UG-R22 Curriculum
With effective from 2022-23

Chemical Engineering

Scheme of Instruction and Syllabi of
B.Tech I to VIII Semester of
Four Year Degree Course

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY
(An Autonomous Institute | Affiliated to Osmania University)
Accreditated by NBA & NAAC (A++)
Kokapet Village, Gandipet Mandal, Hyderabad -500075, Telanagana.
E-mail: principal@cbit.ac.in, Website: www.cbit.ac.in
Phone No. : 040-24193276 / 277 / 279

SCHEME OF INSTRUCTION AND SYLLABI
Of
B.E. / B.TECH. I to VIII SEMESTERS

FOR

B.TECH. CHEMICAL ENGINEERING

(Inline with AICTE Model Curriculum with effect from AY 2022-23)

(R–22 Regulation)

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

Affiliated to OU, Approved by AICTE, Accredited by NBA, NAAC (A++)

Kokapet Village, Gandipet Mandal, Hyderabad– 500 075. Telangana

E-Mail: principal@cbit.ac.in; Website: www.cbit.ac.in;

Phone Nos.: 040-24193276 / 277 / 279

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (AUTONOMUS)

DEPARTMENT OF CHEMICAL ENGINEERING

VISION & MISSION OF THE INSTITUTE

Institute Vision

To be a center of excellence in Technical Education and Research

Institute Mission

To address the emerging needs through quality technical education and advanced research

DEPARTMENT VISION & MISSION

Department Vision

To become the most sought center of excellence engaged in training and shaping students as professionals for higher education and process industries both in India and abroad and allow the students to do R & D projects and publish same in the reputed journals.

Department Mission

Imparting contemporary technical education and training manpower to create a skilled human resource talent pool to serve, manage the process industries globally with a sense of responsibility towards society and the environment.

Program Educational Objectives (PEOs)

PEO1: To train the students for identifying problems relevant to design and general practice of chemical engineering field.
PEO2: To provide experience in the three significant design areas of equipment, process and plant operation of chemical industries.
PEO3: To educate the students in understanding the multifaceted aspects of chemical engineering and in applying the various computational methods studied, for problem analysis and solution.
PEO4: To prepare the students to pursue post graduate studies or to succeed in industry / technical profession through global technical education

Program Outcomes (POs)

PO1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and engineering specialization for solving complex engineering problems
PO2	**Problem analysis**: Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling to complex engineering activities, with an understanding of the limitations.
PO6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and normsof the engineering practice.
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with t h e society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSO)

PSO1	Undertake research activities in the area of heat and mass transfer, separation processes, Reaction engineering, related to Green Chemical Engineering.
PSO2	Undertake real life projects in process industries and allied fields.

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

Scheme of Instructions of I Semester of B.Tech. – Chemical Engineering
(In line with AICTE Model Curriculum with effect from AY 2022-23)

DEPARTMENT OF CHEMICAL ENGINEERING

SEMESTER – I

S. No	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours per Week			SEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1	22MTC02	Calculus	3	1	-	3	40	60	4
2	22CYC01	Chemistry	3	0	-	3	40	60	3
3	22EEC01	Basic Electrical Engineering (BEE)	2	1	-	3	40	60	3
4	22CSC01	Problem Solving andProgramming	2	1	-	3	40	60	3
PRACTICAL									
5	22CYC02	Chemistry Lab	-	-	3	3	50	50	1.5
6	22MBC02	Community Engagement	-	-	3	3	50	-	1.5
7	22CSC02	Problem Solving andProgramming Lab	-	-	3	3	50	50	1.5
8	22MEC37	Robotics & Drones Lab	-	2	2	4	100	-	3
9	22EEC02	Basic Electrical Engineering Lab	-	-	2	3	50	50	1
TOTAL			**10**	**5**	**13**				**21.5**

L: Lecture **T: Tutorial** **D: Drawing** **P: Practical**

CIE - Continuous Internal Evaluation **SEE - Semester End Examination**

22MTC02 **CALCULUS**
(CHEMICAL)

Instruction	3 L+1T Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	4

COURSE OBJECTIVES: This course aims to
1. To explain the solutions of system of linear equations by Matrix Methods.
2. To discuss mean value theorems.
3. To explain the Partial Derivatives and the extreme values of functions of two variables.
4. To explain the shape of curves, their areas and volumes of revolutions.
5. To discuss the convergence and divergence of the series.

COURSE OUTCOMES: After the completion of this course, the student will be able to
1. Apply the Matrix Methods to solve the system of linear equations.
2. Analyze the geometrical interpretation of Mean value theorems and curvature.
3. Determine the extreme values of functions of two variables.
4. Find the shape of the curve, surface areas and volumes of revolution.
5. Examine the convergence and divergence of infinite Series.

CO-PO Articulation Matrix:

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	3	3	3	-	-	-	-	-	-	-	2
CO 2	3	3	3	3	-	-	-	-	-	-	-	2
CO 3	3	3	3	3	-	-	-	-	-	-	-	2
CO 4	3	3	3	3	-	-	-	-	-	-	-	2
CO 5	3	3	3	1	-	-	-	-	-	-	-	1

UNIT-I
Matrices: Rank of a matrix, Echelon form, consistency of linear system of equations, Linear dependence and independence of vectors. Eigen values, Eigenvectors, Properties of Eigen values and Eigen vectors, Cayley Hamilton theorem, Quadratic form, Reduction of quadratic form to canonical form by linear transformation, Nature of quadratic form.

UNIT-II
Calculus: Rolle's Theorem, Lagrange's Mean value theorem, Cauchy's Mean value theorem (without proofs). Curvature, Radius of curvature, Centre of curvature, Evolute and Involute, Envelopes.

UNIT-III
Partial Differentiation and Its Applications: Functions of two or more variables, Partial derivatives, Higher order partial derivatives, Total derivative, Differentiation of implicit functions, Jacobians, Taylor's expansion of functions of two variables, Maxima and minima of functions of two variables.

UNIT-IV
Applications of definite integrals: Curve tracing of standard curves (Cartesian only), Applications of definite integrals to evaluate length of curves, surface areas and volumes of revolutions.

UNIT-V

Sequences and Series: Convergence of sequence and series. Tests for convergence of series: Comparison test, limit comparison test, D'Alembert's ratio test, Raabe's test, Cauchy's root test, Alternating series, Leibnitz's series, absolute and conditional convergence**.**

TEXTBOOKS:

1. B.S.Grewal, "Higher Engineering Mathematics", 44th Edition, Khanna Publishers, 2017.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", 9th Edition, John Wiley & Sons, 2006.

SUGGESTED READING:

1. B.V.Ramana., "Higher Engineering Mathematics", 11th Reprint, Tata McGraw-Hill, New Delhi, 2010.
2. R.K.Jain, S.R.K.Iyengar, "Advanced Engineering Mathematics", 5th edition, Narosa Publications, 2016.
3. David.Poole, "Linear Algebra: A Modern Introduction", 2nd Edition, Brooks/ Cole, 2005.

22CYC01

CHEMISTRY
(CHEMICAL)

Instruction:	3L Hours per Week
Duration of Semester End Examination:	3 Hours
Semester End Examination:	60 Marks
Continuous Internal Evaluation:	40 Marks
Credits:	3

COURSE OBJECTIVES: This course aims to

1. This syllabus helps at providing the concepts of chemical bonding and chemical kinetics to the students aspiring to become practicing engineers
2. Thermodynamic and Electrochemistry units give conceptual knowledge about processes and how they can be producing electrical energy and efficiency of systems.
3. To teach students the value of chemistry and to improve the research opportunities knowledge of stereochemistry and organic reactions is essential.
4. Water chemistry unit impart the knowledge and understand the role of chemistry in the daily life.
5. New materials lead to discovering of technologies in strategic areas for which an insight into Polymers, nanomaterials and basic drugs of modern chemistry is essential.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Identify microscopic chemistry in terms of molecular orbitals, intermolecular forces and rate of chemical reactions.
2. Discuss the properties and processes using thermodynamic functions, electrochemical cells and their role in batteries and fuel cells.
3. Illustrate the major chemical reactions that are used in the synthesis of organic molecules.
4. Classify the various methods used in the treatment of water for domestic and industrial use.
5. Outline the synthesis of various Engineering materials & Drugs.

CO-PO Articulation Matrix

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	2	-	-	2	2	-	-	-	-	2
CO 2	3	2	2	-	-	2	2	-	-	-	-	2
CO 3	3	2	3	-	-	2	2	-	-	-	-	2
CO 4	3	2	3	-	-	2	2	-	-	-	-	2
CO 5	3	2	2	-	-	2	2	-	-	-	-	2

UNIT-I

Atomic and molecular structure and Chemical Kinetics: Atomic and molecular structure: Molecular Orbital theory - atomic and molecular orbitals. Linear combination of atomic orbitals (LCAO) method. Molecular orbitals of diatomic molecules. Molecular Orbital Energy level diagrams (MOED) of diatomic molecules & molecular ions (H_2, He_2^+, N_2 , O_2 , O_2^- , CO, NO). Pi- molecular orbitals of benzene and its aromaticity.

Chemical Kinetics: Introduction, Terms involved in kinetics: rate of reaction, order & molecularity; First order reaction-Characteristics: units of first order rate constant & its half-life period, second order reaction-Characteristics: units of second order rate constant & its half- life period. Numericals.

UNIT-II

Use of free energy in chemical equilibria: Use of free energy in chemical equilibria: Thermodynamic functions: Internal energy, entropy and free energy. Significance of entropy and free energy (criteria of spontaneity). Free energy and emf (Gibbs Helmholtz equations and its applications). Cell potentials, electrode potentials, and – Reference electrodes (NHE, SCE) electrochemical series. Nernst equation and its applications. Determination of pH using combined Glass & Calomel electrode. Potentiometric Acid base & Redox Titrations. Numericals.

Battery technology: Rechargeable batteries & Fuel cells.

Lithium batteries: Introduction, construction, working and applications of Li-MnO_2 and Li-ion batteries.

Fuel Cells: Introduction, difference between conventional cell and fuel cell, limitations & advantages. Construction, working & applications of methanol-oxygen fuel cell.

UNIT- III

Stereochemistry and Organic reactions: Stereochemistry: Representations of 3 dimensional structures, Types of stereoisomerism- Conformational isomerism – confirmations of n-butane (Newman and sawhorse representations), Configurational isomerism -Geometrical (cis-trans) isomerism & Optical isomerism- optical activity, Symmetry and chirality: Enantiomers (lactic acid)&Diastereomers (Tartaric acid), Absolute configurations, Sequence rules for R&S notation.

Types of Organic reactions: Substitution Reactions- Electrophilic substitution (Nitration of Benzene); Nucleophilic Substitution (S_N1& S_N2); Free Radical Substitution (Halogenation of Alkanes)

Addition Reactions: Electrophilic Addition – Markonikoff's rule, Free radical Addition - Anti Markonikoff's rule (Peroxide effect), Nucleophilic Addition – (Addition of HCN to carbonyl compounds)

Eliminations-E1 and E2 (dehydrohalogenation of alkyl halides), Cyclization (Diels - Alder reaction)

UNIT–IV

Water Chemistry: Hardness of water – Types, units of hardness, Disadvantages of hard water, Alkalinity and Estimation of Alkalinity of water, Boiler troubles - scales & sludge formation, causes and effects, Softening of water by lime soda process (Cold lime soda process), ion exchange method and Reverse Osmosis. Specifications of potable water & industrial water. Disinfection of water by Chlorination; break point chlorination, BOD and COD definition, Estimation (only brief procedure) and significance, Numericals.

UNIT-V

Engineering Materials and Drugs: Introduction, Terms used in polymer science; Thermoplastic polymers (PVC) &Thermosetting polymers (Bakelite); Elastomers (Natural rubber). Conducting polymers- Definition, classification and applications.

Polymers for Electronics: Polymer resists for integrated circuit fabrication, lithography and photolithography

Nano materials-Introduction to nano materials and general applications, basic chemical methods of preparation-Sol-gel method. Carbon nanotubes and their applications. Characterisation of nanomaterials by SEM and TEM (only Principle).

Drugs-Introduction, Synthesis and uses of Aspirin (analgesic), Paracetamol (Antipyretic), Atenolol (antihypertensive).

TEXT BOOKS

1. P.C. Jain and M. Jain, "Engineering Chemistry", Dhanpat Rai Publishing Company Ltd., New Delhi,16th edition (2015).
2. W.U. Malik, G.D.Tuli and R.D.Madan, "Selected topics in Inorganic Chemistry", S Chand & Company Ltd, New Delhi, reprint (2009).
3. R.T. Morrison, R.N. Boyd and S.K. Bhattacharjee, "Organic Chemistry", Pearson,Delhi, 7thedition(2019).
4. A Textbook of Polymer Science and Technology , Shashi Chawla ,Dhanpat Rai & Co. (2014)
5. T. Pradeep, Nano: The Essentials, Tata McGraw-Hill Education, Delhi, 2012
6. G.L. David Krupadanam, D. Vijaya Prasad, K. Varaprasad Rao, K.L.N. Reddy and C.Sudhakar, "Drugs", Universities Press (India) Limited, Hyderabad (2007).

SUGGESTED READINGS

1. B. H. Mahan, "University Chemistry", Narosa Publishing house, New Delhi, 3rd edition (2013).
2. B.R. Puri, L.R. Sharma and M.S. Pathania, "Principles of Physical Chemistry", S. Nagin Chand & Company Ltd., 46th edition(2013).
3. T.W. Graham Solomons, C.B. Fryhle and S.A. Snyder, "Organic Chemistry", Wiley,12th edition (2017).
4. P.W. Atkins, J.D. Paula, "Physical Chemistry", Oxford, 8th edition (2006).

22EEC01

BASIC ELECTRICAL ENGINEERING

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES: This course aims to

1. To understand the behaviour of different circuit elements R, L & C, and the basic concepts of electrical AC circuit analysis
2. To comprehend the basic principle of operation of AC and DC machines
3. To infer about different types of electrical wires and cables, domestic and industrial wiring, safety rules and methods of earthing.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Understand the concepts of Kirchhoff's laws and their application various theorems to get solution of simple dc circuits.
2. Predict the steady state response of RLC circuits with AC single phase/three phase supply.
3. Infer the basics of single phase transformer
4. Describe the construction, working principle of DC machine and 3-phase Induction motor.
5. Acquire the knowledge of electrical wires, cables, earthing, Electrical safety precautions to be followed in electrical installations and electric shock and its safety and energy calculations.

CO-PO-PSO Matrix

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO-1	3	3	2	-	-	-	-	-	1	2	-	3
CO-2	3	3	2	-	-	-	-	-	1	2	-	3
CO-3	3	3	2	1	-	-	-	-	1	2	-	3
CO-4	2	1	-	-	-	-	-	-	1	2	-	3
CO-5	2	-	2	-	-	-	-	-	1	2	-	3

UNIT-I

DC Circuits: Electrical circuit elements (R,L and C), voltage and current sources, Kirchhoff current and voltage laws, analysis of simple circuits with dc excitation, Superposition, Thevenin's and Norton's Theorems.

UNIT-II

AC Circuits: Representation of sinusoidal waveforms, peak and RMS values, phasor representation, real power, reactive power, apparent power, power factor, Analysis of single-phase ac circuits consisting of R, L, C, series RL and RC. Three phase balanced circuits, voltage and current relations in star and delta connections.

UNIT-III

Single Phase Transformer: Construction, Working principle, EMF Equation, Ideal and Practical transformer, Equivalent circuit of Transformer, OC and SC tests on a transformer, Efficiency and Regulation

UNIT-IV

DC and AC Machines: DC Generators: Construction, Principle of operation, EMF equation, Classification, Characteristics of shunt generators. DC Motors: Classification, Torque Equation, Characteristics and Speed control of DC Shunt and Series Motors, Losses and efficiency Three - Phase Induction Motors: Principle of operation, Applications

UNIT-V

Electrical Installations: Electrical Wiring: Types of wires and cables, Electrical Safety precautions in handling electrical appliances, electric shock, and first aid for electric shock, safety rules. Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, Earthing (Elementary Treatment only), Elementary calculations for energy consumption

TEXT BOOKS:

1. L. S. Bobrow, Fundamentals of Electrical Engineering, Oxford University Press, 2011.
2. E. Hughes, Electrical and Electronics Technology, Pearson, 2010.

SUGGESTED READING:

1. D. P. Kothari & I. J. Nagrath, “Basic Electrical Engineering”, Tata McGraw Hill, 2010.
2. V. D. Toro, “Electrical Engineering Fundamentals”, Prentice Hall India, 1989
3. D.C. Kulshreshtha, “Basic Electrical Engineering”, McGraw Hill, 2009
4. P.V. Prasad, S. Sivanagaraju, R. Prasad, "Basic Electrical and Electronics Engineering" Cengage Learning, 1st Edition, 2013

22CSC01

PROBLEM SOLVING AND PROGRAMMING

Instruction	2L + 1T Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES: This course aims to

1. Develop logical skills and basic technical skills so that students should be able to solve basic computational problems.
2. Learn any basic programming language.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Understand real world problems and develop computer solutions for those problems.
2. Understand the basics of Python.
3. Apply Python for solving basic programming solutions.
4. Create algorithms/flowcharts for solving real-time problems.
5. Build and manage dictionaries to manage data.
6. Handle data using files.

CO-PO-PSO Matrix

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12
1	3	1	1	-	1	-	-	-	-	-	-	1
2	3	1	1	-	1	-	-	-	-	-	-	1
3	3	1	1	-	1	-	-	-	-	-	-	1
4	3	1	1	-	1	-	-	-	-	-	-	1
5	3	1	1	-	1	-	-	-	-	-	-	1
6	3	1	1	-	1	-	-	-	-	-	-	1

UNIT I

Introduction to Programming - *Evolution of languages*: Machine, Assembly and High-level languages. *Software requirements for programming*: OS, compiler, linker, loader, editor. Design specification: Algorithms and Flowcharts.

UNIT II

Data Types and Operators, Variable, Sequences and Iteration - Data types, Expressions, Precedence Rules, Operators: arithmetic, relational, logical, bit-wise and miscellaneous operators; local variable, global variables, List, String, Tuples, Sequence mutation and accumulating patterns.

UNIT III

Conditional Statement, Loops, Arrays and Strings, user-defined Data Types - if..else, for, while, nested iteration, Concept and use of arrays, declaration and usage of arrays, 2-dimensional arrays, different types of user defined data types.

UNIT IV

Dictionaries and Dictionary Accumulation, Functions/Methods - Dictionary basics, operations, methods, accumulation, advantages of modularizing program into functions, function definition and function invocation. Positional parameters passing arrays to functions, recursion, library functions.

UNIT V

File Handling and Memory Management - Concepts of files and basic file operations, writing/reading data to/from a .csv file, Memory Management Operations.

TEXT BOOKS AND REFERENCES:

1. R.S. Salaria, "Programming for Problem Solving", First Edition, Khanna Book Publishing Co., Delhi.
2. Jeeva Jose, "Taming Python by Programming", Revised Edition, Khanna Book Publishing Co., Delhi.
3. Mark Lutz, "Learning Python", 5th Edition, O'Reilly Media, Inc.
4. Python Crash Course: A Hands-On, Project-Based Introduction to Programming by Eric Matthes, No Starch Press.
5. "Programming in Python", R.S. Salaria, Khanna Book Publishing Co., Delhi.

