



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
L	T	P		Theory Marks		Practical Marks		
			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%



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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	20%
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	
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, Cengage Learning Publisher
4. Engineering Chemistry by N. Krishnamurthy, P. Vallinaygam and D. Madhavan, Prentice Hall of India Pvt. Ltd.
5. Engineering Chemistry by K. Sessa 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



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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
L	T	P		Theory Marks		Practical Marks		
				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%



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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 Heasley, 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%



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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%

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
L	T	P		Theory Marks		Practical Marks		
			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



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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 Balagurusamy 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



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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 $1^2+2^2+3^2+\dots+n^2$
26. Write a C program to find $1+1/2+1/3+1/4+\dots+1/n$.
27. Write a C program to find $1+1/2!+1/3!+1/4!+\dots+1/n!$.
28. Write a program to evaluate the series $sum=1-x+x^2/2!-x^3/3!+x^4/4!-\dots-x^9/9!$
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



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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 $F(x) = x - x^3 / 3! + x^5 / 5! - x^7 / 7! + \dots x^n / n!$.
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.



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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
L	T	P		Theory Marks		Practical Marks		
				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%



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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



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Basic Civil Engineering	Satheesh Gopi	Pearson Publisher
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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 Engineering
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 C	Examination Marks				Total Marks
L	T	P		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	% 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



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering

Subject Code: 3110005

	Construction and working of following machines: <ul style="list-style-type: none"> • 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:

- D. C. Kulshreshtha, "Basic Electrical Engineering", McGraw Hill, 2009.
- Basic Electrical Engineering - Nagsarkar and Sukhija, Oxford University Press
- B. L. Theraja, "Electrical Technology – Part I and II", S. Chand and Co. 2012
- D. P. Kothari and I. J. Nagrath, "Basic Electrical Engineering", Tata McGraw Hill, 2010.
- L. S. Bobrow, "Fundamentals of Electrical Engineering", Oxford University Press, 2011.
- E. Hughes, "Electrical and Electronics Technology", Pearson, 2010.
- 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



GUJARAT TECHNOLOGICAL UNIVERSITY

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Subject Code: 3110005

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
L	T	P		Theory Marks		Practical Marks		
				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



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Subject Code: 3110006

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 stroke 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		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



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Bachelor of Engineering

Subject Code: 3110007

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



GUJARAT TECHNOLOGICAL UNIVERSITY
Bachelor of Engineering
Subject Code: 3110007

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		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



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering

Subject Code: 3110012

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 metal pipes



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- 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



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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 Traffic 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 Tool**

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 /



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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 & Sons 1998
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
L	T	P		Theory Marks		Practical Marks		
			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, Involute 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%



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	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



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Subject Code: 3110013

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
L	T	P		Theory Marks		Practical Marks		
			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'Hôpital'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, \square^{\square} 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 $2\square$ periodic functions, Dirichlet's conditions for representation by a Fourier series, Orthogonality of the trigonometric system, Fourier Series of a function of period $2\square$, 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%



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering

Subject Code: 3110014

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.		
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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 C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				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 phases would be one day each. The following is the guidelines indicating the possible activities under each phase of the Induction Program.

Initial Phase (First Day)		
<p>Following are the activities to be carried on the first day:</p> <ul style="list-style-type: none"> ● 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)		
<p>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 addition in suggested activities for each of the phases.</p>		
Module Name	Objectives	Suggested Activities
1. Physical Activity (24 hours)	1. Improve bone health 2. Improve cardio respiratory and muscular fitness 3. Understand the anatomy, basic biomechanical principles and terminology. 4. Examine the effect of nutrition, rest and other lifestyle factors that contribute to the better 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
<p>Guidelines:</p> <ul style="list-style-type: none"> ● 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- 		

Module Name	Objectives	Suggested Activities
2. Creative Arts (12 hours)	<ol style="list-style-type: none"> 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. 	<ol style="list-style-type: none"> 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)	<ol style="list-style-type: none"> 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. 	<ol style="list-style-type: none"> 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)	<ol style="list-style-type: none"> 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. 	<ol style="list-style-type: none"> 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.
- Writing the review of the well known books, movies etc and sharing.

