection. Further division of topics is not recommended.

4.11. Tables, figures, and Equations:

- All tables and figures should be printed on the same papers used to print the text.
- As far as possible, tables and figures are presented in portrait style.
- All tables, figures, and equations must be numbered sequentially and chapter-wise using Arabic numerals. It must reflect the chapter number also, e.g. 2.1, 6.25 etc. Use boldface letters and numbers (separated by a single space) to number a figure and table, e.g., Figure 2.1, Table 3.2. While a caption (figure number) should be placed below the figure, a caption (table number) should be placed above the table. A figure/table should be separated from its number by 1.5 lines. Equations shall form a separate line, having 6 points paragraph separation above and below, with equation numbers within parenthesis and flushed to the right.
- When a figure or table is referred to in the body of the text, the first letter of the word needs to be capitalized with appropriate abbreviations as, for instance, Table 2.17 and Fig. 3.24.
- When an equation is referred to in the text and appears as the first word of the sentence, it needs to be capitalized without any abbreviation as, for instance, Equation (2.5). In all other cases of referring an equation, simply write the equation number in parenthesis as, for example, (2.5).
- All figures and tables shall be appropriately captioned using sentence style format and immediately below the corresponding numbers with an additional space of 6 points in between. If more than one line is needed for the caption they should be separated with single line spacing. A caption needs to be justified with the table/figure borders.

- Font sizes of legends, axis labels etc. of figures should be sufficiently large so that even after compression of the figure, they are legible enough (having same sizes as in the general text).
- Short (less than around half of the writable page area) figures and tables should be presented immediately following their first mention in the text and preferably on the upper portion (before the text) of the following page or bottom portion of the same page, but separated by single lines spacing from the text. If they are placed in between then they should be separated by single lines spacing from both above and below. On the other hand, large figures and tables should be presented on page(s) following their first mention in the text.
- Images, Photographs, etc. must be scanned in resolution at least 600 dpi.

4.12. References

All references must be cited in the text by the reference number using superscripts. No links between superscripts in the text and actual references in the Reference Sections may be used. Notes may be used to cite manuscripts in preparation,

Unpublished observations and personal communications. References cited should follow the style given below example:

PAPERS

1. Thiel WJ and Nguyen LT, "Fluidized bed film coating of an ordered powder mixture to produce micro encapsulated ordered units." *J. Pharm. Pharmacol.* **1984**, *36*, 145-152.
2. Isyumov N, "Criteria for acceptance of wind induced motionsof tall buildings", International Conference on Tall buildings, Rio DeJanerio, CTBUH, 2003.

WEB SITE

1. Boggs, D, "Acceleration and Drift due to Gust forces", accessed on 10 July 2009, www.cppwind.com/papers/structural/PEAKvsRMS.pdf

BOOKS

1. PelzarMJ., Chan ECS., and Krieg NR. In Microbiology; 5th Edn; Tata McGraw Hill Publishing Company Limited, New Delhi, 1993, pp 536.

DISSERTATIONS

1. Vaishnav D.K, PhD Thesis, "……." Gujarat Technological University, July 2012.
2. Pathak VK. Ph.D. Thesis, "……..",Gujarat University, 1979.

PATENTS

1. Trevor M, Aggelos N and Helmut S. Process for the preparation of aceclofenac. European Patents EP 1082290 A1, 1999.

Authors are responsible for obtaining written approval for all personal communications and sending a copy of the manuscript to those cited as authors of personal communications.

5. Review Cards

5.1. Photo copy of all review comment cards of all the previous reviews viz. Dissertation Phase I, Mid Sem. along with Remedial of review (if applicable) should be submitted along with the thesis. Thesis will not be accepted without Photo Copy of all Review Comment Cards. Review comment cards should be attached as appendices after references. After review comment cards, student has to put compliance report of all such comments.