NPTEL/SWAYAM COURSE:

1. Introduction to Problem Solving and Programming, Video Lectures, Prof. D Gupta, IIT Delhi.
2. Problem Solving Aspects and Python Programming, Dr. S Malinga, Dr Thangarajan, Dr. S V Kogilavani, Kongu Engineering College.
3. https://www.coursera.org/specializations/python-3-programming

22CYC02

CHEMISTRY LAB
(CHEMICAL)

Instruction:	3P Hours per Week
Duration of Semester End Examination:	3 Hours
Semester End Examination:	50 Marks
Continuous Internal Evaluation:	50 Marks
Credits:	1.5

COURSE OBJECTIVES: This course aims to

1. To impart fundamental knowledge in handling the equipment / glassware and chemicals in chemistry laboratory.
2. To provide the knowledge in both qualitative and quantitative chemical analysis
3. The student should be conversant with the principles of volumetric analysis
4. To apply various instrumental methods to analyse the chemical compounds and to improve understanding of theoretical concepts.
5. To interpret the theorical concepts in the preparation of new materials like drugs and polymers.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Identify the basic chemical methods to analyse the substances quantitatively & qualitatively.
2. Estimate the amount of chemical substances by volumetric analysis.
3. Determine the rate constants of reactions from concentration of reactants/ products as a function of time.
4. Calculate the concentration and amount of various substances using instrumental techniques.
5. Develop the basic drug molecules and polymeric compounds.

CO-PO Articulation Matrix

PO/PSO CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	2	-	-	2	2	-	-	-	-	2
CO 2	3	2	1	-	-	1	2	-	-	-	-	2
CO 3	3	2	3	-	-	2	2	-	-	-	-	2
CO 4	3	2	2	-	-	2	2	-	-	-	-	2
CO 5	3	2	3	-	-	2	2	-	-	-	-	2

LIST OF EXPERIMENTS:

1. Introduction: Preparation of standard solution of oxalic acid and standardisation of NaOH.
2. Estimation of metal ions (Co^{+2} & Ni^{+2}) by EDTA method.
3. Estimation of temporary and permanent hardness of water using EDTA solution
4. Determination of Alkalinity of water
5. Determination of rate constant for the reaction of hydrolysis of methyl acetate. (first order)
6. Determination of rate constant for the reaction between potassium per sulphate and potassium Iodide. (second order)
7. Estimation of amount of HCl Conductometrically using NaOH solution.
8. Estimation of amount of HCl and CH_3COOH present in the given mixture of acids Conductometrically using NaOH solution.
9. Estimation of amount of HCl Potentiometrically using NaOH solution.
10. Estimation of amount of Fe^{+2} Potentiometrically using $KMnO_4$ solution
11. Preparation of Nitrobenzene from Benzene.
12. Synthesis of Aspirin drug and Paracetamol drug.
13. Synthesis of phenol formaldehyde resin.

TEXT BOOKS

1. J. Mendham and Thomas , "Vogel's text book of quantitative chemical analysis", Pearson education Pvt.Ltd. New Delhi ,6th ed. 2002.
2. Senior practical physical chemistry by B.D.Khosla, V.C.Garg & A.Gulati,; R. Chand & Co. : New Delhi (2011).

SUGGESTED READINGS

1. Dr. Subdharani , "Laboratory Manual on Engineering Chemistry", Dhanpat Rai Publishing, 2012.
2. S.S. Dara , "A Textbook on experiment and calculation in engineering chemistry", S.Chand and Company, 9th revised edition, 2015.

22MBC02 **COMMUNITY ENGAGEMENT**

Instruction	3P Hours per week
SEE	Nil
CIE	50 Marks
Credits	1.5

COURSE OBJECTIVES: This course aims to

1. Develop an appreciation of Rural culture, life-style and wisdom among the Students.
2. Learn about the various livelihood activities that contribute to Rural economy.
3. Familiarize the Rural Institutions and the Rural Development Programmes in India.

COURSE OUTCOMES: After the completion of this Course, Student will be able to

1. Gain an understanding of Rural life, Culture and Social realities.
2. Develop a sense of empathy and bonds of mutuality with Local Communities.
3. Appreciate significant contributions of Local communities to Indian Society and Economy.
4. Exhibit the knowledge of Rural Institutions and contributing to Community's Socio-Economic improvements.
5. Utilize the opportunities provided by Rural Development Programs.

Module I Appreciation of Rural Society

Rural life style, Rural society, Caste and Gender relations, Rural values with respect to Community, Nature and Resources, elaboration of 'soul of India lies in villages' (Gandhi), Rural Infrastructure.

Module II Understanding Rural Economy and Livelihood

Agriculture, Farming, Landownership, Water management, Animal Husbandry, Non-farm Livelihood and Artisans, Rural Entrepreneurs, Rural markets, Rural Credit Societies, Farmer Production Organization/Company.

Module III Rural Institutions

Traditional Rural organizations, Self-Help Groups, Panchayati Raj Institutions (Gram Sabha), Gram Panchayat, Standing Committees, Local Civil Society, Local Administration.

Module IV Rural Development Programmes

History of Rural Development in India, Current National Programmes: Sarva Shiksha Abhiyan, Beti Bhachao, Beti Padhao, Ayushman, Bharat, Swachh Bharat, PM Awas Yojana, Skill India, Gram Panchayat Decentralised Planning, NRLM, MNREGA etc.

TEXT BOOKS:

1. Singh, Katar, Rural Development: Principles, Policies and Management, Sage Publications, New Delhi, 2015.
2. A Hand book on Village Panchayat Administration, Rajiv Gandhi Chair for Panchayati Raj Studies, 2002.
3. United Nations, Sustainable Development Goals, 2015, un.org/sdgs
4. M.P Boraia, Best Practices in Rural Development, Shanlax Publishers, 2016.

Journals:

1. Journal of Rural development (published by NIRD & PR, Hyderabad).
2. Indian Journal of Social Work, (by TISS, Bombay).
3. Indian Journal of Extension Educations (by Indian Society of Extension Education).
4. Journal of Extension Education (by Extension Education Society).
5. Kurukshetra (Ministry of Rural Development, GOI).
6. Yojana (Ministry of Information & Broadcasting, GOI).

22CSC02 `PROBLEM SOLVING AND PROGRAMMING LAB

Instruction	3P Hours per week
Duration of SEE	3 Hours
SEE	50 Marks
CIE	50 Marks
Credits	1.5

COURSE OBJECTIVES: This course aims to

1. Master the fundamentals of writing Python scrips.
2. Learn Python elements such as variables, flow controls structures, and functions.
3. Discover how to work with lists and sequence data, and files.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Understand various Python program development Environments.
2. Demonstrate the concepts of Python.
3. Implement algorithms/flowcharts using Python to solve real-world problems.
4. Build and manage dictionaries to manage data.
5. Write Python functions to facilitate code reuse.
6. Use Python to handle files and memory.

CO-PO-PSO Matrix

PO/PSO CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
1	3	2	1	-	-	-	-	-	-	-	-	1
2	3	3	2	2	3	-	-	-	-	-	-	1
3	2	3	3	2	3	-	-	-	-	-	-	1
4	2	3	3	2	2	-	-	-	-	-	-	1
5	2	3	3	3	3	-	-	-	-	-	-	1
6	2	3	3	3	3	-	-	-	-	-	-	1

Laboratory / Practical Experiments:

1. Explore various Python Program Development Environments.
2. Demonstration of input/output operations.
3. Demonstration of operators.
4. Demonstration of selective control structures.
5. Demonstration of looping control structures.
6. Demonstration of List, Tuple and Set
7. Demonstration of Python Dictionaries.
8. Implementation of searching and sorting techniques.
9. Implementation of string manipulation operations.
10. File handling and memory management operations.

Text Books and References:

1. R.S. Salaria, “Programming for Problem Solving”, First Edition, Khanna Book Publishing Co., Delhi.
2. Jeeva Jose, “Taming Python by Programming”, Revised Edition, Khanna Book Publishing Co., Delhi.
3. Mark Lutz, “Learning Python”, 5th Edition, , O'Reilly Media, Inc.,
4. Python Crash Course: A Hands-On, Project-Based Introduction to Programming by Eric Matthes, No Starch Press.
5. “Programming in Python”, R.S. Salaria, Khanna Book Publishing Co., Delhi.

NPTEL/SWAYAM Course:

1. Introduction to Problem Solving and Programming, Video Lectures, Prof. D Gupta, IIT Delhi.
2. Problem Solving Aspects and Python Programming, Dr. S Malinga, Dr Thangarajan, Dr. S V Kogilavani, Kongu Engineering College.
3. https://www.coursera.org/specializations/python-3-programming.

22MEC37

ROBOTICS AND DRONES LAB

(Common to All Branches)

Instruction	2T + 2P Hours per week
CIE	100 Marks
Credits	3

COURSE OBJECTIVES: This course aims to

1. To develop the students' knowledge in various robot and drone structures and their workspace.
2. To develop multidisciplinary robotics that have practical importance by participating in robotics competitions
3. To develop students' skills in performing spatial transformations associated with rigid body motions, kinematic and dynamitic analysis of robot systems.
4. Through projects done in lab, increase the true hands-on student learning experience and enhance their conceptual understanding, increase students' ability, competence and teamwork skills on dealing with real-life engineering problems

COURSE OUTCOMES: After completion of course, students would be able to

1. Demonstrate knowledge of the relationship between mechanical structures of robotics and their operational workspace characteristics
2. Understand mechanical components, motors, sensors and electronic circuits of robots and build robots.
3. Demonstrate knowledge of robot controllers.
4. Use Linux environment for robotic programming.
5. Write Python scripts to control robots using Python and Open CV.

COURSE ARTICULATION MATRIX

PO#/ CO#	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	P0 10	PO 11	PO 12
CO1	3	2	1	1	1	2	1	1	1	2	2	2
CO2	2	3	1	2	3	1	1	1	1	2	2	1
CO3	2	2	2	2	2	1	1	1	1	2	2	2
CO4	2	2	1	2	2	2	1	1	1	2	2	2
CO5	1	1	1	1	1	3	3	3	1	3	3	3

LAB EXPERIMENTS:

1. Assembling of robot mechanical components, mounting of motors, sensors, electronic circuits to the chassis.
2. Connecting to electronic circuitry: motor drivers, incremental encoders proximity sensors, micro controller,
3. Different types of batteries, selection of suitable battery for application, safety precaution.
4. Introduction to Linux Command Line Interface: basic file and directory management and other useful commands
5. Controlling robot using Python: i) Move robot using Python code, ii) Make robot move in patterns using Python
6. Robot programming with Sensor inputs: i) Read sensor data using Python, ii) Visualize sensor data using Python, iii) Code robot to avoid obstacles by using sensor data
7. Open CV: i) Create an Image and display an image; ii) Read and change pixel values; iii) Create colored shapes and save image; iv) Extract the RGB values of a pixel; v) Reading and Writing Videos
8. Open CV: i) Extraction of Regions of Interest; ii) Extraction of RGB values of a pixel

9. Coding robot to work with colors, follow colored objects, identifying shape of the object-oriented
10. Projects: i)Making a line follower robot using a Camera; ii) Writing code for a complex function
11. Assembly of a drone

SUGGESTED READINGS

1. https://www.geeksforgeeks.org/robotics-introduction/
2. https://www.ohio.edu/mechanical-faculty/williams/html/PDF/IntroRob.pdf
3. https://www.idtechex.com/en/research-report/new-robotics-and-drones-2018-2038-technologies-forecasts-players/584
4. https://dronebotworkshop.com/

22EEC02

BASIC ELECTRICAL ENGINEERING LAB

Instruction	2P Hours per week
Duration of Semester End Examination	3 Hours
Semester End Examination	50 Marks
CIE	50 Marks
Credits	1

COURSE OBJECTIVES: This course aims to

1. To acquire knowledge on different types of electrical elements and to verify the basic electrical circuit laws and theorems.
2. To determine the parameters and power factor of a coil, calculate the time and frequency responses of RLC circuits and to familiarize with measurement of electric power & energy.
3. To determine the characteristics of Transformers, dc, ac machines and switch gear components

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Comprehend the circuit analysis techniques using various circuital laws and theorems.
2. Analyse the parameters of the given coil and measurement of power and energy in AC circuits
3. Determine the turns ration/performance parameters of single-phase transformer
4. Infer the characteristics of DC shunt motor different tests.
5. Illustrate different parts and their function of electrical components, equipment and machines.

CO-PO Matrix

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	2	2	-								2
CO 2	3	2	1	-								2
CO 3	3	2	3	-								2
CO 4	3	2	2	-								2
CO 5	3	2	3	-								2

List of Laboratory Experiments/Demonstrations:

1. Verification of KCL and KVL.
2. Verification of Thevenin's theorem.
3. Verification of Norton's theorem.
4. Charging and discharging of Capacitor.
5. Determination of parameters of a choke or coil by Wattmeter Method.
6. Power factor improvement of single-phase AC System.
7. Active and Reactive Power measurement of a single-phase system using
   (i) 3-Ammeter method (ii) 3-Voltmeter method
8. Measurement of 3-Phase Power in a balanced system
9. Calibration of single-phase energy meter.
10. Verification of Turns/voltage ratio of single-phase Transformer.
11. Open Circuit and Short Circuit tests on a given single phase Transformer
12. Brake test on DC Shunt Motor
13. Speed control of DC Shunt Motor
14. Demonstration of Measuring Instruments and Electrical Lab components.
15. Demonstration of Low-Tension Switchgear Equipment/Components
16. Demonstration of cut - out section of Machines like DC Machine, Induction Machine etc.

Note: TEN experiments to be conducted to cover all five Course Outcomes.

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

Scheme of Instructions of II Semester of B.Tech. – Chemical Engineering
(In line with AICTE Model Curriculum with effect from AY 2022-23)

DEPARTMENT OF CHEMICAL ENGINEERING

SEMESTER –II

S. No	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours per Week			SEE in Hours SEE	Maximum Marks		
			L	T	P		CIE	SEE	
THEORY									
1	22MTC05	Vector Calculus and Differential Equations	3	1	-	3	40	60	4
2	22PYC07	Physics	3	0	-	3	40	60	3
3	22CEC01	Engineering Mechanics	3	1	-	3	40	60	4
4	22EGC01	English	2	-	-	3	40	60	2
PRACTICAL									
5	22PYC10	Physics Lab	-	-	3	3	50	50	1.5
6	22EGC02	English lab	-	-	2	3	50	50	1
7	22MEC01	CAD AND DRAFTING	-	1	3	3	50	50	2.5
8	22MEC38	Digital Fabrication Lab	-	-	3	3	50	50	1.5
TOTAL			**11**	**3**	**11**				**19.5**

L: Lecture **T: Tutorial** **D: Drawing** **P: Practical**

CIE - Continuous Internal Evaluation **SEE - Semester End Examination**

22MTC05

VECTOR CALCULUS AND DIFFERENTIAL EQUATIONS (CHEMICAL)

Instruction	3 L+1T per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	4

COURSE OBJECTIVES: This course aims to

1. To explain scalar and vector functions with its Physical interpretations.
2. To discuss vector line, surface and volume integrals.
3. To explain relevant methods to solve first order differential equations.
4. To discuss the solution of higher order Differential Equations
5. To learn Numerical solution of ODE and Engineering problems.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Apply the vector differential operators to Scalars and Vector functions.
2. Solve line, surface & volume integrals by Greens, Gauss and Stoke's theorems.
3. Calculate the solutions of first order linear differential equations.
4. Solve higher order linear differential equations.
5. Find solution of algebraic, transcendental and ODE by Numerical Methods.

CO-PO Articulation Matrix:

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	3	3	3	-	-	-	-	-	-	-	2
CO 2	3	3	3	3	-	-	-	-	-	-	-	2
CO 3	3	3	3	3	-	-	-	-	-	-	-	2
CO 4	3	3	3	3	-	-	-	-	-	-	-	2
CO 5	2	2	2	2	-	-	-	-	-	-	-	1

UNIT-I

Vector Differential Calculus and multiple Integrals: Scalar and Vector point functions, vector operator Del, Gradient, Directional derivative, Divergence, Curl, Del applied twice to point functions, Del applied to product of point functions (vector identities), Irrotational fields and Solenoidal fields, Double integral, Change of order of Integration and Triple integrals.

UNIT-II

Vector Integral Calculus: Line integral, Surface integral and Volume integral. Verification of Green's theorem in a plane (without proof), verification of Stroke's theorem (without proof) and Gauss's divergence theorem (without proof).

UNIT-III

First Order Ordinary Differential Equations: Exact differential equations, Equations reducible to exact equations, Linear equation, Bernoulli's equation, Clairaut's equation, Riccati's equation, Orthogonal trajectories, Rate of decay of Radio-active materials**.**

UNIT-IV

Higher Orders Linear Differential Equations: Higher order linear differential equations with constant coefficients, rules for finding Complementary function, Particular Integral and General solution. Method of variation of parameters, solution of Cauchy- Euler equation, LR and LCR circuits

UNIT-V

Numerical Methods: Solution of Algebraic and transcendental equations by Bisection method, Regula-Falsi method Newton-Raphson method. Numerical Solutions of First Order Ordinary differential equations by Taylor's series method, Euler's method, Modified Euler's method and Runge-Kutta method of fourth order.

TEXT BOOKS:

1. B.S.Grewal, "Higher Engineering Mathematics", 44th Edition, Khanna Publishers, 2017.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", 9th Edition, John Wiley & Sons, 2006.

SUGGESTED READING:

1. N.P.Bali and Dr. Manish Goyal, "A text book of Engineering Mathematics", 9th edition, Laxmi Publications, 2017.
2. R.K.Jain, S.R.K.Iyengar, "Advanced Engineering Mathematics", 5th edition, Narosa Publications, 2016.

22PYC07

PHYSICS
(BIOTECH & CHEMICAL)

Instruction	3L Hours per week
Duration of SEE	3Hours
SEE	60Marks
CIE	40Marks
Credits	3

COURSE OBJECTIVES: This course aims to

1. Learn the basic concepts of wave nature of light
2. Know about the properties of magnetic and dielectric materials
3. Understand the basics of nanomaterials
4. Familiarize with fundamental ideas of quantum mechanics

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Demonstrate the physical properties of the light.
2. Find the applications of lasers and optical fibers in engineering and technology.
3. Identify different types of magnetic and dielectric materials.
4. Recall the fundamentals of nanomaterials.
5. Apply the ideas of quantum mechanics for related problems

CO-PO Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C01	3	1	1	1	1	2	2	1	1	2	1	2
C02	3	1	2	1	2	2	2	1	2	2	2	2
C03	2	2	1	1	1	1	1	1	1	2	1	2
C04	3	2	2	2	2	2	2	1	1	2	1	2
C05	3	2	2	2	2	1	2	2	1	2	1	2

UNIT-I

Wave Optics: Huygen's principle–Superposition of waves –Interference of light by splitting of wavefront and amplitude–Fresnel's biprism–Interference in thin films (reflected light) – Newton's rings –Fraunhofer diffraction from a single slit – Double slit diffraction–Concept of N-slits–Diffraction grating and its resolving power. Polarization: Introduction–Malus's law–Double refraction –Nicol's prism–Quarter-wave plate and half-wave plate–Optical activity– Laurent's half shade polarimeter.

UNIT-II

Lasers: Characteristics of lasers– Einstein's coefficients–Amplification of light by population inversion– Ruby laser– He-Ne laser– Semiconductor laser–Applications of lasers in engineering and medicine.

Fiber Optics: Introduction–Construction–Principle–Propagation of light through an optical fiber –Numerical aperture and acceptance angle – Step-index and graded-index fibers –Pulse dispersion –Fiber losses –Fiber optic communication system –Applications.

UNIT-III

Dielectric Materials: Introduction–Dielectric polarization–Types of dielectric polarization: electronic & ionic polarizations (quantitative); orientation & space-charge polarizations (qualitative)–Frequency and temperature dependence of dielectric polarization–Determination of dielectric constant (Schering bridge method)–Ferroelectricity–Barium titanate–Applications of ferroelectrics.

Magnetic Materials: Origin of magnetism –Magnetic moment - Bohr magneton–Classification of magnetic materials: dia, para, ferro, anti-ferro and ferrimagnetic materials– Weiss molecular field theory–Domain theory–Hysteresis curve–Soft and hard magnetic materials–Applications.