Module Name	Objectives	Suggested Activities
5. Proficiency modules (6 hours)	<ol style="list-style-type: none"> 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. 	<ol style="list-style-type: none"> 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.	
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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, contributors and successful 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
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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:

- Every student has to maintain a daily diary. Format of the diary is already given.
- 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.
- 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
L	T	P		Theory Marks		Practical Marks		
			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%



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering

Subject Code: 3130004

	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



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering

Subject Code: 3130004

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 C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				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 C	Examination Marks				Total Marks
L	T	P		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



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering

Subject Code: 3130502

	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



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering

Subject Code: 3130502

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 its coefficient of discharge.
- 3 To calibrate an Orifice meter and obtain its coefficient of discharge.
4. To study a Rota meter and obtain its 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 C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				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, Diastereomers, 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



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering (Chemical Engineering)

Subject Code: 3130506

	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 characterization highlighting 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 Arun Bahl & 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 Freeman, 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, Stanley R Crouch, Publisher: Cengage.
9. Instrumental Method of Chemical Analysis by B K Sharma, Publisher: Krishna Prakashan Media.
10. Materials Science and Engineering: A First Course, by V. Raghavan 5th Edition Prentice Hall India, 2004.
11. B. S. Mitchell, An Introduction to Materials Engineering and Science for Chemical and Materials Engineers, John Wiley & Sons, 2004.



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering (Chemical Engineering)

Subject Code: 3130506

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
L	T	P		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	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 P_c , T_c , V_c . 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° , 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



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Subject Code: 3130507

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



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering (Chemical Engineering)

Subject Code: 3130507

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 C	Examination Marks				Total Marks
L	T	P		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



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Bachelor of Engineering

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	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 Igbino ghene, 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



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Bachelor of Engineering

Subject Code: 3130508

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 C	Examination Marks				Total Marks
L	T	P		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



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering

Subject Code: 3140503

	<p>transfer and their significance.</p> <p>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</p> <p>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.</p>	
3	<p>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 transmissivity. 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</p>	6
4	<p>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</p>	12
5	<p>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.</p>	8
6	<p>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.</p>	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



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Bachelor of Engineering

Subject Code: 3140503

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 C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
			ESE (E)	PA (M)	ESE (V)	PA (I)		
3	1	0	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 Calculations 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



GUJARAT TECHNOLOGICAL UNIVERSITY

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Subject Code: 3140507

	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. Litchenthaler, 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 C	Examination Marks				Total Marks
L	T	P		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



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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, Weissmermel K & Arpe H.J., Weinheim, 1978.
9. Pandey G.N., "A Text Book of Chemical Technology", Volume 1 and 2, Vikas Publications 11. B. S. Mitchell.



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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 <i>Saccharomyces cereviceae</i> (Baker's Yeast).
14.	Fermentative production of citric acid using the fungi <i>Aspergillus niger</i> .

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.



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2. Electronic Balance.

List of Open Source Software/learning website:

NPTEL, World Wide Web, etc.



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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 C	Examination Marks				Total Marks
L	T	P		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	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



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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



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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 understand 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 isotherm



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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 SO_x and NO_x 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>



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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 C	Examination Marks				Total Marks
L	T	P		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



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	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 Shastri, 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



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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		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.



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- 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 <i>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</i>	1.5 hrs Classroom engagement (including self-discovery/ solutioning sessions)
2	Identity & Self-esteem <i>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.</i>	Same as above
3	Become a Creator of one’s destiny <i>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.</i>	Same as above
4	Achieving Sustainable Success <i>In this topic, students discover how to achieve sustainable or lasting success, by building one’s “engine of success”, making them successful. Where their focus shifts to building one’s “engine of success” rather than being on chasing the “fruits of success”. This is important,</i>	Same as above



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	<i>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.</i>	
5	Career Development Models <i>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.</i>	Same as above
6	Expanding contribution in every role <i>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.</i>	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
- Contributor Personality Program textbook cum workbook developed by Illumine



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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%



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	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%



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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 C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
			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