6. Thesis Submission

a) For examination purpose, required number of copies (student, guide, co-guide/external guide if any, institute library and GTU library) of the bound thesis are to be submitted to the Institution Head / University with soft copy (CD/DVD) in pdf mode at last page of thesis. Write enrollment no., branch code & name on submitted CD/DVD.

b) **Student has to come with thesis which must be submitted to examiner on day of exam. After completion of exam, student has to collect that thesis duly signed by examiners.**

c) Institute has to submit branch wise one CD/DVD comprising softcopy of thesis of students (in .pdf format) in separate folders, wherein they have to give enrolment number followed by name of students as folder name.

For example: 122050909000_Patel Akash. Different sections of thesis of respective

student should be included under his/her respective folder only.

d) For each branch, separate CD/DVD along with appropriate labeling on the CD/DVD cover is required.

7. Anti-plagiarism Check

7.1. The student has to check his/her dissertation thesis for plagiarism, which indicates % similarity of the languages used during drafting, using Turnitin software.

7.2. GTU has provided the Id & Password to each institute for Turnitin software.

7.3. On the first page of report, % similarity is mentioned with other published literatures. Preferably it should be ≤ 30 %. **If the similarity is > 30 % then the thesis will not accepted by university**.

7.3.Students have to take a print out of 1st page of Turnitin report, detailed Turnitin report and it is required to be signed by respective guide.

7.5. As per UGC Guidelines, all dissertation should be made available on University website. Later on if university receives any complaint regarding plagiarism, respective student and his/her Guide should be liable for all consequences if occurred. As per the UGC norms, University can revoke M.E. degree conferred to such students.

8. Mark Evaluation and Eligibility for DP-II:

8.1 Eligibility for DP2/Thesis submission:

- When demanded, student will have to submit thesis to the university before the final schedule of DP2.
- Those students who have cleared Mid Sem Review will be allowed to appear for DP2.

Evaluation for DP2/Thesis submission:

- Total Marks for DP-2 will be 100. Students will have to secure 50 marks to clear DP2.
- Students will be evaluated for DP-2 on the basis of following parameters/criteria.
    1. Literature Review
    2. Quality of Research & Out come
    3. Paper Publication, if any*

* Note: It is not mandatory for the student to publish paper. In case of publication of Paper, Student will have to present the Certificate of the Publication as mentioned in annexure which must have signature of the guide, signature of principal/director of the institute with the seal of institute. The paper must have been written with Guide.

ANNEXURE - I

[SAMPLE TITLE PAGE]

[Thesis Title]

(5 blank lines)

By

(single line)

[Your name as found in official GTU records and in next line your enrollment number]

(two lines)

[Guide name (with qualification and designation)]

(3 blank lines)

A Thesis Submitted to

Gujarat Technological University in Partial Fulfillment of the Requirements for the Master of Engineering Degree in [Name of Program]

(3 blank lines)

Month and Year

Institute Logo

Institute name and Address

ANNEXURE – II

[SAMPLE THESIS CERTIFICATE PAGE]

CERTIFICATE

This is to certify that research work embodied in this dissertation titled "_____" was carried out by **(Student Name)** at **(Institute Name with college code)** for partial fulfillment of Master of Engineering degree in **(Branch Name)** to be awarded by Gujarat Technological University. This research work has been carried out under my guidance and supervision and it is up to my satisfaction.

[GTU Logo Watermark]

Date :

Place :

Signature and Name of Guide **Signature and Name of Principal**

Seal of Institute

(If the work is carried out in industry then a certificate from industry shall also be attached.)

COMPLIANCE CERTIFICATE

This is to certify that research work embodied in this dissertation titled "_____" was carried out by **(Student Name with Enrollment no.)** at (Institute name & code) for partial fulfillment of Master of Engineering degree to be awarded by Gujarat Technological University. He/ She has complied to the comments given by the Dissertation phase – I as well as Mid Semester Thesis Reviewer to my satisfaction.