UNIT-IV

Nanomaterials: Properties of materials at reduced size–Surface to volume ratio–Quantum confinement–Preparation of nanomaterials: bottom-up approach (sol-gel method) and top-down approach (ball-milling method)–Elementary ideas of carbon nanotubes–Applications of nanomaterials.

UNIT-V

Quantum Mechanics: Introduction–Planck's' law of black body radiation – Wien's law and Rayleigh-Jean's law from Planck's law – Photoelectric effect – Compton effect –de-Broglie hypothesis –Wave-particle duality – Physical significance of ψ –Born's interpretation of the wave function –Verification of matter waves by Davisson-Germer's experiment –Uncertainty principle – Schrodinger wave equation (time-dependent and time-independent) –Particle in infinite square well potential.

TEXT BOOKS:

1. B. K. Pandey and S. Chaturvedi, *Engineering Physics*, Cengage Publications, 2012.
2. M. N. Avadhanulu and P. G. Kshirsagar, *A Text Book of Engineering Physics*, S. Chand Publications, 2014.
3. M. Arumugam, *Materials Science*, Anuradha Publications, 2015.
4. S. L. Gupta and Sanjeev Gupta, *Modern Engineering Physics*, Dhanpat Rai Publications, 2011.

SUGGESTD READING:

1. R. Murugeshan and Kiruthiga Sivaprasath, *Modern Physics* S. Chand Publications, 2014.
2. V. Rajendran, *Engineering Physics*, McGraw-Hill Education Publications, 2013.
3. P.K. Palanisamy, *Engineering Physics*, Scitech Publications, 2012.
4. V. Raghavan, *Materials Science and Engineering*, Prentice Hall India Learning Private Limited; 6th Revised edition, 2015.

22CEC01

ENGINEERING MECHANICS

Instruction	3L+1T Periods per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	4

COURSE OBJECTIVES: This course aims to

1. Understand the resolution of forces and to obtain resultant of all force systems,
2. Understand equilibrium conditions of static loads for smooth and frictional surface
3. Analyse simple trusses for forces in various members of a truss
4. Obtain centroid, centre of gravity for various regular and composite areas and bodies
5. Obtain Moment of inertia for various regular and composite areas and bodies and also to obtain Mass moments of inertia of elementary bodies

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Calculate the components and resultant of coplanar forces system and Draw free body diagrams to analyze the forces in the given structure
2. Understand the mechanism of friction and can solve friction problems
3. Analyse simple trusses for forces in various members of a truss.
4. Determine the centroid of plane areas, composite areas and centres of gravity of bodies.
5. Determine moments of inertia, product of inertia of plane and composite areas and mass moments of inertia of elementary bodies,

CO-PO-PSO Matrix

PO / PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-

UNIT – I

Resolution and Resultant of Force System: Basic concepts of a force system. Components of forces in a plane. Resultant of coplanar concurrent force system. Moment of a force, couple and their applications. Resultant of coplanar non-concurrent force system

Equilibrium of force system: Free body diagrams, equations of equilibrium of planar force systems and its applications. Problems on general case of coplanar force systems.

UNIT – II

Theory of friction: Introduction, types of friction, laws of friction, application of friction to a single body & connecting systems. Wedge and belt friction

UNIT – III

Analysis of Simple Trusses: Introduction to trusses, Assumptions, analysis of simple trusses using method of joints and method of sections.

UNIT– IV

Centroid: Significance of centroid, moment of area, centroid of line elements, plane areas, composite areas, theorems of Pappus & its applications. Center of gravity of elementary and composite bodies

UNIT – V

Moment of Inertia: Definition of MI, Area MI. Polar Moment of Inertia, radius of gyration, transfer theorem, Moment of Inertia of elementary & composite areas, and Product of inertia. Mass moments of inertia of elementary bodies.

TEXT BOOKS:

1. K. Vijay Kumar Reddy and J. Suresh Kumar, Singer's Engineering Mechanics, BS Publications, Hyderabad, 2011.
2. Ferdinand L Singer, Engineering Mechanics, Harper and Collins, Singapore, 1904.

SUGGESTED READING:

1. A. Nelson, Engineering Mechanics, Tata McGraw Hill, New Delhi, 2010.
2. S. Rajashekaran & G. Sankarasubramanyam, Engineering Mechanics, Vikas publications, Hyderabad, 2002.
3. S.B. Junarkar and H.J Shah, Applied Mechanics**,** Charotar publishers, New Delhi, 2001.
4. Basudeb Bhattacharyya, Engineering Mechanics, Oxford University Press, New Delhi, 2008.
5. A K Tayal, Engineering Mechanics, Umesh Publications, New Delhi, 2010

22EGC01

ENGLISH

(Common to All Branches)

Instruction	2L Hours per week
Duration of SEE	3Hours
SEE	60 Marks
CIE	40 Marks
Credits	2

COURSE OBJECTIVES: This course aims to

1. To the role and importance of communication while developing their basic communication skills in English.
2. To basics of writing coherent paragraphs and formal emails.
3. To techniques of writing a précis and formal letters by using acceptable grammar and appropriate vocabulary.
4. To description, definition and classification of processes while enabling them to draft formal reports following a proper structure.
5. To gaining adequate reading comprehension techniques.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Illustrate the nature, process and types of communication and communicate effectively without barriers.
2. Construct and compose coherent paragraphs, emails and adhering to appropriate mobile etiquette.
3. Apply techniques of precision to write a précis and formal letters by using acceptable grammar and appropriate vocabulary.
4. Distinguish formal from informal reports and demonstrate advanced writing skills by draftin g formal reports.
5. Critique passages by applying effective reading techniques

CO-PO-PSO Articulation Matrix

PO/CO	PO1	PO2	PO3	PO4	PO5	P O6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	1	1	1	1	1	1	1	2	3	3	2	3
CO 2	1	1	1	1	-	1	1	1	2	2	1	2
CO 3	-	2	1	1	-	2	1	1	2	2	1	2
CO 4	1	2	1	2	1	2	2	1	2	2	1	2
CO 5	1	2	1	2	1	1	1	1	1	2	1	2

UNIT-I

Understanding Communication in English: Introduction, nature and importance of communication; Process of communication; Types of communication - verbal and non-verbal; Barriers to communication; Intrapersonal and interpersonal communication; Understanding Johari Window.

Vocabulary &Grammar: The concept of Word Formation; Use of appropriate prepositions and articles.

UNIT-II

Developing Writing Skills I:

Paragraph writing. – Structure and features of a paragraph; Cohesion and coherence. Rearranging jumbled sentences. Email and Mobile etiquette.

Vocabulary & Grammar: Use of cohesive devices and correct punctuation.

UNIT-III

Developing Writing Skills II:

Précis Writing; Techniques of writing precisely. Letter Writing – Structure, format of a formal letter; Letter of request and the response

Vocabulary and Grammar: Subject-verb agreement. Use of prefixes and suffixes to form derivatives. Avoiding redundancies.

UNIT-IV

Developing Writing Skills III:

Report writing – Importance, structure, elements of style of formal reports; Writing a formal report.

Vocabulary and Grammar: Avoiding ambiguity - Misplaced modifiers. Use of synonyms and antonyms.

UNIT-V

Developing Reading Skills:

The reading process, purpose, different kinds of texts; Reading comprehension; Techniques of comprehension – skimming, scanning, drawing inferences and conclusions.

Vocabulary and Grammar: Words often confused; Use of standard abbreviations.

TEXT BOOKS:

1. Language and Life: A Skills Approach, Board of Editors, Orient Black Swan,2017.
2. Swan Michael, Practical English Usage.OUP.1995.

SUGGESTED READINGS:

1. Wood F.T, Remedial English Grammar,Macmillan,2007
2. Zinsser William, On Writing Well, Harper Resource Book, 2001
3. Sanjay Kumar and PushpLata, Communication Skills. Oxford University Press,2011.

22PYC10

PHYSICS LAB
(Biotech & Chemical)

Instruction	3P Hours per week
Duration of SEE	3Hours
SEE	50Marks
CIE	50Marks
Credits	1.5

COURSE OBJECTIVES: This course aims to

1. Apply theoretical physics knowledge in doing experiments
2. Understand the behaviour of the light experimentally
3. Analyze the physical properties of magnetic and dielectric materials
4. Familiarize with motion of electrons in electric and magnetic fields

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Interpret the errors in the results of an experiment.
2. Demonstrate the wave nature of light experimentally
3. Utilize physical properties of magnetic and dielectric materials for various applications
4. Make use of lasers and optical fibers for engineering applications
5. Explain light induced phenomenon and motion of electrons in electric and magnetic fields

CO-PO Articulation Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C01	3	2	2	3	1	3	1	3	3	2	1	2
C02	3	2	1	2	2	2	1	2	2	1	1	3
C03	3	2	3	2	3	1	2	2	3	2	1	2
C04	3	3	2	2	2	1	2	3	2	1	1	3
C05	3	1	2	3	2	1	1	2	2	2	1	2

Experiments

1. Error Analysis : Estimation of errors in the determination of time period of a torsional pendulum
2. Fresnel's Biprism : Determination of wavelength of given monochromatic source
3. Newton's Rings : Determination of wavelength of given monochromatic source
4. Single Slit Diffraction : Determination of wavelength of given monochromatic source
5. Diffraction Grating : Determination of wavelengths of two yellow lines of light of mercury lamp
6. Malus's Law : Verification of Malus's law
7. Double Refraction : Determination of refractive indices of O-ray and E-ray of given calcite crystal
8. Polarimeter : Determination of specific rotation of glucose
9. Laser : Determination of wavelength of given semiconductor laser
10. Optical Fiber : Determination of numerical aperture and power losses of given optical fiber
11. Dielectric constant : Determination of dielectric constant of given PZT sample
12. M & H Values : Determination of magnetic moment M of a bar magnet and absolute value H of horizontal component of earth's magnetic field

13.	B-H curve	:	Determination of hysteresis loss of given specimen
14.	Planck's constant	:	Determination of Planck's constant using photo cell
15.	e/m of an Electron	:	Determination of specific charge of an electron by J.J. Thomson method

NOTE: A minimum of TWELVE experiments should be done.

22EGC02

ENGLISH LAB

(Common to All Branches)

Instruction	2P Hours per week
Duration of SEE	3 Hours
SEE	50 Marks
CIE	50 Marks
Credits	1

COURSE OBJECTIVES: This course aims to

1. To nuances of Phonetics and give them sufficient practice in correct pronunciation.
2. To word stress and intonation.
3. To listen to listening comprehension material for honing their listening skills.
4. To activities enabling them overcome their inhibitions while speaking in English with the focus being on fluency rather than accuracy.
5. To team work, role behavior while developing their ability to discuss in groups and making oral presentations.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Define the speech sounds in English and understand the nuances of pronunciation in English
2. Apply stress correctly and speak with the proper tone, intonation and rhythm.
3. Analyze listening comprehension texts to enhance their listening skills.
4. Determine the context and speak appropriately in various situations.
5. Design and present effective posters while working in teams, and discuss and participate in Group discussions.

CO-PO-PSO Articulation Matrix

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	-	-	-	-	-	-	-	-	1	1	-	1
CO 2	-	-	-	-	-	1	-	1	2	2	1	2
CO 3	-	-	-	-	-	1	1	1	2	1	1	2
CO 4	1	-	-	-	-	1	2	2	2	3	1	3
CO 5	1	1	1	1	1	2	2	2	3	3	2	3

EXERCISES

1. **Introduction to English Phonetics**: Introduction to auditory, acoustic and articulatory phonetics, organs of speech: the respiratory, articulatory and phonatory systems.
2. **Sound system of English**: Phonetic sounds and phonemic sounds, introduction to international phonetic alphabet, classification and description of English phonemic sounds, minimal pairs . The syllable: types of syllables, consonant clusters.
3. **Word stress**: Primary stress, secondary stress, functional stress, rules of word stress.
4. **Rhythm & Intonation** : Introduction to Rhythm and Intonation. Major patterns, intonation of English with the semantic implications.
5. **Listening skills** – Practice with Software available in (K-van solutions)
6. **Public speaking –** Speaking with confidence and clarity in different contexts on various issues.
7. **Group Discussions -** Dynamics of a group discussion, group discussion techniques, body language.
8. **Pictionary –** weaving an imaginative story around a given picture.
9. **Information Gap Activity –** Writing a brief report on a newspaper headline by building on the hints given
10. **Poster presentation –** Theme, poster preparation, team work and representation.

SUGGESTED READING

1. T Balasubramanian. A Textbook of English Phonetics for Indian Students, Macmillan,2008.
2. J Sethi et al. A Practical Course in English Pronunciation (with CD), Prentice Hall India,2005.
3. PriyadarshiPatnaik. Group Discussions and Interviews, Cambridge University Press Pvt Ltd2011
4. ArunaKoneru, Professional Speaking Skills, Oxford University Press,2016

22MEC01

CAD AND DRAFTING

Instruction	1 T + 3 D Hours per week
Duration of SEE	3Hours
SEE	50Marks
CIE	50Marks
Credits	2.5

COURSE OBJECTIVES: This course aims to

1. To get exposure to a cad package and its utility.
2. Understanding orthographic projections.
3. To visualize different solids and their sections in orthographic projection
4. To prepare the student to communicate effectively by using isometric projection.
5. To prepare the student to use the techniques, skills, and modern tools necessary for practice.

COURSE OUTCOMES: At the end of the course, the Students are able to

1. Become conversant with appropriate use of CAD software for drafting.
2. Recognize BIS, ISO Standards and conventions in Engineering Drafting.
3. Construct the projections of points, lines, planes, solids
4. Analyse the internal details of solids through sectional views
5. Create an isometric projections and views

CO-PO-PSO Correlation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	2	2	-	1	2	3	1	3
CO2	3	2	2	1	2	2	-	1	2	2	1	2
CO3	3	3	2	1	2	2	-	1	2	2	1	2
CO4	3	3	3	2	2	2	-	1	2	2	1	2
CO5	3	2	2	1	2	2	-	1	2	2	1	2

LIST OF EXERCISES:

1. Introduction to CAD package: Settings, draw, modify tools, dimensioning and documentation
2. Construction of Conic Sections by General method
3. Orthographic projection: Principles, conventions, Projection of points
4. Projection of straight lines: Simple position, inclined to one plane
5. Projection of straight lines inclined to both the planes (without traces and mid-point)
6. Projection of planes: Perpendicular planes
7. Projection of planes: Oblique planes
8. Projection of solids: Simple position
9. Projection of solids: Inclined to one plane
10. Sections of solids: Prism, pyramid in simple position
11. Sections of solids: Cone and cylinder in simple position
12. Isometric projections and views
13. Conversion of isometric views to orthographic projections and vice-versa.

TEXT BOOKS:

1. N.D.Bhatt, “Elementary Engineering Drawing”, Charotar Publishers, 2012.
2. K.Venugopal, “Engineering Drawing and Graphics + AutoCAD”, New Age International Pvt.Ltd, 2011.
3. Basanth Agrawal and C M Agrawal, “Engineering Drawing”, 2/e, McGraw-Hill Education (India) Pvt. Ltd.

SUGGESTED READING:

1. Shaw M.B and Rana B.C., “Engineering Drawing”, 2/e, Pearson, 2009.
2. K.L. Narayana and P.K. Kannaiah, “Text Book of Engineering Drawing”, Scitech Publications, 2011.

22MEC38

DIGITAL FABRICATION LAB

Instruction	3P Hours per week
Duration of SEE	3 Hours
SEE	50 Marks
CIE	50 Marks
Credits	1.5

COURSE OBJECTIVES: This course aims to

1. Give a feel of Engineering Practices & develop holistic understanding of various Engineering materials and Manufacturing processes.
2. Develop skills of manufacturing, safety, precision, quality, intelligent effort, optimization, positive &team work attitude to get things right the first time.
3. Provide basic knowledge of Steel, Plastic, Composite and other materials for suitable applications.
4. Study of Principle and hands on practice on techniques of fabrication, welding, casting, manufacturing, metrology, and allied skills.
5. Advance important hard & pertinent soft skills, productivity, create skilled manpower which is cognizant of industrial workshop components and processes and can communicate their work in a technical, clear and effective way.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Understand safety measures to be followed in workshop to avoid accidents.
2. Identify various tools used in carpentry, house wiring and plumbing.
3. Make a given model by using workshop trades like carpentry, plumbing, House wiring and 3d modeling using solid works software for Additive Manufacturing.
4. Perform pre-processing operations on STL files for 3D printing, also understand reverse engineering process.
5. Conceptualize and produce simple device/mechanism of their choice.

CO-PO-PSO Correlation Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
O1	1	-	-	-	-	-	-	-	-	-	-	1
CO2	1	-	-	-	1	-	-	-	-	-	-	2
CO3	2	1	1	1	3	-	1	-	-	-	-	2
CO4	2	2	2	1	3	-	-	-	-	-	-	2
CO5	3	2	1	-	3	-	-	-	-	-	-	2

LIST OF EXERCISES:

Group-1

1. To make a lap joint on the given wooden piece according to the given dimensions.
2. To make a dove tail-joint on the given wooden piece according to the given dimensions.
3.
   i. Wiring of one light point controlled by one single pole switch, a three pin socket controlled by a single pole switch
   ii. Wiring of two light points connected in series and controlled by single pole switch. Verify the above circuit with different bulbs. Wiring of two light points connected in parallel from two single pole switches and a three pin socket
4. Stair case wiring-wiring of one light point controlled from two different places independently using two 2-way switches.
5. To make external threads for GI pipes using die and connect the GI pipes as per the given diagram using taps, couplings & bends.
6. a. To connect the GI pipes as per the given diagram using, couplings, unions, reducer & bends.

b. To connect the GI pipes as per the given diagram using shower, tap & valves and Demonstrate by giving water connection

Group- 2

1. To Study the method of Additive Manufacturing process using a 3D printer
2. To create a 3D CAD model of a door bracket using a modeling software
3. To Print a door bracket using an extruder type 3D Printer.
4. To create a 3D CAD model by reverse Engineering
5. To Design an innovative component using the CAD software
6. To Print the selected innovative component by the students using a 3D printer

TEXT 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, Media promoters and publishers private limited, Mumbai, 2010.
2. Kalpakjian S. And Steven S. Schmid, Manufacturing Engineering and Technology, 4th edition, Pearson Education India Edition, 2002.
3. Sachidanand Jha, 3D PRINTING PROJECTS: 200 3D Practice Drawings For 3D Printing On Your 3D Printer, June 7, 2019.

SUGGESTED READING:

1. Gowri P. Hariharan and A. Suresh Babu, Manufacturing Technology – I, Pearson Education, 2008.
2. Oliver Bothmann , 3D Printers: A Beginner's Guide , January 1, 2015

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY

(In line with AICTE Model Curriculum with effect from AY 2023-24)

B. Tech (Chemical Engineering)

SEMESTER– III

S. No	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours per Week			Duration of SEE In Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1	22CSC35	Data Structures using Python	2	-	-	3	40	60	2
2	22MTC10	Partial Differential Equations and Statistics	3	1	-	3	40	60	4
3	22CHC01	Chemical Engineering Thermodynamics-I	3	-	-	3	40	60	3
4	22CHC02	Fluid Mechanics	3	1	-	3	40	60	4
5	22CHC03	Mechanical Unit Operations	3	-	-	3	40	60	3
6	22CHC04	Material and Energy Balance Calculations	3	–	-	3	40	60	3
PRACTICAL									
7	22CSC36	Data Structures using Python Lab	-	-	2	3	50	50	1
8	22CHC05	Fluid Mechanics Lab	-	-	3	3	50	50	1.5
9	22CHC06	Mechanical Unit Operations Lab	-	-	3	3	50	50	1.5
10	22CHI01	MOOCs/Training/ Internship	2-3weeks/ 90 hours			-	50	-	2
TOTAL			**17**	**2**	**8**	**-**	**440**	**510**	**25**
Clock Hours Per Week: 27									

L: Lecture T: Tutorial P: Practical CIE-Continuous Internal Evaluation SEE - Semester End Examination NC- Non-Credit

22CSC35

DATA STRUCTURES USING PYTHON

(Common to BioTech, Chemical, Civil and Mechanical Engineering)

Instruction	2 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	2

COURSE OBJECTIVES: This course aims to

1. Introduce object-orientation concepts in python.
2. Familiarize students with asymptomatic analysis of various functions and implement different sorting techniques.
3. Examine various linear and non-liner data structures.
4. Explore various string functions and hash functions.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Understand classes, objects, linear data structures, nonlinear data structures, time complexity.
2. Use python packages to work with datasets.
3. Implement sorting, searching algorithms and analyse their performance.
4. Build solutions for problems using linear, nonlinear data structures and hashing.
5. Apply pattern matching algorithms for real time problems.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	3	2	1	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	2	1	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	1	-	-	-	-	-	-	-	-	-	-	-
CO 5	2	2	-	-	-	-	-	-	-	-	-	-	-	-

UNIT-I

Overview of Python, Concept of Class, and objects; NumPy: The Basics of NumPy Arrays, Aggregations; Pandas: Pandas Objects, Data Indexing and Selection; **Visualisation:** Simple Line Plots, Simple Scatter Plots, Histograms, Binnings, and Density.