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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
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GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering

Subject Code: 3150005

1	Facing Failures	Factors Affecting Failures Failures are not Always Bad Insignificance of Failures Power of Faith Practicing Faith	<ol style="list-style-type: none">1. Thomas Edison's factory burns down, New York Times Archives, Page 1, 10/12/19142. Lincoln Financial Foundation, Abraham Lincoln's "Failures": Critiques, Forgotten Books, 20173. J.K. Rowling Harvard Commencement Speech Harvard University Commencement, 20084. Born Again on the Mountain: A Story of Losing Everything and Finding It Back, Arunima Sinha, Penguin, 20145. Failing Forward: Turning Mistakes Into Stepping Stones for Success, John C. Maxwell, Thomas Nelson, 20076. Steve Jobs: The Exclusive Biography Paperback, Walter Isaacson, Abacus, 2015
2	Learning from Legends	Tendulkar & Tata Leading Without Leading	<ol style="list-style-type: none">1. Chase Your Dreams: My Autobiography, Sachin Tendulkar, Hachette India, 20172. Playing It My Way: My Autobiography, Sachin Tendulkar, Hodder & Stoughton, 20143. The Wit and Wisdom of Ratan Tata, Ratan Tata, Hay House, 20184. The Tata Group: From Torchbearers to Trailblazers, Shashank Shah, Penguin Portfolio, 20185. The Leader Who Had No Title, Robin Sharma, Jaico Publishing House, 20106. 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	<ol style="list-style-type: none">1. Project Management Absolute Beginner's Guide, Gregory Horine, Que Publishing, 20172. The Fast Forward MBA in Project Management, Eric Verzuh, Wiley, 20113. Guide to Project Management: Getting it right and achieving lasting benefit, Paul Roberts, Wiley, 2013



GUJARAT TECHNOLOGICAL UNIVERSITY

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Subject Code: 3150005

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	<ol style="list-style-type: none">1. Hidden Horizons, Dr. David Frawley and Dr. Navaratna S. Rajaram, 20062. Rishis, Mystics and Heroes of India, Sadhu Mukundcharandas, Swaminarayan Aksharpath, 20113. Physics in Ancient India, Narayan Dongre, Shankar Nene, National Book Trust, 20164. The Rise of Civilization in India and Pakistan, Raymond Allchin, Bridget Allchin, Cambridge University Press, 19825. 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	<ol style="list-style-type: none">1. Power of Habit, Charles Duhigg, Random House Trade Paperbacks, 20142. Change Your Habit, Change Your Life, Tom Corley, North Loop Books, 20163. The Seven Habits of Highly Effective People, Stephen Covey, Simon & Schuster, 20134. Seven Habits of Highly Effective Teens, Sean Covey, Simon & Schuster, 20125. Atomic Habits, James Clear, Random House, 20186. 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	<ol style="list-style-type: none">1. Rich Dad Poor Dad, Robert Kiyosaki, Plata Publishing, 20172. The Warren Buffett Way, Robert Hagstrom, Wiley, 20133. The Intelligent Investor, Benjamin Graham, Harper Business, 20064. 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	<ol style="list-style-type: none">1. “What Makes a Good Life? Lessons from the Longest Study on Happiness”, R. Waldinger, Ted Talks, 20152. Long Walk To Freedom, Nelson Mandela, Back Bay Books, 19953. Outliers, Malcolm Gladwell, Back Bay Books, 2011



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering Subject Code: 3150005

8	Soft Skills	Teamwork & Harmony Networking - Decision Making - Leadership	<ol style="list-style-type: none">1. The 17 Indisputable Laws of Teamwork, John Maxwell, HarperCollins, 20132. Team of Teams: New Rules of Engagement for a Complex World, Stanley McChrystal, Portfolio, 20153. 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 C	Examination Marks				Total Marks
L	T	P		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: 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



GUJARAT TECHNOLOGICAL UNIVERSITY

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	equipments, Overall coefficient and Transfer units, Concept of HETP and HTU, NTU and jH factor, Industrial absorbers. Dilute solutions, Absorption with chemical reaction	
6	<p>Equipments for Gas Liquid Operations: <i>Gas Dispersed:</i> 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</p> <p><i>Liquid Dispersed:</i> 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.</p>	8
7	<p>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.</p>	10
8	<p>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</p>	6
9	<p>Crystallization: Saturation, Nucleation, Principle of crystallization, Crystallization rate, Equilibria and yields, Nucleation, Crystal growth, Caking of crystals, Application of crystallization, Crystallization equipments</p>	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.