[GTU Logo Watermark]

Date :

Place :

Signature and Name of Student

(Student Enrollment No.) **Signature and Name of Guide**

PAPER PUBLICATION CERTIFICATE

This is to certify that research work embodied in this dissertation titled "_____" was carried out by **(Student Name with Enrollment no.)** at **(Institute name & code)** for partial fulfillment of Master of Engineering degree to be awarded by Gujarat Technological University. His/her article **(Full Title)** has been published / accepted for publication by the **(International/National Journal/Conference)** at **(Place)** during/on **(Duration/Date)**.

Date:

Place:

Candidate Name
(Enrollment No.) **Guide Name & Sign.**

Signature/Stamp and Name of Principal
(Seal of the Institute)

THESIS APPROVAL CERTIFICATE

This is to certify that research work embodied in this dissertation titled "_____" was carried out by **(Student Name with Enrollment no.)** at (Institute name & code) is approved for the degree of Master of Engineering with specialization if (Branch Name) by Gujarat Technological University.

[GTU Logo Watermark]

Date :

Place :

Examiner's Sign and Name:

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( ) ( )

ANNEXURE - III

[UNDERTAKING ABOUT ORIGINALITY OF WORK]

We hereby certify that we are the sole authors of this thesis and that neither any part of this thesis nor the whole of the thesis has been submitted for a degree to any other University or Institution.

We certify that, to the best of our knowledge, the current thesis does not infringe upon anyone's copyright nor violate any proprietary rights and that any ideas, techniques, quotations or any other material from the work of other people included in our thesis, published or otherwise, are fully acknowledged in accordance with the standard referencing practices. Furthermore, to the extent that we have included copyrighted material that surpasses the boundary of fair dealing within the meaning of the Indian Copyright (Amendment) Act 2012, we certify that we have obtained a written permission from the copyright owner(s) to include such material(s) in the current thesis and have included copies of such copyright clearances to our appendix.

We declare that this is a true copy of thesis, including any final revisions, as approved by thesis review committee.

We have checked write up of the present thesis using anti-plagiarism database and it is in allowable limit. Even though later on in case of any complaint pertaining of plagiarism, we are sole responsible for the same and we understand that as per UGC norms, University can even revoke Master of Engineering degree conferred to the student submitting this thesis.

[GTU Logo Watermark]

Date :

Signature of Student : _____ **Signature of Guide : _____**

Name of Student :_____ **Name of Guide :_____**

Enrollment No :_____ **Institute Code : _____**

ANNEXURE – IV

[SAMPLE CONTENTS PAGE]

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Gujarat Technological University

Master of Engineering (Dissertation Review Card)

Date: ___/___/___

Applicable from 2019 onwards for New Syllabus - effective from Academic year 2018-19.

Semester:	**3**	**Subject Name & Code:**	**Internal Review -1 3730002**	**IR-1**

Student's Enrollment:													

Name of Student :			
Student's Mail ID:-		**Branch Code**	
Students Contact No.		**Branch Name**	
Theme of Title :			
Title of Thesis :			

Sr. No.	**Comments given by Internal review panel** (Please write specific comments)	Modification done based on Comments
		_____ Guide's Signature

Note : *Above suggestions/modifications/comments must be fulfil/accommodate by the student in DP 1*	**Approved**		*Please tick on any one. If approved, then put marks ≥ 50 %.*
	***Not* Approved**		

Particulars	**Internal Review Panel**	
	Expert 1	Expert 2
Name:		
Institute code & Name:		
Mobile No.:		
Signature:		

Particulars	***Internal Guide's Details***	
	Supervisor	Co-supervisor
Name:		
Institute code & Name:		
Mobile No.:		
Signature:		

Gujarat Technological University

Master of Engineering (Dissertation Review Card)

Date: ___/___/___

Hall No: _____

Applicable from 2019 onwards for New Syllabus - effective from Academic year 2018-19.