UNIT - II

Introduction: Data Structures, Abstract Data Types, Algorithm, Analysis of Algorithms, Running Time Analysis, Commonly Used Rates of Growth, Big O Notation, Omega Notation, Theta Notation, Guidelines for Asymptotic Analysis.

Sorting: Introduction, Classification of Sorting Algorithms, Selection Sort, Merge Sort, Quick Sort, Radix sort, Comparison of Sorting Algorithms.

UNIT-III

Linked Lists: Linked List ADT, Singly Linked Lists, Doubly Linked Lists, Circular Linked Lists; **Stacks:** Stack ADT **Queues:** Queue ADT.

UNIT-IV

Trees: Introduction, Binary Trees, Types of Binary Trees, Properties of Binary Trees, Binary Tree Traversals, Binary Search Trees (BSTs); **Graph:** Introduction, Applications of Graphs, Graph Representation, Graph Traversals

UNIT-V

String Algorithms and Hashing: Introduction, String Matching Algorithms: Brute Force Method, Rabin-Karp. Hash Table ADT, Components of Hashing, Hash Table, Hash Function, Load Factor, Collisions, Collision Resolution Techniques

TEXTBOOKS:

1. Narasimha Karumanchi,"Data Structures and Algorithmic Thinking With Python", Career Monk Publications, 2016
2. Tony Gaddis, “Starting out with Python”, 4th Edition, Global Edition, Pearson Education Limited, 2019
3. Jake Vander Plas, “Python Data Science Handbook”, OReilly, 2017

SUGGESTED READING:

1. Wes McKinney, “Python for Data Analysis Data Wrangling with Pandas, NumPy, and IPython”, 2nd
2. Ed, OReilly, 2018
3. Michael T.Goodrich, Roberto Tamassia, Michael H. Goldwasser, “Data Structure and Algorithms in Python”, Wiley, 2013.
4. Kenneth A. Lambert, "Fundamentals of Python: Data Structures", Cengage Learning,2018.

ONLINE RESOURCES:

1. https://visualgo.net/en
2. https://jakevdp.github.io/PythonDataScienceHandbook/
3. https://www.coursera.org/specializations/data-structures-algorithms
4. https://nptel.ac.in/courses/106/106/106106182/
5. https://www.cs.usfca.edu/~galles/visualization/Algorithms
6. https://www.edx.org/course/algorithms-and-data-structures

22MTC10

PARTIAL DIFFERENTIAL EQUATIONS AND STATISTICS

(CHEMICAL)

Instruction	3 L+1T Hours per week
Duration of Semester End Examination	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	4

COURSE OBJECTIVES: This course aims to

1. To explain the expansion of functions in sine and cosine series.
2. To form PDE and to find its solution.
3. To know the model of wave and heat equations.
4. Able to analyze random phenomena using basic probability.
5. To learn fitting of distribution and predicting the future values.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Calculate the Euler's coefficients for Fourier series expansion of a function.
2. Solve Linear and Nonlinear PDEs.
3. Solve One-Dimension Wave and Heat equations and Two Dimensional Laplace equations.
4. Use the basic probability for fitting the Random phenomenon.
5. Analyze the random fluctuations of probability distribution and Principles of Least Squares approximations for the given data.

CO-PO Articulation Matrix

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	-	-	-	-	-	-	-	1	3	3
CO2	2	2	2	2	-	-	-	-	-	-	-	1	2	2
CO3	2	2	2	2	-	-	-	-	-	-	-	1	3	-
CO4	2	2	2	1	-	-	-	-	-	-	-	1	0	2
CO5	2	2	2	1	-	-	-	-	-	-	-	1	2	2

UNIT-I

Fourier series: Periodic functions, Euler's formulae, Conditions for a Fourier series expansion, Fourier series of Functions having points of discontinuity, Change of interval, even and odd functions, Half range Sine & Cosine Series.

UNIT-II

Partial Differential Equations: Formation of Partial Differential Equations, Linear Equations of First Order (Lagrange's Linear Equations), Solution of First Order Nonlinear Partial Differential Equations (Standard forms) and Charpits Method.

UNIT-III

Applications of Partial Differential Equations: Solution by Method of Separation of Variables, Solution of One dimensional Wave equation, Solution of One dimensional Heat equation, Solution of Two dimensional Laplace equation and its related problems.

UNIT-IV

Basic probability: Basic probability, Conditional probability, Baye's theorem. Random variable, Discrete probability distribution and Continuous probability distribution. Expectation, Addition and Multiplication theorem of expectation, properties of variance, Moments (Moments about the mean and moments about a point)

UNIT-V

Probability Distributions and Curve Fitting: Poisson distribution, MGF and Cumulants of the Poisson distribution, Normal distribution, Characteristics of Normal distribution, MGF and CGF of Normal distribution, Areas under normal curve. Correlation, Coefficient of Correlation and Lines of Regression. Curve fitting by the Method of Least Squares, Fitting of Straight lines, Second degree parabola and exponential curves.

TEXT BOOKS:

1. B.S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 44th Edition, 2017.
2. S.C.Gupta, V.K.Kappoor, "Fundamentals of Mathematical Statistics", Sultan Chand and Sons, 2014.

SUGGESTED READING:

1. Erwin kreyszig, "Advanced Engineering Mathematics", 9th Edition, John Wiley & Sons, 2006.
2. S. J. Farlow, "Partial Differential Equations for Scientists and Engineers", Dover Publications, 1993.
3. Sheldon Ross, "A First Course in Probability", 9th Edition, Pearson publications, 2014.

22CHC01

CHEMICAL ENGINEERING THERMODYNAMICS-I

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisites: Material & Energy Balance Computations, Engineering Physics

COURSE OBJECTIVES: This course aims to

1. Basic thermodynamic laws and Principles.
2. Concept of energy conservation through the study of the First and Second laws of thermodynamics.
3. Concept of Entropy and its importance in energy conversion.
4. Chemical Engineering problems involving various types of systems and processes.
5. Application of Thermodynamics to flow process.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Understand the fundamental concepts of thermodynamics to engineering applications.
2. Apply mass and energy balances to closed and open systems and study the PVT behavior of pure substances.
3. Apply the laws of thermodynamics and estimate the heat and work requirements for Industrial Processes.
4. Evaluate thermodynamic properties of ideal and real mixtures and the efficiency of flow processes.
5. Analyze liquefaction, refrigeration and different power cycles.

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	-	-	-	-	-	-	-	-	2	-
CO2	3	3	2	2	1	-	-	-	-	-	-	1	1	1
CO3	3	3	3	2	1	1	1	-	-	-	-	-	1	1
CO4	3	3	2	1	1	-	-	-	-	-	-	-	1	1
CO5	3	2	2	2	1	1	1	-	-	-	-	1	1	2

UNIT I

Introduction: The scope of thermodynamics, Dimensions and units, temperature and Zeroth Law of Thermodynamics, Force, volume, pressure, work, heat, Energy classifications- energy in transit, thermodynamic state and state functions, reversible and irreversible processes, equilibrium, The phase rule.

UNIT-II

The first law and other basic concepts: Joules Experiments; The first law of thermodynamics and Internal Energy; Energy balance for closed systems; enthalpy; constant-V and constant- P processes; heat capacity; Mass and energy balance for open systems.

Volumetric properties of pure fluids: The PVT behaviour of pure substances; the ideal gas; virial equations of state; applications of the virial equations; Cubic equations of state; generalized correlations for gases; generalized correlations for liquids.

UNIT-III

The second law of thermodynamics: Statements of the second law; heat engines; thermodynamic temperatures scales, Carnot Engine with Ideal-Gas-State Working Fluid, Entropy; Entropy changes of an ideal gas; mathematical statement of the second law; Entropy balance for open systems; calculation of ideal work and lost work; the third law of thermodynamics; entropy from the microscopic view point.

UNIT-IV

Thermodynamic properties of fluids: Property relations for homogeneous phases; residual properties; Residual properties from the virial equations of state; generalized property correlation for gases, two phase systems; thermodynamic diagrams; tables of thermodynamic properties.

Application of thermodynamics to flow processes: Duct flow of compressible fluids - pipe flow, nozzles, throttling process; turbines; compression processes – compressors and pumps.

UNIT-V

Production of power from heat: The steam power plant-the Rankine cycle; Internal combustion Engines- the Otto engine, the diesel engine.

Refrigeration and liquefaction: The Carnot refrigerator; the vapor compression cycle; the comparison of refrigeration cycles; the choice of refrigerant; absorption refrigeration; the heat pump; liquefaction processes.

TEXTBOOKS:

1. Smith, J.M., Van Ness, H.C., Abbott, M.M and Swihart, M.T., "Introduction to Chemical Engineering Thermodynamics ", 8thed, Tata McGraw Hill., 2018.

SUGGESTED READINGS:

1. Gopinath Halder., "Introduction to Chemical Engineering Thermodynamics", 2nd Edition, PHI Learning Pvt Ltd, 2014
2. M J Moran, H P Shapiro, D Boettner, and M B Bailey., "Principles of engineering Thermodynamics", 8th Ed, Wiley, 2015.
3. Kyle, B.G., "Chemical and Process Thermodynamics", 3rd ed. "Pearson, Prentice Hall of India Pvt. Ltd., 1999.
4. K.V. Narayanan., "Chemical Engineering Thermodynamics", Prentice Hall of India Pvt Ltd., 2009
5. Hougen, O.A., Watson, K.M and Ragatz, R.A., "Chemical Process Principles, Part II ", Thermodynamics, 2nd Edition, CBS Publications New Delhi, 2004.
6. Y.V.C. Rao., "Chemical Engineering Thermodynamics", University Press Hyderabad, 2005.

22CHC02

FLUID MECHANICS

Instruction	3 L+ 1T Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	4

Pre-requisites: Engineering Physics, Differential Equations

COURSE OBJECTIVES: This course aims to

1. Fluid flow phenomena for incompressible and compressible fluids.
2. Conservation of momentum principles to fluid flow.
3. Flow in Pipes, Channels and flow past immersed bodies.
4. Concepts of Compressible Fluids and Non Newtonian fluids
5. Fluidization phenomena and methods for transporting the fluids

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Distinguish different types of fluids, manometers
2. Apply Shell balances to illustrate fluid flow phenomena
3. Identify the concepts of incompressible flow in pipes, channels and associated frictional losses
4. Explain the concept of fluidization and flow through packed beds.
5. Choose the types of pumps for different fluids under different conditions and Identify equipment to be used to measure fluid flow.

CO –PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1	-	-	-	-	-	-	-	1	2	2
CO2	3	3	2	1	-	-	-	-	-	-	-	1	2	2
CO3	3	3	2	2	1	-	-	-	-	-	-	1	2	2
CO4	3	3	2	1	-	-	-	-	-	-	-	1	2	2
CO5	3	3	2	1	-	-	-	-	-	-	-	1	2	2

UNIT – I

Fluid Flow Phenomena and Fluid Statics: Definition of fluid, shear rate and shear stress, Newtonian and Non-Newtonian fluids, Time dependent flow, viscosity and momentum flux, compressible, incompressible, real and ideal fluids, viscosities of gases and liquids, Laminar and Turbulent flows, Reynolds experiment, Boundary layers, Hydrostatic equilibrium, U-tube manometer, inclined manometer and two fluid manometer and inverted manometer.

UNIT - II

Basic Equations of Fluid Flow: path lines, streamlines and stream tube, mass balance–equation of continuity, one dimensional flow, mass velocity, differential momentum balance-equations of motion, Couette flow, macroscopic momentum balances, momentum of stream and momentum correction factor, layer flow with free surface. Mechanical energy equation-Bernoulli equation- corrections for effects of solid boundaries, kinetic energy correction factor, corrections for fluid friction, pump work in Bernoulli equation.

UNIT-III

Incompressible Flow in Pipes and Channels and Frictional Losses: Shear stresses and skin friction, fanning friction factor, flow in noncircular channels, laminar flow of Newtonian and Non-Newtonian fluids, velocity distribution, Hagen - Poiseuille equation, Turbulent flow, universal velocity distribution, Roughness, Moody‟s friction factor chart. Pipes and valves, fittings. Friction losses due to sudden expansion and contraction, Effects of fittings and valves, form frictional losses in the Bernoulli Equation. Dimensional analysis and Buckingham π –theorem and Rayleigh theorem its applications and limitations.

UNIT–IV

Flow past immersed bodies and Fluidization, Potential flow, vortisity. Differential analysis: mass and momentum balances, Navier-Stokes equation, Unidirectional flow, Viscous flow, Stokes law, Skin drag and pressure drag and drag coefficient, Flow through packed beds of solids – Kozeny Carman equation, Burke-Plummer equation and Ergun equation. Boundary layer theory, Boundary layer separation, Drag and lift force on immersed body

UNIT– V

Transportation and Metering of Fluids: Centrifugal and Positive Displacement Pumps, Characteristics of pumps, selection and design of pumps, suction lift and cavitation, NPSH, Flow meters- Venturimeter, orifice meter, Pitot tube, Rotameter, Notches and Weirs, Compressors and blowers.

TEXTBOOKS:

1. W. L. McCabe, J. C. Smith and P. Harriott, Unit Operations of Chemical Engineering, 7th Ed., Tata-McGraw Hill Chemical Engineering Series, New Delhi, 2005.
2. C.J. Geankopolis, “Transport processes and unit operations”, 3rd Ed., Prentice Hall Publishers, USA, 1993.

SUGGESTED READINGS:

1. James O. Wilkes, “Fluid Mechanics for Chemical Engineers with Micro fluids and CFD”, 2nd Ed., University of Michigan, Prentice Hall Intl., 2006.
2. Kurmi, R.S., “Hydraulics, Fluid Mechanics and Hydraulic Machines”, 20th Ed., S. Chand and Company Pvt. Ltd., New Delhi, 2014.

22 CHC03

MECHANICAL UNIT OPERATIONS

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisites: Mathematics, Physics, Chemistry

COURSE OBJECTIVES: This course aims to

1. Principles of size reduction using various equipment.
2. Techniques for separating solids based on size by different methods.
3. Different kinds of filtration units.
4. Various aspects of Mixing and Agitation of solids and liquids.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Choose the suitable size reduction and transportation equipment for solids based on their properties
2. Select equipment for industrial application with respect to size separation techniques.
3. Design equipment for industrial application with respect to separation of solid-fluid operations.
4. Apply the different filtration techniques for industrial application.
5. Identify the suitable technique for blends and mixing of liquids and solids.

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	3	2	1	2	2	1	-	1	1	3	2
CO2	3	3	2	2	2	1	2	1	1		1	1	3	3
CO3	3	3	3	3	3	1	2	2	2	1	1	2	3	3
CO4	3	3	2	3	2	1	2	2	1	-	1	1	3	2
CO5	3	3	2	2	3	1	2	1	1	-	1	1	3	3

UNIT-I

Particle Technology: Characteristics of solid particles – screen analysis, Differential and cumulative mean diameters for mixture of particles, properties of particulate masses. Handling and transport of solids, storage equipment for mechanical conveyors and elevators, pneumatic transport.

Communition: principles of Communition laws and energy requirements. Size reduction - Description and working of crushing and grinding equipment – jaw, Gyratory and Roll crusher, Hammer mill, Rod mill and Ball mill, Ultra-fine grinders. Cutting machines – Open and closed circuit grinding.

UNIT-II

Size Separation: Industrial screening equipment -Grizzlies, Tromels and gyratory. Capacity and effectiveness of screen. Flotation, Frothing and dispersing agents, magnetic separation, electrostatic precipitators.

Particle dynamics: Principles of motion of particles through fluids, drag coefficient for spheres, motion of spherical particles. Free and hindered settling. Classifiers, Jigging. Sorting classifiers – Heavy medium and differential settling methods. Principle and working of cyclones and hydro cyclones.

UNIT-III

Solid-Liquid Separation Operations: Flocculation – Batch sedimentation – Thickeners – Thickener design. Principles of centrifugal sedimentation – Centrifugal classifiers and decanters – tubular, disc, bowl and scroll centrifuges.

UNIT-IV

Filtration: Equations for batch filtration. Description of plate and frame filter press, shell and leaf filters. Rotary vacuum drum filters. Membrane filtration, Centrifugal filters. Filter aids, Theory of constant rate and centrifugal filtration.

UNIT-V

Mixing and Agitation: Agitation equipment for liquids – Circulation velocities and power consumption in agitated vessels. Scale up of agitation equipment – Equipment for blending and mixing of liquids – Suspension of solid particles. Dispersion of gas in liquids. Gas holdup and power requirement. Dispersion of liquids in liquids. Equipment for mixing of solids and pastes – Mixers for dry powders – mixing index.

TEXTBOOKS:

1. W. L. McCabe, J. C. Smith and P.Harriott , Unit Operations of Chemical Engineering, 7thEd., Tata- McGraw Hill Chemical Engineering Series, New Delhi, 2005.
2. Foust A.S, Wenzel L.A., "Principles of Unit Operations", 2nd Ed., John Wiley and sons, New York, 1981.

Suggested Readings:

1. Coulson, J. M., and Richardson, J. F., "Chemical Engineering Series", Vol. 2, 4th Ed., Pergamon Press Oxford, UK, 1991.
2. C M Narayanan and B C Bhattacharya, "Mechanical Unit Operation for Chemical Engineering", Khanna Publishers, 3rd Ed, 2011.

22CHC04

MATERIAL ENERGY BALANCE CALCULATIONS

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES: This course aims to
1. Basis for all further chemical engineering courses that are part of the curriculum.
2. Basic calculations of process engineering.
3. Material balance calculations for with and without chemical reactions.
4. Properties and laws for analyzing vapors and liquids
5. Energy balance calculations and its importance.

COURSE OUTCOMES: After the completion of this course, the student will be able to
1. Convert physico-chemicalquantitiesfromonesystemofunitstoanotherandexpress composition of systems on different basis of calculation.
2. Solve material balance problems without chemical reactions for single and multi-unit systems.
3. Solve material balance problems with chemical reactions
4. Solve energy balance problems for non-reactive systems
5. Estimation heat of reaction for reactive systems.

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	3	2	-	-	-	2	2	1	1	3	2
CO2	3	2	3	3	2	-	-	-	2	2	1	1	3	2
CO3	3	2	3	3	2	-	-	-	2	2	1	1	3	2
CO4	3	2	3	3	3	-	-	-	2	2	1	1	3	2
CO5	3	2	3	3	3	-	-	-	2	2	1	1	3	2

UNIT-I

Introduction to process calculations: Units and Dimensions-Conversion of Units – Dimensional homogeneity; Process and process variables – process flow sheet, process unit, process streams, density, specific gravity, specific gravity scales, mass and volumetric flow rates, mole concept and mole balance, molecular and equivalent weights; Composition of streams on different basis; Gases, Vapors and Liquids: Equations of state, mixture of ideal gases-Dalton's and Amagat's laws, Vapor pressure, Clausius- Clapeyron equation, Cox chart, Duhring's plot, Raoult's law.