GUJARAT TECHNOLOGICAL UNIVERSITY

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Subject Code: 3150501

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



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Bachelor of Engineering
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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 C	Examination marks				Total marks
L	T	P		Theory marks		Practical marks		
				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, Gyration 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



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	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



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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 understanding regarding mechanical operation done in industries under different conditions.



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150504

Semester – V

Subject Name: Instrumentation and Process Control

Type of course: Professional Core Course

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		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

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	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



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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: Psychrometer 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, McGrawHill (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.



GUJARAT TECHNOLOGICAL UNIVERSITY

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Subject Code: 3150504

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 be 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. Responses of second order system: U-tube manometer or damped vibrator
5. Response of Interacting tanks
6. Response of Non-interacting tanks
7. Calibration of thermocouple 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 processing to 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 C	Examination marks				Total marks
L	T	P		Theory marks		Practical marks		
				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



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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.

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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. 3rd 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)



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering

Subject Code: 3150505

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, Gyrotory 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 understanding regarding mechanical operation done in industries under 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		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



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Bachelor of Engineering

Subject Code: 3150506

	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).



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Bachelor of Engineering

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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 C	Examination marks				Total marks
L	T	P		Theory marks		Practical marks		
				ESE (E)	PA (M)	PA (I)	ESEV)	
3	0	0	4	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs	%weightage
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 and Refractories: 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



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Bachelor of Engineering

Subject Code: 3150507

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:



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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 C	Examination Marks				Total Marks
L	T	P		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 : 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 transformation, 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



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Bachelor of Engineering

Subject Code: 3150508

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



GUJARAT TECHNOLOGICAL UNIVERSITY

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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 Course

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		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



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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.



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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 C	Examination Marks				Total Marks
L	T	P		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)



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Subject code: 3160002

	<p>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”.</p> <p>Students learn how to build this way of thinking, in this topic.</p>	
2	<p>Creating Value</p> <p>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.</p>	Same as above
3	<p>Engaging deeply</p> <p>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.</p>	Same as above
4	<p>Enlightened self-interest & collaboration at work</p> <p>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”).</p>	Same as above
5	<p>Human-centered thinking & Empathy</p> <p>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.</p>	Same as above
6	<p>Trust Conduct</p> <p>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.</p>	Same as above
Showcase Lab Sessions		3 hrs
Project work		Beyond classroom



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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



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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%



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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 C	Examination Marks				Total Marks
L	T	P		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



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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.