Semester:	**3**	**Subject Name & Code:**	**Dissertation Phase 1 - 3730003**	**DP-1**

Student's Enrollment:												

Name of Student :			
Student's Mail ID:-		**Branch Code**	
Students Contact No.		**Branch Name**	
Theme of Title :			
Title of Thesis :			

OBSERVATIONS

1. Appropriateness of title with proposal. (Yes/ No) _____
2. Whether the selected theme is appropriate according to the title ? (Yes / No) _____
3. Justify rational of proposed research. (Yes/ No) _____
4. Clarity of objectives. (Yes/ No) _____

Sr. No.	**Comments given by External Examiners (DP-I)** (Please write specific comments)	Modification done based on Comments
		_____ **Guide's Signature**

Note :
Above suggestions/modifications/comments must be fulfil/accommodate by the student in IR-2

Approved ☐

Not Approved ☐

Please tick on any one.
If approved, then put marks ≥ 50 %.

Particulars	***Details of External Examiner***	
	Expert 1	Expert 2
Name:		
Institute code & Name:		
Mobile No.: (optional)		
Email Id:		
Signature:		

Gujarat Technological University

Master of Engineering (Dissertation Review Card)

Date: ___/___/___

Applicable from 2019 onwards for New Syllabus - effective from Academic year 2018-19.

Semester:	**4**	**Subject Name & Code:**	**Internal Review -2 – 3740001**	**IR-2**

Student's Enrollment:													

Name of Student :			
Student's Mail ID:-		**Branch Code**	
Students Contact No.		**Branch Name**	
Theme of Title :			
Title of Thesis :			

Sr. No.	**Comments given by Internal Examiners (IR-2)** (Please write specific comments) i) The appropriateness of the major highlights of work done; State here itself if work can be approved with some additional changes. ii) Main reasons for approving the work. iii) Main reasons if work is not approved.	Modification done based on Comments
		_____ **Guide's Signature**

Note : *Above suggestions/modifications/comments must be fulfil/accommodate by the student in DP-2*	**Approved**		*Please tick on any one.* *If approved, then put marks ≥ 50 %.*
	Not Approved		

Particulars	***Details of Internal Examiner***	
	Internal Review Panel	**Internal Review Panel**
Name:		
Institute code & Name:		
Mobile No.:		
Email Id:		
Signature:		

Gujarat Technological University

Master of Engineering (Dissertation Review Card)

Date: ___/___/___

Hall No : _____

Applicable from 2019 onwards for New Syllabus - effective from Academic year 2018-19.

Semester:	**4**	**Subject Name & Code:**	**Dissertation Phase-2 3740002**	**DP-2**

Student's Enrollment:												

Name of Student :			
Student's Mail ID:-		**Branch Code**	
Students Contact No.		**Branch Name**	
Theme of Title :			
Title of Thesis :			

Sr. No.	**Comments given by External Examiners (DP-II)** (Please write specific comments) i) Main reasons for approving the work. ii) Main reasons if work is not approved.	Modification done based on Comments
		_____ **Guide's Signature**

Approved ☐

Not Approved ☐

Please tick on any one.
If approved, then put marks ≥ 50 %.

Particulars	***Details of External Examiner***	
	Expert 1	Expert 2
Name:		
Institute code & Name:		
Mobile No.: (Optional)		
Email Id:		
Signature:		

GUJARAT TECHNOLOGICAL UNIVERSITY
(Established by Government of Gujarat under Gujarat Act No.: 20 of 2007)
ગુજરાત ટેકનોલોજીકલ યુનિવર્સિટી
(ગુજરાત સરકારના ગુજરાત અધિનિયમ ક્રમાંક : ૨૦/૨૦૦૭ દ્વારા સ્થાપિત)

Ref. No: GTU/EXAM/ME/ 10271 Date: 14th October 2019

Read: 1. Submission Dated 17-12-2018
2. Minutes of Meeting of Academic Council Dated 26-04-2019
3. Minutes of Meeting of Faculty of Engineering Dated 10-04-2019

Circular

Subject: Mandatory to clear Internal Review-I subject for appearing in DP-1 and Internal Review-II / Mid Sem Review to appear for DP-II.

All the students of M.E. and their guides are hereby informed to take note that, it compulsory for the students to clear the "Internal Review" subjects before appearing in DP1 and DP-II.