UNIT-II

Solving material balance problems without chemical reaction: Basic laws of conservation; Process classification; Material balance equation, general steps for solving material balance problem, M.B for single unit and multi-unit systems; Degrees of freedom analysis and significance; M.B problems of various unit operations – mixing, splitter, absorption, distillation, evaporation, crystallization, leaching, extraction, drying, Solubility, dissolution and crystallization under steady state conditions.

UNIT-III

Material Balance with Chemical Reaction: Material Balance with chemical reaction, Concept of stoichiometry and mole balances, limiting and excess reactant, % conversion, % excess, yield and selectivity; examples; Combustion calculations -Proximate and ultimate analysis of coal and analysis of flue gas. Material balances for by-pass, recycle and purge Operations; problems on multi-unit systems.

UNIT-IV

Energy Balances on non-reactive processes: Thermophysics–Energy balance equation for open and closed system, Procedure, Heat Capacity, changes in pressure and temperature; Calculation of enthalpy changes without and with phase change, Heat of solution and mixing.

UNIT-V

Energy balances on reactive processes: Thermo chemistry - Standard heat of reaction, formation and combustion, Hess Law, Effect of temperature; Kirchoff‟s equation; Energy balances on reactive systems; combustion and fuels – Adiabatic flame temperature; Simultaneous material and energy balances.

TEXTBOOKS:

1. Felder,R.M.; Rousseau, R.W. “Elementary Principles of Chemical Processes”, Third Edition, John Wiley & Sons, 2000.
2. Himmelblau, D.M., iggs, J.B. “Basic Principles and Calculations in Chemical Engineering”, Eighth Ed., Pearson India Education Services.
3. Hougen O.A., Watson K.M., Ragatz R.A., Chemical Process Principles (Part-I): Material and Energy Balances, 2nd Edition, CBS Publishers, 2004.

SUGGESTED READING:

1. Bhatt, B.I., Vora, S.M. “Stoichiometry”, Fourth Edition, Tata McGraw Hill Publishing Company Ltd, 2004
2. Narayanan K.V. Lakshmikutty B., “Stoichiometry and Process Calculations”, PHI Learning Pvt. Ltd., 7th Edition, 2015.
3. Sikdar, D.C., “Chemical Process Calculations”, Prentice Hall of India, 2013.

22CSC36

DATA STRUCTURES USING PYTHON LAB

Instruction	2 P Hours per week
Duration of SEE	3 Hours
SEE	50 Marks
CIE	50 Marks
Credits	1

COURSE OBJECTIVES: This course aims to

1. Introduce data structures in python.
2. Familiarize with visualization techniques and tools in python.
3. Implement ADT for linear and non linear structures.
4. Analyze the performance of sorting and searching techniques
5. Gain knowledge on applying data structures in real world problems.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Demonstrate Classes, Objects, linear data structures, nonlinear data structures.
2. Store, retrieve and visualize datasets using Python built-in packages.
3. Evaluate the performance of sorting techniques.
4. Build optimal solutions using linear data structures, nonlinear data structures and hashing.
5. Apply pattern matching algorithms for real time problems.

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	3	2	1	-	-	-	-	-	-	-	-	-	-	-
CO 2	2	2	-	-	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	1	-	-	-	-	-	-	-	-	-	-	-
CO 4	3	2	1	-	-	-	-	-	-	-	-	-	-	-
CO 5	3	2	1	-	-	-	-	-	-	-	-	-	-	-

LIST OF EXPERIMENTS:

1. Demonstration of class and objects.
2. Read a dataset, describe, visualize and provide inference.
3. Implement the Sorting algorithms: Selection Sort, Merge Sort, Quick Sort, Radix Sort.
4. Define Single Linked List ADT: Insertions, Deletions, Display
5. Define Doubly Linked List ADT and perform all standard operations.
6. Define Stack and Queue ADTs and implement standard operations
7. Implementation of Binary Search Tree: Insertion, Deletion, Traversal
8. Implementation of Graph traversal techniques.
9. Implementation of Hashing.
10. Implementation of Rabin-Karp algorithm

TEXTBOOKS:

1. Narasimha Karumanchi, "Data Structures and Algorithmic Thinking with Python", Career Monk Publications, 2016
2. Jake VanderPlas, Python Data Science Handbook, OReilly, 2017

SUGGESTED READING:

1. Michael T. Goodrich, Roberto Tamassia, Michael H. Goldwasser, “Data Structure and Algorithms in Python”, Wiley, 2013.

2. Kenneth A. Lambert, "Fundamentals of Python: Data Structures", Cengage Learning,2018.
3. Narasimha Karumanchi, “Data Structures and Algorithms for GATE”, Career Monk Publications,2011.
4. Wes McKinney, “Python for Data Analysis Data Wrangling with Pandas, NumPy, and IPython”,2nd Ed, O Reilly, 2018

Online Resources:

1. https://www.geeksforgeeks.org/data-structures/
2. https://www.coursera.org/specializations/data-structures-algorithms3.
3. https://nptel.ac.in/courses/106/106/106106182/
4. https://www.cs.usfca.edu/~galles/visualization/Algorithms

22CHC05

FLUID MECHANICS LAB

Instruction	3 P Hours per week
Duration of SEE	3 Hours
SEE	50 Marks
CIE	50 Marks
Credits	1.5

COURSE OBJECTIVES: This course aims to

1. Gain knowledge in verification of principles of fluid flow
2. Achieve training to use various flow measuring devices
3. Practice estimating frictional losses
4. Accumulate knowledge in measuring pressure, discharge and velocity of fluid flow.
5. Gain knowledge in usage of pumps

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Identify variable area flow meters and variable head flow meters
2. Explain the fluid flow characteristics.
3. Demonstrate the Bernoulli principle
4. Analyze the flow of fluids through closed conduits, open channels
5. Interpret the characteristics of pumps

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	-	2	-	-	-	1	2	1	-	1	2	2
CO2	2	2	-	2	-	-	-	1	2	1	-	1	2	2
CO3	2	2	-	2	-	-	-	1	2	1	-	1	2	2
CO4	2	2	-	2	-	-	-	1	2	1	-	1	2	2
CO5	2	2	-	2	-	-	-	1	2	1	-	1	2	2

LIST OF EXPERIMENTS: Minimum of 10 experiments in the list are to be performed

1. Determination of discharge coefficient for Orifice meter and Venturimeter and their variation with Reynolds number
2. Determination of weir meter constant K for V notch / rectangular notch
3. Determination of discharge coefficient for Mouthpiece under constant head and variable head
4. Calibration of rotameter and study of variation of flow rate with tube to float diameter.
5. Determination of friction factor for flow through straight pipes of different diameters and study of variation of friction factor with Reynolds number
6. Determination of friction losses in pipe fittings
7. Determination of characteristic curves for centrifugal pumps
8. Determination of friction factor for packed beds
9. Determination of velocity profile of air in pipe by pitot tube
10. Determination of critical velocity by Reynolds Experiment

TEXTBOOKS:

1. W. L. McCabe, J. C. Smith and P. Harriott, Unit Operations of Chemical Engineering,7 th Ed., Tata- McGraw Hill Chemical Engineering Series, New Delhi, 2005.

SUGGESTED READING:

1. Kurmi, R.S., “Hydraulics, Fluid Mechanics and Hydraulic Machines”, 20th Ed., S. Chand and Company Pvt. Ltd., New Delhi, 2014

22CHC06

MECHANICAL UNIT OPERATIONS LAB

Instruction	3 P Hours per week
Duration of SEE	3 Hours
SEE	50 Marks
CIE	50 Marks
Credits	1.5

Prerequisites: Mathematics, Physics, Chemistry

COURSE OBJECTIVES: This course aims to

1. Provide the opportunity to acquire practical skills in mechanical unit operations.
2. Introduce the principles, importance of material handling.
3. Provide an overall view of size reduction equipment.
4. Demonstrate the techniques of separating solids based on size by different methods.
5. Impart the concept and functioning of the filtration unit.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Assess the nature of solids, their characterization, handling and the processes involving solids
2. Analyze the performance of size reduction equipment and calculate the power and efficiency requirements
3. Identify the principle, construction and operation of various classification equipment
4. Select the suitable Solid -Liquid industrial separation equipment based on settling, density and centrifugal force
5. Estimate the cake properties in a filtration operation

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	3	2	1	2	3	3	3	1	1	3	3
CO2	3	3	2	2	2	1	2	3	3	3	1	1	3	3
CO3	3	3	3	3	2	1	2	3	3	3	2	2	3	3
CO4	3	3	2	3	2	1	2	3	3	3	2	1	3	3
CO5	3	3	2	2	2	1	2	3	3	3	2	1	3	3

LIST OF EXPERIMENTS: Minimum of 10 Experiments in the list are to be performed

1. Verification of the laws of size reduction using Jaw crusher.
2. Verification of the laws of crushing using drop weight crusher and determination of work index.
3. Determination of laws of crushing in a pulverizer.
4. Verification of the laws of crushing and determine angle of nip using roll crusher.
5. Verification of the comminution laws and critical speed of a ball mill.
6. Analysis of various sizes of given material by sieve analysis and determination of cumulative and differential analysis.
7. Determination of the specific cake resistance and medium resistance in a vacuum filter or plate and frame filter press.
8. Calculation of the effectiveness of screen in horizontal and inclined position (vibrating screens)
9. Determination of separation factors of air and hydraulic classifiers.
10. Determine settling rate classification of particles using cyclone separator and to determine the efficiency.
11. Determination of the froth flotation characteristics in mineral concentration.
12. Study of the sedimentation characteristics of a thickener and design of a continuous thickener

TEXTBOOKS:

1. W. L. McCabe, J. C. Smith and P. Harriott , Unit Operations of Chemical Engineering, 7th Ed., Tata-McGraw Hill Chemical Engineering Series, New Delhi, 2005.
2. Foust A.S, Wenzel L.A., "Principles of Unit Operations", 2nd Ed., John Wiley and sons, NewYork, 1981.

Suggested Readings:

1. Coulson, J. M., and Richardson, J. F., "Chemical Engineering Series", Vol. 2, 4th Ed., Pergamon Press Oxford, UK, 1991.
2. C M Narayanan and B C Bhattacharya, "Mechanical Unit Operation for Chemical Engineering", Khanna Publishers, 3rd Ed, 2011.

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY

(In line with AICTE Model Curriculum with effect from AY 2023-24)

B. Tech (Chemical Engineering)

SEMESTER IV

S. No	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours per Week			Duration of SEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1	22CHC07	Chemical Engineering Thermodynamics-II	3	-	-	3	40	60	3
2	22CHC08	Chemical Technology	3	-	-	3	40	60	3
3	22CHC09	Heat Transfer	3	-	-	3	40	60	3
4	22CHC10	Instrumentation and Material Characterization	2	-	-	3	40	60	2
5	22CHC11	Mass Transfer Operations- I	3	1	-	3	40	60	4
6	22CHEXX	Professional Elective I	3	-	-	3	40	60	3
7	22EGM01	Indian Constitution and Fundamental Principles	2	-	-	2	--	50	NC
PRACTICAL									
8	22CHC12	Heat Transfer Lab	-	-	3	3	50	50	1.5
9	22CHC13	Instrumentation and Material Characterization Lab	-	-	3	3	50	50	1.5
TOTAL			**19**	**01**	**06**	**-**	**340**	**510**	**21**
Clock Hours Per Week: 26									

Professional Elective I	
22CHE01	Energy Engineering
22CHE02	Food Processing Technology
22CHE03	Pulp and Paper Technology
22CHE04	Water Conservation and Management

22CHC07

CHEMICAL ENGINEERING THERMODYNAMICS – II

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES: This course aims to

1. Familiarize with the theory of Solution Thermodynamics
2. The concepts of fugacity in mixtures and various methods to obtain Fugacity Coefficient in mixtures.
3. Phase Rule and Various models used to determine the activity coefficients.
4. Calculation procedure to generate Vapour- Liquid Equilibrium (VLE) in form of T-x-y or P-x-y formiscible binary mixtures.
5. Methodology adopted to determine equilibrium constant.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Evaluate Partial molar, Residual and Excess properties.
2. Estimate Fugacity and Fugacity Coefficients for miscible binary Mixtures and also pure species.
3. Determine the activity coefficient using various models
4. Analyze Bubble and Dew point calculations for Ideal and Non Ideal solutions using VLE data
5. Predict equilibrium constant and composition of product mixture at given temperature and pressure

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3	3	1	1	1	0	0	1	1	0	1	3	3
2	3	2	1	0	0	0	1	0	0	0	0	1	3	3
3	3	1	1	1	0	0	0	0	1	1	0	1	3	3
4	3	3	2	0	0	1	0	0	0	0	0	0	3	3
5	3	3	1	0	0	0	1	0	0	1	0	1	3	3

UNIT I

Solution Thermodynamics theory: Fundamental property relation, Chemical potential and phase equilibria, Partial molar properties, Determination of partial molar properties, Relation between the partial molar properties, The Gibbs-Duhem equation, Ideal gas mixture, Fugacity and fugacity coefficient for pure species, Fugacity and fugacity coefficient for a species in solution

UNIT-II

Solution Thermodynamics applications: Generalized Correlations for the Fugacity Coefficient, Ideal solution, Excess properties. Liquid phase properties from VLE data, Models for the Excess Gibbs free energy, Activity coefficient as the partial molar excess Gibbs free energy, One parameter and two parameter Margules equations, van Laar equations for activity coefficients.

UNIT-III

VLE using activity coefficient models, Estimating the constants in the Whol's, Margules and Van Laar equations from VLE data, infinite dilution data and azeotropic data, Property change of mixing, Basics of UNIFAC model, NRTL model, UNIQUAC model (Qualitative treatment only).

UNIT-IV

Phase Equilibrium: The nature of equilibrium, The phase rule and the Duhem theorem, Qualitative behaviour of VLE, P-x-y and T-x-y diagrams, Raoult's law for VLE, VLE by modified Raoult's law, Henry's Law, Liquid- liquid equilibrium, VLLE, SLE, SVE, Azeotrope formation, Types of Azeotropes. Methodology for Bubble and dew point calculations, Flash calculations.

UNIT-V

Chemical Reaction Equilibria: The Reaction Coordinate, Application of Equilibrium Criteria to Chemical Reactions, The Standard Gibbs-Energy Change and the Equilibrium Constant, Effect of Temperature on the Equilibrium Constant, Evaluation of Equilibrium Constants, Relation of Equilibrium Constants to Composition, Equilibrium Conversions for Single Reactions, Phase Rule and Duhem's Theorem for Reacting Systems Multireaction Equilibria

TEXTBOOKS:

1. Smith J.M., Van Ness H.C., Abbott M.M., Swihart M.T., Introduction to Chemical Engineering Thermodynamics, 8th Edition, Tata McGraw Hill, 2018.
2. Narayanan K. V., Chemical Engineering Thermodynamics, PHI, 2000.

SUGGESTED READINGS:

1. Milo D. Koretsky, Engineering and Chemical Thermodynamics, 2nd Edition, John Wiley &Sons, Inc., 2013.
2. Introduction to Chemical Engineering Thermodynamics. Front Cover. Gopinath Halder, Prentice-Hall Of India Pvt. Limited, 2009.
3. Y.V.C. Rao., "Chemical Engineering Thermodynamics", University Press Hyderabad, 2005.
4. Kyle B.G., Chemical and Process Thermodynamics, 3rd Edition, Pearson, 1999

22CHC08

CHEMICAL TECHNOLOGY

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES: This course aims to

1. Concept of unit operations and unit processes in chemical process industry.
2. Flow diagrams that explain the conversion of raw materials to finished products.
3. Exposure to Organic and Inorganic processes.
4. Process limitations and scale-up information.
5. Application of catalysts in various processes.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Differentiate between unit operation and unit processes.
2. Estimate the chemical industry growth and opportunities.
3. Develop flow diagrams of different processes.
4. Classify between Inorganic and Organic processes.
5. Design processes based on conditions space time, yield, conversion, recycle methods, temperature and pressure.

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	3	3	2	2	2	0	0	0	0	0	1	2	1
2	3	1	3	2	2	0	0	0	0	0	0	0	1	2
3	3	1	3	1	1	0	0	0	0	0	0	1	2	2
4	3	0	2	2	3	1	0	0	0	0	0	0	1	1
5	0	0	1	2	2	2	0	0	0	0	0	0	0	1

UNIT-I

Classification of Indian Chemical Industry, Introduction to unit operations and unit processes. Metallurgical Industry overview – classification of metals, manufacturing of pig Iron by blast furnace, Inorganic chemical industries (sulfuric acid, phosphoric acid, chlor-alkali industry). Overview of Pharmaceutical industry and classification of pharmaceutical chemical forms.

UNIT-II

Production of Green Hydrogen. Manufacturing of Ammonia. Urea manufacturing by various processes. Manufacturing of Mono ammonium Phosphate, Di ammonium Phosphate. Manufacturing of Single super Phosphate and Triple super Phosphate.

UNIT-III

Introduction to Ceramics and its applications, Cement: Raw materials, Manufacturing of Portland cement, Cement types and composition. Glass: Raw materials - Manufacturing – Types of glasses – uses.

UNIT-IV

Classification of Plastics, Manufacturing of Phenol formaldehyde resin, Polyethylene, Polypropylene, PVC, PVA, Synthetic fibers-Manufacturing of Nylon–6-6, Polyester Fiber-Classification of rubbers and Manufacturing of SBR.

UNIT-V

Natural products industry: Pulp and Paper-Methods of pulping production. Recovery of chemicals from black liquor. Production of paper. Oils, Soaps and Detergents: Definitions, constituents of oils, Extraction and expression of vegetable oil. Refining and Hydrogenation of oils. Continuous process for the production of Fatty acids and Soap. Sugar: Raw and refined sugar, By products of sugar industries.

TEXTBOOKS:

1. Rao, M. G. and Sittig, M., "Dryden's outlines of Chemical Technology for the 21st Century, 3rd Ed., Affiliated East-West Press, New Delhi, 1998.
2. George T. Austin, ―Shreve's Chemical Process Industries‖, 5th edition. McGraw Hill Book Company, 1984.

SUGGESTED READINGS:

1. Remington-The Science and Practice of Pharmacy (Vol.1& 2), David B. Troy, 21st edition, 2006, Lippincott Williams &Wilkins.
2. Andreas Jess and Peter Wasserscheid, "Chemical Technology: An Integral Textbook", John Wiley and Sons, Inc., New York, 2000.
3. Faith, W. L., Keys, D. B. and Clark, R. L., "Industrial Chemicals", 4th Ed., John Wiley, 1980.
4. Fertilizer Association of India, "Handbook of Fertilizer Technology", 2nd Ed., Scientific Publisher, New Delhi, 2009.

22 CHC09

HEAT TRANSFER

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisites: Material and Energy Balance Calculations, Mechanical Unit Operations, Fluid Mechanics

COURSE OBJECTIVES: This course aims to

1. Basic concepts of heat transfer
2. Convective heat transfer and the concept of dimensional analysis
3. Concept and functioning of different heat exchangers
4. Heat transfer with change of phase and the functioning of evaporators
5. Radiation laws and the concept of radiation shields

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Understand the different modes of heat transfer, conduction heat transfer through the different geometries under steady & unsteady state conditions
2. Calculate the heat transfer coefficients under the forced, natural convection and understand the concepts of heat exchangers and its design
3. Analyze the heat transfer phenomena in fluids involving phase changes
4. Identify the type of evaporator required for a specific purpose and its design
5. Understand the concept of radiation, laws of radiation and the impact of radiation shields

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	2	2	-	2	2	1	1	3	2
CO2	3	3	3	1	1	2	2	-	2	2	1	1	3	2
CO3	3	3	3	1	1	2	3	-	2	2	1	1	2	3
CO4	3	3	2	1	1	2	2	-	2	2	1	1	2	2
CO5	3	3	3	1	1	2	3	-	2	2	1	1	2	3

UNIT-I

Fundamentals of Heat Transfer - Modes of Heat Transfer, Derivation of Heat conduction equations in rectangular co-ordinates, thermal diffusivity, Differential equations of heat transfer-special forms – cylindrical co-ordinates system. One dimensional problem, heat transfer from extended surfaces, two dimensional problems, Lumped capacity systems, Insulation.