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Module No.	Module	References
1	Facing Failures	<ol style="list-style-type: none">1. Thomas Edison's factory burns down, New York Times Archives, Page 1, 10/12/19142. <u>Lincoln Financial Foundation</u>, Abraham Lincoln's "Failures": Critiques, Forgotten Books, 20173. J.K. Rowling Harvard Commencement Speech Harvard University Commencement, 20084. Born Again on the Mountain: A Story of Losing Everything and Finding It Back, <u>Arunima Sinha</u>, Penguin, 20145. Failing Forward: Turning Mistakes Into Stepping Stones for Success, <u>John C. Maxwell</u>, Thomas Nelson, 20076. Steve Jobs: The Exclusive Biography Paperback, <u>Walter Isaacson</u>, Abacus, 20157. Failing Forward: Turning Mistakes Into Stepping Stones for Success, <u>John C. Maxwell</u>, Thomas Nelson, 2007
2	Learning from Legends	<ol style="list-style-type: none">1. Chase Your Dreams: My Autobiography, Sachin Tendulkar, Hachette India, 20172. Playing It My Way: My Autobiography, Sachin Tendulkar, Hodder & Stoughton, 20143. The Wit and Wisdom of Ratan Tata, Ratan Tata, Hay House, 20184. The Tata Group: From Torchbearers to Trailblazers, Shashank Shah, Penguin Portfolio, 20185. The Leader Who Had No Title, Robin Sharma, Jaico Publishing House, 20106. In the Joy of Others: A Life-Sketch of Pramukh Swami Maharaj, Mohanlal Patel and BAPS Sadhus, Swaminarayan Aksharpath, 2013
3	My India My Pride	<ol style="list-style-type: none">1. Rishis, Mystics, and Heroes of India, Sadhu Mukundcharandas, Swaminarayan Aksharpath, 20112. Physics in Ancient India, <u>Narayan Dongre</u>, <u>Shankar Nene</u>, National Book Trust, 20163. <u>The Rise of Civilization in India and Pakistan</u>, Raymond Allchin, Bridget Allchin, <u>Cambridge University Press</u>, 19824. <u>The Āryabhatīya of Āryabhata: An Ancient Indian Work on Mathematics and Astronomy</u> (1930), <u>Walter Eugene</u> Clark, University of Chicago Press, reprint, Kessinger Publishing, 2006
4	Remaking Yourself	<ol style="list-style-type: none">1. Power of Habit, Charles Duhigg, Random House Trade Paperbacks, 20142. Change Your Habit, Change Your Life, Tom Corley, North Loop Books, 20163. The Seven Habits of Highly Effective People, Stephen Covey, Simon & Schuster, 20134. Seven Habits of Highly Effective Teens, Sean Covey, Simon & Schuster, 20125. Atomic Habits, James Clear, Random House, 20186. How a handful of tech companies control billions of minds every day, Tristan Harris, TED Talk, 2017
5	From House to Home	<ol style="list-style-type: none">1. "What Makes a Good Life? Lessons from the Longest Study on Happiness", R. Waldinger, Ted Talks, 20152. Long Walk To Freedom, Nelson Mandela, Back Bay Books, 19953. Outliers, Malcolm Gladwell, Back Bay Books, 2011
6	Soft Skills	<ol style="list-style-type: none">1. The 17 Indisputable Laws of Teamwork, John Maxwell, HarperCollins, 20132. Team of Teams: New Rules of Engagement for a Complex World, Stanley McChrystal, Portfolio, 20153. Predictably Irrational, Revised and Expanded Edition: The Hidden Forces That Shape Our Decisions, <u>Dan Ariely</u>, Harper Perennial, 2010
7	Selfless Service	<ol style="list-style-type: none">1. Open: An Autobiography, Andre Agassi, Vintage, 10 August 20102. 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]



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		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]
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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.



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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 C	Examination Marks				Total Marks
L	T	P		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	<p>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.</p> <p>Multicomponent distillation : key components, minimum and total reflux, short cut method: FUG (Fenske-Underwood-Gilliland) method, Rigorous methods: Lewis-Matheson calculations, Thiele and Geddes method, etc.</p>	26
2	<p>Humidification Operations:</p> <p>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. Psychrometric chart & Psychrometric relations for air-water system, adiabatic saturation curves, wet bulb temperature theory, Lewis relation, Adiabatic operations, cooling towers.</p>	11
3	<p>Adsorption and Ion exchange:</p> <p>Adsorption: Definitions and industrial applications, Types of adsorption, nature of</p>	13



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	commonly used adsorbents, Adsorption Equilibria, Single gases and vapors, Adsorption hysteresis, 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_{t0G} and H_{t0G} , 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 Harker, 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



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Subject Code: 3160501

	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
L	T	P		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	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



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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



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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.