For old ME Syllabus (Effective from Academic Year 2014-15):

- To appear for DP-1 candidate must have successfully cleared Internal Review-1.
- To appear for Mid Sem Review candidate must have successfully completed DP-1.
- To appear for DP-2 candidate must have successfully completed Mid Sem Review.

For New ME Syllabus (Effective from Academic Year 2018-19):

- To appear for DP-1 candidate must have successfully cleared Internal Review-1.
- To appear for Internal Review-2 candidate must have successfully completed DP-1.
- To appear for DP-2 candidate must have successfully completed Internal Review-2.

Students will have to keep all the review cards and submit it to the examiner for the reference at the time of DP-1, IR-2/MSR, DP2.

Internal Review-I in Sem-3 and Internal Review II in Sem 4 will have to be conducted by institute at college level. Students can download blank review cards from below link.

Link to download review cards of ME.: https://www.gtu.ac.in/5

Sd/-
Registrar

Chandkheda : Nr. Campus of Vishwakarma Government Engineering College, Sabarmati - Koba Highway, Nr. Visat Three Roads, Chandkheda, Ahmedabad - 382 424. Gujarat, India Ph. : 079 - 232 67 500 Fax : +91 - 79 232 67 580
Ahmedabad : 2nd Floor, ACPC Building, L. D. College of Engineering Campus, Navrangpura, Ahmedabad, (Gujarat) India - 380 015. Phone : + 91 - 79 - 26 300 499 / 599 Fax : + 91 - 79 - 26 30 1500
Gandhinagar : K-6 Circle, E-4 Electronic Estate G.I.D.C., Nr. Goverment Polytechnic, Sector-26, Gandhinagar - 382 028 Gujarat.
e-mail : info@gtu.ac.in URL : www.gtu.ac.in

GUJARAT TECHNOLOGICAL UNIVERSITY
(Established by Government of Gujarat under Gujarat Act No.: 20 of 2007)
ગુજરાત ટેકનોલોજીકલ યુનિવર્સિટી
(ગુજરાત સરકારના ગુજરાત અધિનિયમ ક્રમાંક : ૨૦/૨૦૦૭ દ્વારા સ્થાપિત)

Ref. No: GTU/EXAM/ME/525 Date: 16th January 2020

Read: 1. Minutes of Meeting of Academic Council Dated 29-11-2019

Circular

Subject: Schedule of Internal Review-I and Internal Review-II / Mid Sem. Review

All the students of M.E. and their guides are hereby informed to take note of the schedule as mentioned below.

Sem.	Subject (New Course)	Subject (Old Course)	Examination	Time to conduct examination
3	3730002 – Internal Review 1	2730002 – Internal Review	At college level	between 1st to 15th September
3	3730003 – Dissertation Phase 1	2730003 – Dissertation Phase 1	At University level	As per the schedule declared by University (Generally in the month of November or December)
4	3740001 – Internal Review 2	2740001 – Mid Sem Review	At college level	between 20th February to 05th March
4	3740002 – Dissertation Phase 2	2740002 – Dissertation Phase 2	At University level	As per the schedule declared by University (Generally in the month of April or May)

Those students who have not cleared **Mid Sem Review of old course will have to appear at college for examination.**

It is desirable to follow above schedule.

Sd/-
Registrar

Chandkheda : Nr. Campus of Vishwakarma Government Engineering College, Sabarmati - Koba Highway, Nr. Visat Three Roads, Chandkheda, Ahmedabad - 382 424. Gujarat, India Ph. : 079 - 232 67 500 Fax : +91 - 79 232 67 580
Ahmedabad : 2nd Floor, ACPC Building, L. D. College of Engineering Campus, Navrangpura, Ahmedabad, (Gujarat) India - 380 015. Phone : + 91 - 79 - 26 300 499 / 599 Fax : + 91 - 79 - 26 30 1500
Gandhinagar : K-6 Circle, E-4 Electronic Estate G.I.D.C., Nr. Goverment Polytechnic, Sector-26, Gandhinagar - 382 028 Gujarat.
e-mail : info@gtu.ac.in URL : www.gtu.ac.in