UNIT-II

Convective Heat Transfer: - natural and forced convection in laminar and turbulent flow over plates and tubes. Dimensional analysis, thermal boundary layer, analogies and correlations. Design of heat transfer equipment - Double pipe heat exchanger, Concept of LMTD, Shell and tube Exchanger – Kern's method of design, Effectiveness - NTU methods

UNIT-III

Design aspects of finned tube and other compact heat exchangers. Basics of heat Transfer with change of phase - Introduction to boiling. Types of boiling, Regimes of pool boiling and critical heat flux. Nucleate Boiling- Bubble formation, its growth and motion Introduction to condensation, Derivation of Nusselt's equation. Design aspects of Condensers.

UNIT-IV

Types of Evaporators, Capacity and Economy of Evaporators, Design aspects of Evaporators – Material and energy Balances of single and multiple effect evaporators. Heat Transfer to agitated vessels. Description and working of crystallizers.

UNIT-V

Radiation – Fundamentals of Radiation Heat Transfer, Laws of black body Radiation, Radiating heat exchange between non-black body surfaces, combined heat transfer by conduction, convection and radiation, Radiation Shields

TEXTBOOKS:

1. W.L.Mc Cabe, J.C. Smith and P. Harriott, Unit Operations of Chemical Engineering" 7th Edition, Tata-McGraw Hill, New Delhi , 2005
2. D.Q. Kern, "Process Heat Transfer" 1st Edition Tata-McGraw Hill Publishers, New Delhi, 2001

SUGGESTED READINGS:

1. Coulson JM and Richardson, J.F, Chemical Engineering Series, Vol 1, 4th Edition, Pergamon Press Oxford, UK, 1991
2. B K Dutta, Heat Transfer Principles and applications, PHI Learning Pvt Ltd, New Delhi, 2004
3. Holman, J.P.S. Bhattacharya. Heat Transfer, 10th Edition, Tata-McGraw Hill, 2011

22CHC10

INSTRUMENTATION AND MATERIAL CHARACTERIZATION

Instruction	2 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	2

Prerequisites: Engineering Chemistry, Engineering Physics

COURSE OBJECTIVES: This course aims to

1. The components and characteristics of industrial measurement systems
2. Different types of temperature and pressure measuring instruments and their industrial applications
3. Different types of flow meters and level measuring instruments
4. Different types of microscopic analysis
5. Different types of spectroscopic and chromatographic analysis

COURSE OUTCOME: At the end of the course, the students will be able to

1. Understand the measurement techniques of different process variables
2. Select temperature, pressure, level, and flow measuring instruments based on their operation
3. Explain the morphological and crystallographic characterization techniques
4. Infer the characterizations associated with spectroscopy
5. Explain the concepts of rheology and chromatographic analysis

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	-	-	1	2	-	1	-	-	-	2	1	2	2
2	2	-	-	1	3	-	1	-	-	-	1	2	2	2
3	3	1	-	2	3	-	1	-	-	2	2	2	2	2
4	3	1	-	2	3	-	1	-	-	2	2	2	2	2
5	3	1	-	2	3	-	1	-	-	2	2	2	2	2

UNIT- I

Introduction to Instrumentation: Elements of instruments, static and dynamic characteristics, process variables, Measurement of process variables, sensors and transducers, general Industrial instruments – I/P and P/I converters, pneumatic and electric actuators. P& ID diagrams and equipment symbols.

UNIT- II

Importance of industrial instrumentation: Need, significance, applications and classifications. Familiarization with temperature, pressure, level and flow measuring instruments.

UNIT- III

Morphology, surface and Crystallographic Analysis: Theory, working principles, applications of X-ray diffraction (XRD), optical microscopy, scanning electron microscope (SEM), transmission electron microscopy (TEM), BET analysis.

UNIT- IV:

Spectroscopy: Theory, working principles, applications of UV-Vis absorption spectroscopy, fluorescence spectroscopy, Fourier Transform Infra Red (FTIR) spectroscopy, Raman spectroscopy.

UNIT- V:

Chromatography and Rheology: Basic concepts of chromatographic techniques (High-performance liquid chromatography, ion exchange chromatography, gel chromatography, and gas chromatography), viscometer, and tensiometer.

TEXTBOOKS:

1. Characterization of Materials, 2 Volume Set by Elton N. Kaufmann-Wiley-Interscience 2003.
2. Principles of Instrumental Analysis by D.A. Skoog, F.J. Holler, and T.A. Nieman, 7th edition, Cengage Learning, 2018.
3. Principles of industrial instrumentation, D. Patranabis, 2nd ed., Tata McGraw Hill Edu. (India) Pvt. Ltd., New Delhi, 2013.

SUGGESTED READINGS:

1. Instrumental Method of Chemical Analysis by G.R. Chatwal, and S.K. Anand, Himalaya Publishing House, 2005.
2. Chromatographic Methods by A. Braithwaite, and F.J. Smith, 5th edition, Blackie Academic and Professional, London, 1996.

22CHC11

MASS TRANSFER OPERATIONS-I

Instruction	3 L+1T Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	4

Prerequisite: Knowledge of differential and partial differential equations and MEBC.

COURSE OBJECTIVES: This course aims to

1. Identify diffusion phenomena in various chemical processes.
2. Calculate mass transfer coefficients at interfaces of multiphase mass transfer systems.
3. Design equipment for gas-liquid mass transfer operations.
4. Understand the humidification operation with design of cooling tower.
5. Understand the drying concept with its mechanism.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Apply the concepts of diffusion mass transfer to fluids and solids.
2. Estimate the mass transfer coefficients of mixtures.
3. Design Absorber/Stripper by equilibrium methods
4. Design the cooling tower with the concept of humidification.
5. Interpret the drying mechanism by estimating the total drying period.

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	-	-	1	2	-	-	-	2	3	3	3
CO2	3	3	2	-	2	-	2	-	2	-	2	3	3	3
CO3	3	3	3	2	1	2	2	-	-	-	-	-	3	3
CO4	3	3	2	-	2	-	2	-	2	-	2	3	3	3
CO5	3	3	3	-	-	-	-	-	-	-	-	2	2	3

UNIT-I

Diffusion Mass Transfer: Introduction of Mass transfer operations & their applications, Choice of separation methods, Concept of driving force and flux, Molecular and eddy diffusion –Fick's first and second law, Steady state molecular diffusion in binary mixtures of gases, liquids and solids, Gas and liquid phase diffusion coefficient measurement and prediction, diffusivity in solids and its applications, Film mass transfer coefficients for the cases of equimolar counter diffusion and diffusion of one component (A) in stagnant component (B).

UNIT – II

Mass Transfer Coefficient & Interphase Mass Transfer: Mass transfer coefficients, Mass Transfer Theories-Film theory, penetration theory, surface renewable theory, Interphase mass transfer theory, Overall mass transfer coefficients – Two resistance theory – Gas phase and liquid phase-controlled situations. Gas – liquid contact: Description of Continuous and stage wise contact equipment. Correlations for mass transfer coefficients and Reynolds & Colburn analogies.

UNIT – III

Absorption and Stripping: Introduction to absorption, Equilibrium in gas-liquid system, and minimum liquid rate, Design of packed column 27 based on Individual and overall mass transfer coefficients, Counter current multistage operations, Determination of number of plates – absorption factor. Determination of number of transfer units and height of a continuous contact packed absorbers. Kremer – Brown equation

UNIT – IV

Humidification: Basic concepts of vapor-gas mixtures- absolute humidity, relative humidity and adiabatic saturation temperature, dew point and wet bulb temperatures, psychometric charts – Enthalpy of gas vapor mixtures, Humidification, and dehumidification – Operating lines and design for cooling towers.

UNIT – V

Drying: Moisture contents of solids – equilibrium moisture, bound and unbound moisture. Design conditions – Rate of batch drying under constant drying conditions – Mechanism of batch drying – total time for batch drying, Description of batch and continuous dryers.

TEXTBOOKS:

1. R.E. Treybal, "Mass Transfer operations", 3rd Edition, McGraw Hill Book Co., 1981
2. B. K. Datta "Principles of Mass Transfer and Separations Processes" PHI Learning Private Limited, New Delhi, 2009.

SUGGESTED READINGS:

1. Christie John Geonkoplis "Transport Processes and Separation Process Principles", 4th edition. PHI, New Delhi.
2. J Coulson and Richardson,"Fluid Flow, Heat and Mass Transfer", Volume 1, 6th Edition, Pergoman Press, 2009
3. W.L.McCabe, Julian C. Smith, Peter Harriott, Unit Operations of Chemical Engineering, 7th Edition, 2005.

22CHE01 **ENERGY ENGINEERING**

(Professional Elective I)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES: This course aims to

1. Gain knowledge on various energy sources and their applications
2. Know emerging technologies viz., fuel cells, biofuels etc.
3. Know the processes of crude fuels
4. Understand the advantages and disadvantages of various energy sources
5. Familiarize the concepts of energy audit and conservation

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Explain the conventional and non-conventional energy sources and discuss the characterization and production methods of non-conventional energy sources.
2. Illustrate the principles and applications of solar energy and photovoltaic cells.
3. Summarize the basic principles of wind energy, hydropower and tidal Energy
4. Explain the importance of biofuels and classify them
5. Demonstrate the need for energy auditing and conservation, identify strategies for reducing energy consumption and increasing efficiency.

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	1	-	-	3	-	-	-	-	-	-	-	-
CO2	1	2	1	-	-	3	-	-	-	-	-	-	-	-
CO3	1	2	1	-	-	3	3	-	-	-	-	-	2	2
CO4	1	2	1	-	-	3	3	-	-	-	-	-	2	2
CO5	1	2	1	-	-	3	3	-	-	-	-	-	2	1

UNIT-I

Introduction: Introduction to conventional and non-conventional energy sources, alternative energy sources, their significance and availability

Conventional Energy Sources: Wood and wood Charcoal, products of wood carbonization Coal and Coal derived fuels, characteristics, production methods and uses.

Oil and Gases: Fuels derived from oil and gases, Characteristics, production methods and uses. Technology for combustion of fuels derived from oil and gas. Shale oil and gas, oil sands

UNIT-II

Non-conventional Energy Sources: Solar Energy: Basics, Types of Solar Energy Collectors, Applications-Solar Distillation, pumping, production of hydrogen.

Photo Voltaic Cells: Introduction, Types of photo voltaic Cells, Applications, Electrical Storage and Future developments

UNIT-III

Wind-Energy: Introduction, Basic principles of wind energy conversion. Types of wind machines

Hydropower: Introduction, Capacity and Potential, Small hydro, Environmental and social impacts.

Tidal Energy: Introduction, Capacity and Potential, Principle of Tidal Power, Components of Tidal Power Plant, Classification of Tidal Power Plants

UNIT-IV

Bio Fuels: Introduction, Bio mass conversion technologies- Wet processes, dry processes, Bio-gas generation. Factors affecting bio-digestion, Classification of biogas plants Production methods, characteristics, uses of biodiesel, bio-butanol and bio-ethanol, Second generation bio-fuel feed stocks

UNIT-V

Energy Auditing and Conservation: Short term, medium-term, long-term schemes, energy conversion, energy index, energy cost, representation of energy consumption, Sankey diagram, energy auditing. Conservation methods in process industries, theoretical analysis, practical limitations

TEXTBOOKS:

1. G D Rai, Non -conventional energy sources, Khanna Publishers, 4th edition, 2000
2. Samir Sarkar, Fuels and Combustion, Universities Press, 3rd Edition, 2009

SUGGESTED READINGS:

1. S P Sukhatme, J Nayak, Solar Energy: Principles of Thermal Collection and Storage, Tata McGraw-Hill, 2008
2. S B Spandya, Conventional Energy Technology: Fuel and Chemical Energy, Tata McGraw-Hill, 1987
3. John Twidell and Tony Weir, Renewable Energy Resources, Routledge, 2015
4. W R Murphy , Energy management, 1st Edition, , G McKay Butterwolfer and Co. Ltd.,2001

22CHE02

FOOD PROCESSING TECHNOLOGY

(Professional Elective I)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES: This course aims to

1. Basic food processing methods.
2. Physical, chemical, and/or microbiological changes in food and mechanical manipulation.
3. Learn fundamentals of modifying food to meet current nutrition recommendations.
4. Learn to find credible sources of information on food science and nutrition.
5. Food processing Applications and Packaging

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Understand food demand scenario with respect to world and India
2. Explain heat effects and food processing on sensory and nutritional characteristics of food
3. Analyze various techniques of raw material preparation and design process equipment to achieve the desired quality of food.
4. Develop novel food processes that have a minimal effect on food quality.
5. Know different types of packaging and packaging materials for effective food packaging.

CO-PO-PSO Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	2	2	2	3	3	3	3	2	2	2	1	1
CO2	3	2	2	2	3	2	1	1	1	-	-	3	3	2
CO3	3	3	3	3	3	2	2	1	1	-	-	3	3	3
CO4	3	3	3	3	3	2	2	1	1	-	-	3	3	3
CO5	3	3	2	3	2	1	2	2	1	-	-	3	3	2

UNIT – I

Introduction: General aspects of food industry, World food demand and Indian scenario, Constituents of food – components of food technology, Quality and nutritive aspects, Product and Process development – stages of new product development process, engineering challenges in the Food Processing Industry.

UNIT – II

Basic principles: Properties of foods and processing theory, Heat transfer, Effect of heat on micro-organisms, Basic Food Biochemistry and Microbiology: Food Constituents; Food fortification, Water activity, Effects of processing on sensory characteristics of foods, Effects of processing on nutritional properties, Food safety, good manufacturing practice and quality Process Control in Food Processing.

UNIT – III

Ambient Temperature Processing: Raw material preparation - cleaning, sorting, grading, peeling; Size reduction of solid and liquid foods; Mixing and forming; Separation and concentration of food components - Centrifugation, filtration, expression, extraction, Membrane concentration, Fermentation and enzyme technology, Irradiation, Effect on micro-organisms, Processing using electric fields, high hydrostatic pressure, light or ultrasound.

UNIT – IV

Heat processing using steam, water and air: Blanching, Pasteurization, Heat sterilization, Evaporation and distillation, Extrusion, Dehydration, Baking and roasting; Heat processing by direct and radiated energy: Dielectric heating, Ohmic heating, Infrared heating, Gamma irradiation.

UNIT – V

Post Processing Applications Packaging – purpose, functions, characteristics, types of packaging - Theory and Types of packaging materials; Coating or enrobing, Printing, Interactions between packaging and foods, Environmental considerations.

TEXTBOOKS:

1. Fellows P., Food Processing Technology: Principles and Practice, Wood head publishing, 4th Edition, 2016.
2. Toledo R, Fundamentals of Food Process Engineering, Springer, 3rd Edition, 2010.

SUGGESTED READING:

1. Singh R.P. & Heldman D.R., Introduction to Food Engineering, Academic Press, 3rd Edition, 2000

22CHE03 PULP AND PAPER TCHNOLOGY

(Professional Elective I)

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

COURSE OBJECTIVES: This course aims to

1. Basic concepts of pulp and paper making processes
2. Comprehensive overview of products, process variables, equipment operation
3. Details of physical and chemical characteristics of fibrous raw materials and black liquor
4. Various types of pulping and bleaching methodologies
5. Recovery of energy and chemicals used in pulping processes with due techno-economic and environmental considerations.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Distinguish the important wood and fiber properties that affect paper quality
2. Identify, formulate and solve design problems pertaining to pulp digester
3. Select appropriate bleaching technique for required paper quality
4. Evaluate different grades of paper and boards based on testing methods
5. Identify the factors that drive paper industry trends

CO-PO- PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	2	2	3	1	-	-	-	-	2	2	2
CO2	2	2	2	2	2	-	1	-	-	-	-	1	2	3
CO3	3	2	2	1	1	-	1	-	-	-	-	2	2	2
CO4	3	1	2	2	1	-	1	-	-	-	-	2	3	3
CO5	3	1	2	2	-	-	2	1	-	-	-	2	2	2

UNIT I

Introduction: Importance of paper, Definition of pulp. Distribution of wood constituents – Cellulose, Hemi-cellulose, Lignin, Extractives and Inorganic components. Wood parts &types: Ultra structure of cell wall, Wood cell types, Early &Latewood, Softwoods & Hardwoods. Comparison of different raw materials for pulp & paper making.

UNIT II

Overview of pulping process: Mechanical Pulping: Pressurized ground pulping, Refiner Pulping, Chemo (thermo) mechanical pulping processes. Kraft Pulping: Composition & analysis of white liquor, Description of Kraft cooking process, Kraft recovery, process variables, Pulp yield, End uses of kraft pulps.

UNIT III

Pulp and black liquor characterization: Pulp testing methods – Kappa number, water retention value, CED viscosity, drainability, beater evaluation, zero span tensile strength.

Black liquor characterization - Chemical properties, viscosity, calorific value, thermal conductivity, specific heat, black liquor oxidation, desilication and concentration of black liquor.

UNIT IV

Bleaching operations: Objective of bleaching – Elemental chlorine free and Total chlorine free bleaching; Bleaching agents – form, function, advantages and disadvantages, bleaching sequences, Bleachability and its measurement, factors affecting the bleaching process.

Stages of bleaching – Oxygen delignification, Chlorination, Extraction, Hypochlorite bleaching, Ozone bleaching, Peroxide bleaching, ECF and TCF bleaching systems for chemical and mechanical pulps.

UNIT V

Paper Making and its Properties: Paper Testing Methods – Flow sheet of overall pulp and paper making process, Strength properties, Surface properties, Optical properties & Absorption properties. Different grades of paper, boards & news print specifications; BIS and ISO standards of paper. Paper properties dependence on paper making processes.

Paper recycling process, Effluent treatment processes with environmental considerations.

TEXTBOOKS:

1. Kenneth W. Britt, “Handbook of Pulp & Paper Technology”, 2nd Edition, Reinhold Publishing Corporation, 2004.
2. G. A Smook., “Handbook for Pulp & Paper Technologists”, 3rd Edition, Angus Wilde Publications, 2003.

SUGGESTED READINGS:

1. Hakan Karlsson, “Fiber Guide-Fiber analysis and process applications in the pulp & paper industry”, Ab Lorentz &Wetre, 1st Edition, 2006.
2. Fengel D. and Wegener G, “Wood-Chemistry, Ultra structure, Reactions”, Walter de Gruyter, Berlin, 2nd Edition, 1989.
3. EIRI Board. “Handbook of Pulp & Paper, Paper board and Paper based Technology”, Engineers India Research Institute, 2nd Edition, 2015

22CHE04 **WATER CONSERVATION AND MANAGEMENT**

(Professional Elective-I)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Pre-requisites: Environmental science (mandatory non-credit course)

Course Objectives: This course helps the students to understand:

1. Water sources, usage and need to protect them.
2. Water quality and standards
3. Water audits and testing methods.
4. Water management system.
5. Need for water conservation.

Course outcomes: At the completion of this course, students will be able to

1. Identify with the water storage methods in practice based on available sources and supply.
2. Understand the water quality parameters and analysis methods.
3. Categorize the basic characteristics of water and their testing methods.
4. Associate with the objectives of water harvesting and recycling methods.
5. Use of water conservation methods at work place, agriculture, service and process industry.