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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/>



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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 C	Examination Marks				Total Marks
L	T	P		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



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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' 7th Edition 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



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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 permeation 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



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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 C	Examination Marks				Total Marks
L	T	P		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



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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, 2nd Edition, Khanna Publishers, Delhi, 1998



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- George Austin, Shreve's Chemical Process Industries, 5th edition McGraw Hill publication –New Delhi.
- W.L.Nelson, Petroleum Refinery Engineering, McGraw Hill, New York, 1958.
- James H, Gary & Glenn E. Handwerk, ' Petroleum Refining, Technology & Economics', 4th Edition, Marcel Dekker, Inc, 2001.
- Speight, J. G., The Chemistry and technology of Petroleum, 5th Edition, M. Dekker, 1991.
- 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 Ramsbottom 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 Saybolt 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 Abel'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:

- Pensky Martin apparatus
- Cleveland Flash and Fire Point Apparatus:



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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 C	Examination Marks				Total Marks
L	T	P		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: 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 properties Functionality principle, Theory of polymer solutions: solubility parameter, Mark-Houwink-Sakurada 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



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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, Ferdinand & 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)



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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
L	T	P		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	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



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Bachelor of Engineering

Subject Code: 3160512

	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



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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_{La} 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
L	T	P		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	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



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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.



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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 Publishing 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		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	%weight age
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



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	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
CO-4	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 C	Examination Marks				Total Marks
L	T	P		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



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	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.



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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		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.



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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 C	Examination Marks				Total Marks
L	T	P		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



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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
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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)



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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**



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- 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 C	Examination Marks				Total Marks
L	T	P		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	Process design of Piping and Pumps: Introduction, Process design of piping, NPSHA & NPSHR, 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



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Subject Code: 3170502

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 N_{toG} , H_{toG} & 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



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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- Heinemann, 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, 2ndEdn., 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.



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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 C	Examination Marks				Total Marks
L	T	P		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	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



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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.



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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 transshipment 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 C	Examination Marks				Total Marks
L	T	P		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	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.



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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.



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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 C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
			ESE (E)	PA (M)	ESE (V)	PA (I)		
3	0	0	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



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering

Subject Code: 3170510

	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 NO _x , 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



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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 C	Examination Marks				Total Marks
L	T	P		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 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 C	Examination Marks				Total Marks
L	T	P		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



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Bachelor of Engineering

Subject Code: 3170512

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



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3170512

CO-4	apply CFD simulation for design of equipments and operations	30
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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 knowledge 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 C	Examination Marks				Total Marks
L	T	P		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 : 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

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Bachelor of Engineering

Subject Code: 3170513

	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-Jeeves 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



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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



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Bachelor of Engineering

Subject Code: 3170513

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 plates 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
L	T	P		Theory Marks		Practical Marks		
			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



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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, Elsevier, 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:



GUJARAT TECHNOLOGICAL UNIVERSITY

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Subject Code: 3170514

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 C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				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



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	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, Elsevier, 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



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering

Subject Code: 3170515

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 C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				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



GUJARAT TECHNOLOGICAL UNIVERSITY

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Subject Code: 3170516

	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



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering

Subject Code: 3170516

	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 C	Examination Marks				Total Marks	
L	T	P		Theory Marks		Practical Marks			
			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)



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering

Subject Code: 3180501

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>


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TEACHING SCHEME / DETAIL SYALLBUS

Course: Branch: Sem/Year: Effective From:

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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 Chandkheda, Ahmedabad – 382424 - Gujarat

079-23267521/570

info@gtu.ac.in , registrar@gtu.ac.in

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TEACHING SCHEME / DETAIL SYALLBUS

BE 05 - CHEMICAL ENGINEERING 12018-19 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	Hours			Total	Credit				Total
							L.	T.	P.		E	M	I	V	
+	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



TEACHING SCHEME / DETAIL SYALLBUS

BE ▾ 05 - CHEMICAL ENGINEERING ▾ 5 ▾

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

Exp.	Subcode	Branch code	Eff_from	SubjectName	Category	Sem /Year	Hours			Total	Credit				Total
							L.	T.	P.		E	M	I	V	
+	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



TEACHING SCHEME / DETAIL SYALLBUS

BE 05 - CHEMICAL ENGINEERING 62018-19 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

Exp.	Subcode	Branch code	Eff_from	SubjectName	Category	Sem /Year	Hours			Total	Credit				Total
							L.	T.	P.		E	M	I	V	
+	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



TEACHING SCHEME / DETAIL SYALLBUS

BE 05 - CHEMICAL ENGINEERING 72018-19 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	Hours			Total	Credit				Total
							L.	T.	P.		E	M	I	V	
+	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