CO-PO-PSO MATRIX

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	-	-	-	3	3	2	1	1	1	1	-	1
CO2	-	-	-	-	-	3	3	2	1	1	1	1	-	1
CO3	-	-	-	-	-	3	3	2	1	1	1	1	-	1
CO4	-	-	-	-	-	3	3	2	1	1	1	1	-	1
CO5	-	-	-	-	-	3	3	2	1	1	1	1	-	1

UNIT – I Introduction:

Sources of water, Hydrologic cycle, multiple cycles – evaporation, precipitation, infiltration, runoff and subsurface flow. sources of water supply, need to protect them, types of water storage systems in practice like bowlis, tanks.

UNIT – II Water quality and standards:

water quality classification system in India, water quality parameters - Physical, chemical and microbiological characteristics of water, standards of drinking water prescribed by different agencies, permissible limits of constituents of raw water supplied to industries, tolerance limits of inland surface water, tolerance limits of industrial effluents.

UNIT – III Water management:

Water management services in India, key issues and principles of water management, integrated water resource management in India. Necessity and objectives of watershed management approaches, types of water harvesting – afforestation, rainwater harvesting, benefits, Water recycling – benefits and reuse drives.

UNIT – IV Water conservation:

Water conservation methods for minimising evaporation, water conservation practices, Khadins, Johads, Kuhls, Kattas, Check-dams. Water conservation practices - Case studies in fields of agriculture, work place, service industry, process industry.

UNIT – V Water audits and testing:

Water rights and laws, water policy objectives, water quality related issues in India, major factors for water quality degradation, water quality – testing, preserving and control methods. Analysis of water –Physical, chemical and bacteriological tests practiced.

Text Books:

1. Elements of Water Pollution Control Engineering, OP Gupta, Khanna Publishing House, Delhi, 2019.
2. Glenn O. Schwab and R K Frevert, Water Conservation and Management Soil and Water Conservation Engineering, 3rd Ed., John Wiley & Sons, 1981

Suggested reading:

1. Water Supply and Sanitary Engineering, Rangwala, Charotar Publications, 2006.

22EGM01 INDIAN CONSTITUTION AND FUNDAMENTAL PRINCIPLES

(BE/B.Tech - Common to all branches)

Instruction	2 L Hours per week
Duration of Semester End Examination	2 Hours
Semester End Examination	50 Marks
CIE	-
Credits	0

Prerequisite: Basic Awareness of Indian Constitution and Government.

COURSE OBJECTIVES: The course will introduce the students to:

1. Understand the history of framing of the Indian Constitution.
2. Awareness on Fundamental Rights, Duties and Directive Principles of State Policy.
3. Explore the organization of Union Government, and functions of President and Prime Minister.
4. Gain an insight into the inter-functionality of Union Legislature and Judiciary
5. Educate on the local governance and problems in development of rural and urban areas.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Understand the history of framing of the Indian Constitution and its features.
2. Assess the realization of Fundamental Rights and Directive Principles of State Policy.
3. Analyze the challenges to federal system and position of the President and the Prime Minister in the Union Government.
4. Underline the role of the Legislature and the Judiciary in Union Government and their mutual relations.
5. Evolve the development of the local governments in India and assess the role of Collector in district administration.

CO-PO Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	-	-	1	-	-	1	1	1	1	-	-	-	-	-
CO 2	-	-	2	-	-	3	2	2	1	-	-	-	-	-
CO 3	-	-	1	-	-	1	1	-	-	-	-	-	-	-
CO 4	-	-	1	-	-	1	1	-	-	-	-	-	-	-
CO 5	-	-	2	-	-	3	2	1	1	-	-	-	-	-

UNIT-I

Constitutional History and Framing of Indian Constitution: East India Company rule (1757-1857): Social, Economic, Political and Administrative impact of Company rule in India. British Rule (1858-1947): Indian National Movement, Government of India Acts 1909, 1919 and 1935, and Indian Independence Act 1947. Framing of the Indian Constitution: Constituent Assembly, Preamble and Salient Features.

UNIT-II

Fundamental Rights, Duties and Directive Principles of State Policy: The Fundamental Rights**:** Features and significance of Rights. Fundamental Duties: Importance and the legal status of Duties. Directive Principles of State Policy: Socialist, Gandhian and Liberal-intellectual principles, importance and relevance.

UNIT-III

Union Government and its Administration: Federalism: Division of legislative and financial powers between the Union and the State. Union Executive: Role and position of President, Prime Minister and Council of Ministers. Emergency Provisions: National Emergency, Constitutional Emergency and Financial Emergency.

UNIT-IV

Union Legislature and Judiciary: Union Legislature: Parliament of India-Composition and functions of Parliament, and Parliamentary Committees. Union Judiciary: Supreme Court of India-Composition and Functions.

UNIT-V

Local Self Governments: Rural Local Governments: Zilla Parishad- CEO and functions of Zilla Parishad, Mandal Parishad- Role of Elected and Officials, Gram Panchayat- Sarpanch, Secretary and Gram Sabha. Urban Local Governments: Structure and functions of Municipalities and Municipal Corporations. District Collector: Powers and functions of Collector.

TEXTBOOKS:

1. Sastry Ravindra, (Ed), "Indian Government & Politics", Telugu Akademy, 2nd edition, 2018.
2. "Indian Constitution at Work", NCERT, First edition 2006, Reprinted in 2022.

SUGGESTED READING:

1. D.D. Basu, "Introduction to the Constitution of India", Lexis Nexis, 2015.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar, "Framing of Indian Constitution", 1st Edition, 2015.
3. Granville Austin, "The Indian Constitution: The Cornerstone of a Nation", OUP, 2nd Edition, 1999.
4. M.V. Pylee, "India‟s Constitution", S. Chand Publishing, 16th Edition, 2017.
5. Rajeev Bhargava (ed), "Politics and Ethics of the Indian Constitution", OUP, 2008.

22CHC12 HEAT TRANSFER LAB

Instruction	3 P Hours per week
Duration of SEE	3 Hours
SEE	50 Marks
CIE	50 Marks
Credits	1.5

Prerequisites: Material and Energy Balance Calculations, Mechanical Unit Operations, Fluid Mechanics

COURSE OBJECTIVES: This course aims to

1. Understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries
2. Familiarize heat exchangers - working principles and basic geometries.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Evaluate the heat transfer rate through the solids and to determine thermal conductivity of different materials of varying geometries under the steady state conditions.
2. Estimate heat transfer coefficients and determine effectiveness of pin fin for free and forced convection
3. Determine surface emissivity of a test plane and Stefan-Boltzmann's constant and compare with theoretical values
4. Determine critical heat flux in pool boiling.
5. Estimate heat transfer coefficients and determine effectiveness of heat exchangers to analyze their performance.

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	2	2	-	2	2	1	1	3	2
CO2	3	3	3	1	1	2	2	-	2	2	1	1	3	2
CO3	3	3	3	1	1	2	3	-	2	2	1	1	2	3
CO4	3	3	2	1	1	2	2	-	2	2	1	1	2	2
CO5	3	3	3	1	1	2	3	-	2	2	1	1	2	3

LIST OF EXPERIMENTS

(Minimum of 10 Experiments in the list are to be performed)

1. Determination of Thermal conductivity of given insulating powder under steady state conditions
2. Determination of interface temperatures in composite wall under steady state conditions
3. Determination of Heat Transfer through Lagged Pipe.
4. Determination of Thermal Conductivity for a given Asbestos Insulating powder.
5. Determination of Critical Heat Flux for a given Nichrome wire
6. Determination of inside heat transfer coefficient in coil heat exchangers
7. Determination of overall heat transfer coefficient and effectiveness of a Double pipe heat exchanger
8. Determination of heat transfer area in a 1-2- shell and tube heat exchangers
9. Determination of heat transfer coefficient in a single tube by film wise and drop wise condensation
10. Determination of emissivity and Boltzmann’s constant of a sample body
11. Determination of heat transfer coefficient in forced convection
12. Determination of fin efficiency of longitudinal fins of extended surface
13. Determination of peak flux and critical temperature drop in pool boiling of saturated liquid

14. Determination of heat transfer coefficient of a pin fin under free convection
15. Determination of heat transfer coefficient of a pin fin under forced convection

TEXTBOOKS:

1. W L McCabe, J C Smith and P Harriott, Unit Operations of Chemical Engineering, 7th Ed., Tata-McGraw Hill Chemical Engineering Series, New Delhi, 2005

22CHC13

INSTRUMENTATION AND MATERIAL CHARACTERIZATION LAB

Instruction	3 P Hours per week
Duration of SEE	3 Hours
SEE	50 Marks
CIE	50 Marks
Credits	1.5

COURSE OBJECTIVES: This course aims to

1. Principles of different process instruments
2. Working principle of microscopes
3. Working principles and analysis processes of spectroscopic techniques
4. Working principles and analysis processes of characterization processes related to rheology and interfacial tension
5. Working principles and analysis processes of Chromatographic techniques

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Calibrate different process instruments.
2. Analyze and calculate the dimensions of microparticle
3. Estimate material concentrations in solutions
4. Identify functional groups and the composition of the materials
5. Determine viscosity and surface tension of liquids

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	3	1	-	-	2	2	1	1	3	2
CO2	3	2	-	3	3	1	-	-	2	2	1	1	2	2
CO3	3	2	-	3	3	1	-	-	2	2	1	1	2	3
CO4	-	1	-	2	3	1	-	-	2	2	1	1	2	3
CO5	3	2	-	3	3	1	-	-	2	2	1	1	2	2

LIST OF EXPERIMENTS

(Minimum of Ten Experiments in the list are to be performed)

1. Calibration of flow measuring instrument-Rotameter
2. Calibration of temperature measuring instrument-Mercury in glass thermometer
3. Estimation of the dimension of microparticles using Optical microscopy
4. Calculation of Dye concentration using UV-Vis spectroscopy
5. Calculation of Dye concentration using Fluorescence spectroscopy.
6. Identification of functional groups using FTIR Spectroscopy.
7. Calculation of heavy metal concentration using Atomic Absorption microscopy
8. Determination of viscosity using Viscometer/Rheometer
9. Determination of surface tension using Tensiometer
10. Estimation of gas composition using Gas chromatography
11. Calculation of alcohol concentration using High Pressure Liquid Chromatography
12. Estimation of Contact angle using contact angle goniometer

TEXTBOOKS:

1. Characterization of Materials, 2 Volume Set by Elton N. Kaufmann -Wiley-Interscience 2003.
2. Principles of Instrumental Analysis by D.A. Skoog, F.J. Holler, and T.A. Nieman, 7th edition, CengageLearning, 2018.
3. Principles of industrial instrumentation, D. Patranabis, 2nd ed., Tata McGraw Hill Edu. (India) Pvt. Ltd.,New Delhi, 2013.

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

Choice Based Credit System (With effect from 2024-2025)

B.Tech (Chemical Engineering)

V Semester

S.No	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours per			Duration of SEE in Hrs	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1	22MBC01	Engineering Economics & Accountancy	3	-	-	3	40	60	3
2	22CHC14	Chemical Reaction Engineering I	3	-	-	3	40	60	3
3	22CHC15	Mass Transfer Operations II	3		-	3	40	60	3
4	22CHC16	Process Modeling and Simulation	3		-	3	40	60	3
5	22CHEXX	Professional Elective - II	3	-	-	3	40	60	3
6	22XX OYY	Open Elective- I	3	-	-	3	40	60	3
7	22CEM01	Environmental Science	2			2	-	50	Non Credit
8	22CHI02	Internship	-	-	-	-	50	-	2
PRACTICAL									
9	22CHC17	Mass Transfer Operations Lab	-	-	3	3	50	50	1.5
10	22CHC18	Process Modeling and Simulation Lab	-	-	3	3	50	50	1.5
TOTAL			**20**	**-**	**06**	**-**	**390**	**510**	**23**
Clock Hours per week 26									

S.No	Course Code	**Professional Elective II**
1	22CHE05	Sustainable Engineering
2	22CHE06	Fertilizer Technology
3	22CHE07	Pollution Control in Process Industries
4	22CHE08	Polymer Science and Technology

S.No	Course Code	**Open Elective I**
1	22MEO01	Principles of Design Thinking
2	22CAO03	Introduction to Deep learning
3	22EEO06	Waste Management
4	22EGO01	Technical Writing Skills

22MBC01

ENGINEERING ECONOMICS AND ACCOUNTANCY

Instruction	3L Hours per week
Duration of Semester End Examination	3 Hours
Semester End Examination	60 Marks
CIE	40 Marks
Credits	3

Course Objectives:

This course aims to:

1. To demonstrate the importance of Managerial Economics in Decision Making.
2. To explain the concept of Accountancy and provide basic knowledge on preparation of Final accounts.
3. To understand the importance of Project Evaluation in achieving a firm's Objective.

Course Outcomes:

Upon completion of this Course, student will be able to:

1. Apply fundamental knowledge of Managerial Economics concepts and tools.
2. Analyze various aspects of Demand Analysis, Supply and Demand Forecasting.
3. Understand Production and Cost relationships to make best use of resources available.
4. Apply Accountancy Concepts and Conventions and preparation of Final Accounts.
5. Evaluate Capital and Capital Budgeting decisions based on any technique.

CO-PO Articulation Matrix

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	1	1	3	1	1	1	1	1	1	1	-	-
CO 2	2	2	2	2	-	1	1	1	-	1	-	1
CO 3	1	2	1	2	2	-	2	1	-	1	-	-
CO 4	2	2	1	2	2	1	1	3	-	1	-	-
CO 5	1	3	1	2	1	1	2	-	-	1	2	1

UNIT - I

Introduction to Managerial Economics: Introduction to Economics and its evolution - Managerial Economics - its Nature and Scope, Importance; Relationship with other Subjects. Its usefulness to Engineers; Basic concepts of Managerial economics - Incremental, Time perspective, Discounting Principle, Opportunity Cost, Equimarginal Principle, Contribution, Negotiation Principle.

UNIT - II

Demand and Supply Analysis: Demand Analysis - Concept of Demand, Determinants, Law of demand - Assumptions and Exceptions; Elasticity of demand - Price, Income and Cross elasticity - simple numerical problems; Concept of Supply - Determinants of Supply, Law of Supply; Demand Forecasting - Methods.

UNIT - III

Production and Cost Analysis: Theory of Production - Production function - Isoquants and Isocosts, MRTS, Input-Output Relations; Laws of returns.

Cost Analysis: Cost concepts – Types of Costs, Cost-Output Relationship – Short Run and Long Run; Market structures – Types of Competition, Features of Perfect Competition, Price Output Determination under Perfect Competition, Features of Monopoly Competition, Price Output Determination under Monopoly Competition Break-even Analysis – Concepts, Assumptions, Limitations, Numerical problems.

Unit - IV

Accountancy: Book-keeping, Principles and Significance of Double Entry Bookkeeping, Accounting Concepts and Conventions, Accounting Cycle, Journalization, Ledger accounts, Trial Balance concept and preparation of Final Accounts with simple adjustments.

Unit - V Capital and Capital Budgeting: Capital and its Significance, Types of Capital, Estimation of Fixed and Working capital requirements, Methods and sources of raising finance. Capital Budgeting, Methods: Traditional and Discounted Cash Flow Methods - Numerical problems.

Text Books:

1. Mehta P.L."Managerial Economics: Analysis, Problems and Cases", Sultan Chand & Son's Educational publishers, 2016.
2. Maheswari S.N. "Introduction to Accountancy", Vikas Publishing House, 12th Edition, 2018.

Suggested Readings:

1. Panday I.M. "Financial Management", 11th edition, Vikas Publishing House, 2016.
2. Varshney and K L Maheswari, Managerial Economics, Sultan Chand, 2014.
3. M. Kasi Reddy and S. Saraswathi, Managerial Economics and Financial Accounting, Prentice Hall of India Pvt Ltd, 2007.
4. R. Aryasri, Managerial Economics and Financial Analysis, McGraw-Hill, 2018.

22CH C 14 CHEMICAL REACTION ENGINEERING I

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Pre-requisites: Material and Energy Balance

Course Objectives: This course will help the students to understand the:
1. Analyze experimental kinetic data to determine reaction mechanisms.
2. Design different types of chemical reactors (Batch, Tube, and CSTR).
3. Assess the advantages and disadvantages of reactor types.
4. Understand the concepts of non-ideal reactors.

Course Outcomes: At the completion of this course, students will be able:
1. Classify reactions, rate and forms of rate expressions.
2. Summarize fundamentals of kinetics and interpret the data including relationships between moles, concentration, extent of reaction and conversion.
3. Explain Batch, CSTR, and PFR performance equations from general material balances for homogeneous and heterogeneous reactions.
4. Identify the right reactor among single, multiple, recycle reactors and determine the effect of temperature on reactor performance.
5. Analyze the non-ideality of reactors.

CO-PO-PSO Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	1	-	1	1	-	-	1	1	1	2
CO2	3	3	3	3	2	-	1	-	-	-	1	1	2	2
CO3	3	3	3	3	1	-	1	-	1	-	1	2	3	3
CO4	3	3	3	3	2	-	-	-	-	1	1	2	3	3
CO5	3	3	3	3	1	-	3	-	-	-	1	-	3	2

UNIT- I

Analysis and Correlation of experimental kinetic data: Introduction: Classification of Reactions, Definition and variables affecting the rate of reaction. The rate equation and Stoichiometric relations for a single phase reaction $aA+bB \rightarrow rR+sS$. Single and multiple reactions, Elementary and non-Elementary reactions, Molecularity and order of Reaction, Specific reaction rate constant, Testing kinetic models – Steady state approximation, Equilibrium treatment, Fitting a rate law for the given reaction mechanism, predictability of reaction rate from theory. Temperature dependency from Arrhenius‟ law, Thermodynamics, Collision theory and Transition state theory, Comparison of theories with Arrhenius‟ law.

UNIT- II

Analysis and Correlation of experimental kinetic data: Constant volume batch reactor: Analysis of total pressure data, conversion. Integral method of analysis of data for single reaction, multiple reactions, Homogeneous catalyzed reactions, Auto catalytic reactions, Reversible reactions, and Reactions of shifting orders. Half-life method, Partial analysis of the rate equation. Differential method of analysis of data.

Variable Volume Batch Reactor: Fractional change in volume of the system, Differential method of analysis, Integral method of analysis.

UNIT- III

Concepts Introduction to Reactor Design: Ideal reactors for a single reaction, generalized material balance, design equations-Ideal batch reactor, Space time – space velocity, Steady state mixed flow reactor, Steady state plug flow reactor, Holding time and space time for flow reactors, graphical interpretation. Design for single reactions, Size comparison of single reactors, Multiple reactor systems, Recycle reactor, Auto catalytic reactions –optimum recycle operation, Reactor combinations

UNIT- IV

Design for Multiple Reactions: Series, Parallel and Independent reactions, Selectivity, Yield, Qualitative discussion about product distribution, Quantitative treatment of product distribution and of reactor size.

Temperature and Pressure effects for single reactions, Heat of reaction from thermodynamics, Heat of reaction and Temperature, Equilibrium constants and equilibrium conversions from Thermodynamics. General graphical design procedure, Optimum temperature progression. Heat effects, Adiabatic Operations, Non adiabatic operations. Exothermic reactions in mixed flow reactors – a qualitative treatment.

UNIT- V

Basics of Non-Ideal flow: The residence time distribution (R T D), State of aggregation of the flowing stream, earliness of mixing, Role of R T D, state of aggregation and earliness of mixing in determining reactor behavior. Exit age distribution of fluid, Experimental methods for finding E – pulse and step input experiments, Relationship between F and E curves. The convolution integral. Conversion in non- ideal flow reactors,

Dispersion model-Axial dispersion and correlations for axial dispersion.