TEACHING SCHEME / DETAIL SYALLBUS

BE ▾ 05 - CHEMICAL ENGINEERING ▾ 4 ▾

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

Exp.	Subcode	Branch code	Eff_from	SubjectName	Category	Sem /Year	Hours			Credit		Max Marks			
							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



TEACHING SCHEME / DETAIL SYALLBUS

BE 05 - CHEMICAL ENGINEERING 8

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

Exp.	Subcode	Branch code	Eff_from	SubjectName	Category	Hours			Credit				Max Marks		
						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 C	Examination Marks				Total Marks
Th	Tut	Lab		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	%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 T_c , P_c and V_c	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. Litchenthaler, 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 NANOTECHNOLOGY 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 nanotechnology 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
Th	Tut	Lab		Theory Marks		Practical Marks		
			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, Field 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 Kunii 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 C	Examination Marks				Total Marks
L	T	P		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 - Wheeler's 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, propagation 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		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.	<p>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</p>		
2.	<p>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</p>		
3.	<p>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</p>		
4.	<p>Unit 4: Synthesis of Separation Trains Criteria for selection of separation methods, selection of equipment: Absorption, Liquid-liquid extraction Membrane separation, adsorption, leaching, drying, crystallization, Ideal distillation -</p>		

	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.Loeb - 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 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		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, Geometric 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, Regula-falsi method and Wegstein 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 C	Examination Marks				Total Marks
L	T	P		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		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 Training-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		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 C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				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



GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering

Subject Code - 3723024

	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.



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Master of Engineering
Subject Code - 3723024

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 C	Examination Marks				Total Marks
L	T	P		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

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Master of Engineering

Subject Code: 3723023

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 C	Examination Marks				Total Marks
L	T	P		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



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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, 5th 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.
6. 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.



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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 C	Examination Marks				Total Marks
L	T	P		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.	



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Subject Code: 3723021

6	X-ray Diffraction studies Principles and applications, Various Microscopic analysis such 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 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 microgram	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		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 K_{La} , 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	



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Master of Engineering

Subject Code: 3723020

	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 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 C	Examination Marks				Total Marks
L	T	P		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	% 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	14	27%



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Subject Code: 2733007

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.



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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



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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 C	Examination Marks				Total Marks
L	T	P		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	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 smoothed equation of changes and time smoothed 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



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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-Poiseuille 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-Poiseuille 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



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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 C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
			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.



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Master of Engineering

Subject Code: 3723009

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
L	T	P		Theory Marks		Practical Marks		
				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		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 Training-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		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 C	Examination Marks				Total Marks
L	T	P		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



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Master of Engineering

Subject Code: 3733011

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
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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 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		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 dew point calculation, phase equilibria, Vapour-liquid equilibria, Liquid phase activity coefficients, K-values, Liquid phase activity coefficients, K-values, Liquid-Liquid equilibria, 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



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Subject Code: 3733010

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 Sheetting", 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



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Subject Code: 3733010

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



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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 C	Examination Marks				Total Marks
L	T	P		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
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.



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Master of Engineering

Subject Code: 3733009

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		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-Sakurada 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



GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering (Chemical Engineering-30)

Subject Code: 3733008

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, Ferdinand & 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 C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				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



GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering

Subject Code: 3730009

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 C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				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
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GUJARAT TECHNOLOGICAL UNIVERSITY

Master of Engineering

Subject Code:3730007

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. Pannarselvam, 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 Linear 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 Government Engineering College
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 motions of tall buildings”, International Conference on Tall buildings, Rio De Janeiro, 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. Pelzar MJ., 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 $\leq 30\%$. **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 in (Branch Name) by Gujarat Technological University.

[GTU Logo Watermark]

Date :

Place :

Examiner's Sign and Name:

(_____)

(_____)

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

(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

Winners of : ICT Enabled University Award E-India - 2009 ❖ Manthan Award - 2009 ❖ GESIA Award - 2011
❖ Digital Learning WES - 2011 Award ❖ AIMS International Innovative University Award - 2013

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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)

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

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