Text Books

1. Octave Levenspiel, Chemical reaction Engineering, 3rd Ed, Wiley India Pvt. Ltd, New Delhi, 2006.
2. H. Scott Fogler, Elements of Chemical Reaction Engineering, Prentice Hall, Third Edition, 2002.

Suggested Reading:

1. J. M. Smith, Chemical Engineering Kinetics, McGraw – Hill , Third Edition, 1981
2. L. D. Schmidt, The Engineering of Chemical Reactions, Oxford Press, 2 nd Edition, 2004.

Online Resources:

1. https://archive.nptel.ac.in/courses/103/103/103103153/

22CHC15 **MASS TRANSFER OPERATIONS II**

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Pre-requisites: Mass Transfer Operations I

Course Objectives: This course will

1. Provide students the opportunity to acquire understand the concepts of distillation.
2. Introduce students to the importance and principles of liquid-liquid extraction over distillation.
3. Provide an overall view of design concepts solid liquid extraction process.
4. Understand the concept of adsorption and its applications in industries.
5. Help students to develop an overview of major liquid-liquid and solid liquid separation process and their applications and equipment used in industry.

Course Outcomes: At the completion of this course, students will be able to about

1. Understand the Principle and application of multi component and azeotropic distillation used in the chemical industries.
2. Understand the Principle and designing of distillation column used in the chemical industries.
3. List situations where liquid–liquid extraction might be preferred to distillation.
4. List the situation where solid liquid extraction might be preferred in industry
5. Explain the concept of breakthrough in fixed-bed adsorption.

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	-	3	-	-	-	2	-	2	3	3	2
CO2	3	3	1	-	3	-	-	-	2	-	2	3	3	3
CO3	3	3	3	-	-	-	-	-	-	-	-	2	2	3
CO4	3	3	2	-	3	-	-	-	2	-	2	3	3	3
CO5	3	3	3	-	-	-	-	-	-	-	-	2	2	3

UNIT I

Distillation: VLE phase diagrams, Tie lines and mixture rule Raoult‟s law, Relative Volatility - Flash vaporization and differential distillation for binary mixtures- Steam distillation. Batch distillation with reflux for binary mixtures.

UNIT II

Distillation: Continuous fractionation of binary mixtures, multistage tray towers – Ponchon and Savarit method, Mc Cabe and Thiele method of determination of ideal plates for binary mixtures- enriching section, exhausting section, feed introduction, total reflux, minimum and optimum reflux ratios, use of total and partial condensers. Use of open steam, Principles of azeotropic and extractive distillation.

UNIT III

Liquid-Liquid Extraction: Solubility of ternary liquid systems. Triangular and solvent free coordinate systems. Choice of solvent. Extraction with insoluble and partially soluble systems- single stage, multistage cross current and multistage counter current extraction without reflux and with reflux, Equipment for liquid- liquid extraction operation.

UNIT IV

Leaching: Preparation of solid for leaching, Unsteady state operation, in-place leaching, heap leaching, percolation leaching, Shanks system, agitated vessels, Percolation vs Agitation. Steady state continuous operation equipment- methods of calculation, stage efficiency and particle equilibrium. Single stage leaching, multistage cross current leaching, multistage counter current leaching.

UNIT V

Adsorption: Principles of adsorption and their applications- Types of adsorption- Adsorbents- Adsorption equilibrium- Adsorption Isotherms for vapor and dilute solutions. Single stage and multistage adsorption- unsteady state adsorption, adsorption wave and breakthrough curve and fixed bed adsorption, Equipment for adsorption. Pressure swing adsorption and applications.

Textbooks:

1. Mass Transfer Operations, 3rd ed., R. E. Treybal, McGraw-Hill, New York, 2017.

Suggested Reading:

1. Transport Processes and Separation Process Principles 4th ed., C. J. Geankoplis, PHI, Learning Pvt. Ltd.,New Delhi, 2009.
2. Principles of Mass Transfer and Separation Processes, B.K. Dutta, PHI Learning Pvt. Ltd., New Delhi,2007.

Online Resources:

1. https://archive.nptel.ac.in/courses/103/104/103104046/ [NPTEL-IIT Kanpur]
2. https://archive.nptel.ac.in/courses/103/103/103103145/ [NPTEL-IIT Guwahati]

22CHC16 PROCESS MODELING AND SIMULATION

Instruction	3 Hours per week 3
Duration of SEE	Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Course Objectives:

1. This course is helpful to learn the formulation of a mathematical process model.
2. Students are introduced to framing the equations of chemical process models leading to ODE.
3. Understanding and framing a chemical process model using fundamental principles of conservation.
4. Understanding the lumped parameter model and distributed parameter model
5. Students get familiar with the solution techniques of the developed model equations.
6. Application towards entire chemical plant design.

Course Outcomes:

1. The course helps the students to understand the concepts of modeling and simulation
2. The students will get familiar with conservation laws, continuity equations, equation of motion, and their application in mathematical model buildings
3. The students will be familiarized with mathematical models of Reactors and Separation equipment
4. Students will understand the basic concept for solving the developed model equations
5. Familiarize with the flow sheet for chemical process simulation with the software packages.

CO-PO -PSO Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	1	2	1	2	2	2	1	1	1	0	0	1	2	1
2	1	2	2	2	2	2	1	1	1	0	0	1	2	1
3	3	3	3	3	2	2	3	1	1	0	0	1	3	2
4	3	3	3	3	3	3	3	1	1	0	0	2	3	2
5	3	3	3	3	3	3	2	1	2	1	0	3	3	1

UNIT-I

Introduction: Modelling and simulation, definition, concept and uses of mathematical models, Classification of mathematical models- steady state Vs dynamic models, lumped Vs distributed parameter models, deterministic Vs stochastic models.

Fundamental laws: Principles of formulation, Continuity Equation, Component Continuity Equation, Energy Equation, and Equation of motion.

UNIT – II

Mathematical models of reactor systems: Series of isothermal constant hold-up Continuous Stirred Tank Reactors (CSTRs), CSTRs with variable hold-ups, batch reactor, and gas phase pressurized CSTR, Non-isothermal CSTR.

UNIT – III

Mathematical models of separation and other important systems: Gas absorber, Single component vaporizer, ideal binary distillation column, batch distillation with hold-up, Laminar flow of liquid in the pipe, gravity flow tank.

UNIT – IV

Empirical model building- Method of least squares, linear, polynomial

Solution of non-linear algebraic equations- Bisection, False position, Newton- Raphson method

Numerical solution of ordinary differential equations- Euler's method, Modified Euler's method, Runge- Kutta 4^{th} order method

UNIT – V

Process simulation using modular and equation-based solving approaches- Modular approaches to process simulation: Analysis vs. design mode, sequential modular approach, Simultaneous modular approach, Equation solving approach.

Simulation of Chemical Processes: Introduction to various simulation software packages in chemical engineering, Simulation of models such as isothermal CSTR, batch reactor, and distillation by using MATLAB and ASPEN Plus.

Text Books:

1. William L Luyben, "Process Modeling, Simulation and Control for Chemical Engineers", McGraw Hill Publishing Company, 2nd edition, 1990
2. Numerical Methods for Engineers, S.K. Gupta, Wiley Eastern, New Delhi, 1995
3. Process Plant Simulation, B.V.Babu, Oxford University Press, 2004

Suggested Reading:

1. Steven C. Chapra and Raymond P Canale, "Numerical methods for Engineers", McGraw Hill International, 2nd edition, 1988.

Online Resources

1. **https://archive.nptel.ac.in/courses/103/107/103107096/#** (NPTEL Course by Prof. V. K. Agrawal, IIT Roorkee)

22CHE05 SUSTAINABLE ENGINEERING

Instruction	3LHours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Course Objectives: This course will help the students:

1. To have an increased awareness on issues in areas of sustainability
2. To understand the role of engineering & technology within sustainable development
3. To know the methods, tools and incentives for sustainable product service system development
4. To establish a clear understanding of the role and impact of various aspects of engineering decisions on environmental, societal and economic problems.
5. To communicate results related to their research on sustainable engineering

Course Outcomes: At the completion of this course, students will be able to:

1. Understand the concept of sustainable engineering and its significance in addressing contemporary environmental challenges.
2. Explore the 4R concept of solid waste management and examine various tools and methodologies to assess and mitigate the environmental impacts of engineering activities.
3. To be aware of the principles and requirements of environmental management standards and their application in promoting environmental sustainability.
4. Analyze the challenges and opportunities associated with promoting sustainable habitats such as sustainable cities, sustainable transport, sustainable sources of energy conventional and sustainable materials for green buildings
5. Understand and evaluate the industrial processes through the principles of industrial ecology and industrial symbiosis.

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	3	1	1	2	3	2	1	1	1	3	2	2
CO2	2	2	3	2	1	2	3	2	1	1	1	3	2	2
CO3	2	1	3	1	2	2	3	2	1	2	1	3	2	2
CO4	3	1	3	3	1	3	3	2	2	1	1	3	2	3
CO5	3	3	3	1	2	2	3	2	1	1	2	3	3	3

UNIT I

Introduction of sustainability- Need and concept of Sustainable Engineering, Social-environmental and economic sustainability concepts, Sustainable development and challenges, Sustainable developmental goals, Environmental acts and protocols – Clean Development Mechanism (CDM).

UNIT II

Economic and social factors affecting sustainability, Effects of pollution from natural sources, Solid waste-sources, impacts, 4R (Reduce, Reuse, Recycling, Recover) concept, Tools used to ensure sustainability in engineering activities such as environmental management systems and environmental impact assessment studies.

UNIT III

Global, Regional and Local environmental issues; Carbon emissions – scope 1,2,3; Carbon credits and Carbon trading, Carbon foot print, climate science, Environmental management standards, ISO 14000 series, Life cycle Analysis (LCA)-scope and goal, Procedures of EIA (Environment Impact Assessment) in India.

UNIT IV

Basic concept of sustainable habitat-Sustainable cities, Sustainable transport, Sustainable sources of energy conventional and renewable sources, Green Engineering: Green buildings, Green materials for sustainable design, Methods for increasing energy efficiencies of buildings**.**

UNIT V

Technology and sustainable development, Sustainable urbanization, Social and Technological change, Industrial processes-material selection, Pollution prevention, Industrial ecology, Industrial symbiosis.

Textbooks:

1. Toolseeram Ramjeawon, Introduction to Sustainability for Engineers, CRC Press, Taylor & Francis, 2020.
2. Rag R. L., Introduction to Sustainable Engineering, 2nd Ed, PHI Learning Pvt Ltd, 2016.
3. Allen D. T and Shonnard D. R., Sustainability Engineering Concepts, Design and Case Studies, 1 st Ed, Prentice Hall, 2011.

Suggested Reading

1. Bradley A. S, Adebayo A. O and Maria. P., Engineering Applications in Sustainable Design and Development, 1st Ed, Cengage Learning, 2016.
2. Krishna R. Reddy, Claudio Cameselle, Jeffrey A. Adams., Sustainable Engineering, 1st Ed, Wiley, 2019.

Online resources:

1. Sustainable Engineering concepts and Life cycle analysis
   https://archive.nptel.ac.in/courses/105/105/105105157/

2. Sustainable Energy Technology
   https://onlinecourses.nptel.ac.in/noc23_me138/preview

22CH E06 **FERTILIZER TECHNOLOGY**

Instructions	3 Hours per week
Duration of SEE:	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Pre Requisites: Nil

Course Objectives: This course will help the students to

1. Understand the basic concepts and manufacturing processes of fertilizers.
2. Use fertilizers in improving soil productivity and crop yield.
3. Learn different types of nitrogenous, phosphatic and potash fertilizers.
4. Understand different organic and biofertilizers production methods.
5. Learn the Environmental impact of fertilizer plants.

Course Outcomes: At the end of the course, the student will be able to:

1. Identify the different nutrients and significance of feed stocks for the production of various fertilizers.
2. Apply different manufacture methods for various nitrogenous fertilizers
3. Explain production methods for phosphatic, potassium and mixed complex fertilizers.
4. Explain the need, application techniques and uses of new variety of fertilizers.
5. Summarize effluent treatment methods and impact of fertilizers on environment.

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	-	2	-	1	-	-	-	1	2	1	1
CO2	3	3	2	1	2	1	1	-	-	-	1	1	2	1
CO3	3	3	2	1	2	-	1	-	-	-	2	2	2	2
CO4	3	3	2	1	3	1	2	-	-	-	2	3	2	2
CO5	3	3	2	1	2	1	3	-	-	-	2	3	3	3

UNIT – I

Introduction: Development of Fertilizer industry, Fertilizer Production and consumption in India, Nutrient contents of fertilizers, Plant Nutrients, Role of essential elements for plant growth. Availability of feed stocks. Feedstock and raw materials for Nitrogenous, Phosphatic and Potassic fertilizers.

UNIT – II

Nitrogenous Fertilizers: Ammonia synthesis by Haber and Kellogg processes. By-product ammonia recovery by direct and indirect methods.

Manufacture of urea and other nitrogenous fertilizers such as ammonium sulphate, ammonium nitrate, calcium ammonium nitrate, ammonium chloride. Manufacture of nitric acid.

UNIT – III

Phosphatic fertilizers: manufacture of single and triple super phosphate,

Potassic Fertilizers: Potassium Chloride, Potassium Sulphate, Manufacture of phosphoric acid.

Complex Fertilizers: Production of Mono ammonium phosphate, Di ammonium phosphate and nitro phosphates, Mixed and NPK fertilizers.

UNIT – IV

Miscellaneous fertilizers: Organic Manures, Liquid fertilizers.

Bio fertilizers – Introduction, Nitrogen fixing, Phosphorus solubilizing, Phosphorus mobilizing Biofertilizers.

Advantages over chemical fertilizers, types and uses.

UNIT – V

Fertilizer application techniques: different soil-controlled release fertilizers. General fertilizer storage and handling. Effluent treatment methods for various fertilizer plants. Environmental impact of fertilizer plants on Ecosystem.

Text Books:

1. Brahma Mishra, "Fertilizer Technology and Management", 1st Ed., IK International Publishing House., New Delhi, 2012.
2. Dr. Shalini Suri, "Bio Fertilizers and Bio pesticides", 1st Ed., APH publishing Corporation, New Delhi, 2011.

Suggested Reading:

1. Fertilizer Association of India, "Handbook on Fertilizer Technology", 8th Ed., Scientific Publisher, New Delhi, 2016.
2. M. Gopala Rao and Sitting Marshall, "Dryden's outlines of Chemical Technology for the 21st Century", 3rd Ed., Affiliated East-West Press (Pvt) Ltd, New Delhi, 1998.
3. George T. Austin, "Shreve's Chemical Process Industries", 5th edition. McGraw Hill Publications, New Delhi, 1984.
4. K K Pant, Shailendra Bajpai and Shishir Sinha, "Fertilizer Technology", Stadium Press, 2015.

Online Resources:

1. Soil Fertility And Fertilizers by Prof. Somsubhra Chakraborty, IIT Kharagpur
   https://onlinecourses.nptel.ac.in/noc22_ag14/preview

2. Fertilizer Engineering, Dr. Amit Dhiman, IIT, Roorkee
   https://nptel.ac.in/courses/103107086

22CHE07 **POLLUTION CONTROL IN PROCESS INDUSTRIES**

(Professional Elective II)

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Pre-requisites: Environmental Studies, Mechanical Unit Operations

Course Objectives: This course will help the students to understand the:

5. Effects of pollution on environment and ecosystems
6. Types and sources of pollution from process industries
7. Measurement of air and water pollution in process industries
8. Different methods and equipment used in industrial pollution abatement
9. Pollution control practices in process industries

Course Outcomes: At the completion of this course, students will be able:

6. Differentiate the types of wastes generated in an industry, their effects on living and non-living things
7. Understand the atmospheric dispersion of air pollutants and working principles of particulate control devices.
8. Quantify industrial wastewater and its treatment.
9. Analyze the hazardous and non-hazardous solid wastes and select the treatment and disposal methods.
10. Apply environmental management systems (EMS) to an industrial activity

CO-PO-PSO Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	1	1	2	1	1	1	1	1	2	2	2
CO2	2	2	2	2	1	1	2	1	1	1	1	2	2	2
CO3	2	2	1	1	1	2	2	1	1	1	1	2	3	2
CO4	2	1	2	1	1	2	3	1	1	1	1	2	2	3
CO5	2	2	2	2	1	1	3	1	1	1	1	2	3	3

UNIT- I

Introduction: Definition and types of pollution from chemical industries. Effects of pollution on environment and ecosystems - global warming - greenhouse effect. Laws and standards for pollution. Sources, types, characteristics and effects of air pollutants, liquid effluents, solid wastes in process industries.

UNIT- II

Air Pollution: Meteorological aspects of pollution dispersion, adiabatic and environmental lapse rate, Turbulence and stability of atmosphere. Indoor air pollution - smoke and hydrocarbons. Richardson Number, Plume raise, plume behavior and characteristics, effective stack height.

General Control Methods and Equipment: removal of sulphur dioxide, oxides of nitrogen and carbon, organic vapors from gaseous effluents. Removal of particulate matter - principle and working of settling chambers cyclone separators solid traps, fabric and fiber filters, electro-static precipitators.

UNIT- III

Water Pollution: Concepts and estimation of oxygen demands - DO, BOD, COD, TOD. Oxygen sag curve, BOD curves and modeling. Wastewater Treatment – Concept, significance and classification as Primary, Secondary, Tertiary methods. Principle, working mechanism and applications of biological treatment techniques like stabilization ponds, Aerated lagoons, conventional activated sludge process, aerobic and anaerobic methods, suspended and attached growth processes, fluidized bed contractors. Trickling filters.

UNIT- IV

Industrial Solid Waste Management: Industrial solid wastes types, classification, properties, management and general disposal methods. Industrial solid wastes – environmental effects and disposal methods commonly practiced. Methods practiced in paper and textile industries.

UNIT- V

Pollution control practices in Process Industries: Principle, working mechanism and application of tertiary treatment methods like carbon adsorption, Ion-exchange, Reverse Osmosis, Ultra Filtration in process industries. Sludge treatment and disposal methods like Incineration and land filling. Pollution control in petroleum and fertilizer industries.

Text Books

1. C. S. Rao, "Environmental Pollution Control Engineering", 2nd Ed, New Age International, 2007.
2. S. P. Mahajan, "Pollution control in process industries", 27th Ed, McGraw Hill Pub, 2002.

Suggested Reading:

1. Metcalf and Eddy, "Wastewater Engineering: Treatment and Reuse", 4th Ed, MGH publishing, 2004.
2. M.N Rao and H.V.N Rao, "Air Pollution", Tata McGraw- Hill Publishing Company Limited, New Delhi, 2000.
3. Peavy, H.S., Rowe, D.R. and Technobanolous, G., "Environmental Engineering", McGraw Hill, 1985.

Online resources:

1. Basic Environmental Engineering and Pollution Abatement

   https://archive.nptel.ac.in/courses/103/107/103107215/

22CH E 08 POLYMER SCIENCE AND TECHNOLOGY

Professional Elective II

Instruction	3Hours per week
Duration of SEE	3 Hours
SEE	60Marks
CIE	40Marks
Credits	3

Prerequisites: MEBC, MUO, Chemical Technology, MTO, FM

Course objectives: This course helps the students to:

1. Understand the fundamental- chemical, physical and mechanical behaviour of polymers.
2. Understand the structure-processing-property relationship of polymers
3. Estimate the processing techniques, along with the production of polymers
4. Evaluate the synthesis, manufacture, processing and characterization of different polymers
5. Understand the basic concepts involved in polymer blends, composites and nano composites.

Course Outcomes: At the end of the course students will be able to

1. Explain the basic concepts of polymers, polymerization techniques and behaviour in polymers
2. Distinguish different types of polymerizations.
3. Determine the molecular weight of polymers by different techniques
4. Interpret the various processing techniques used for polymers, rubbers, fibers, polymer blends, and composites
5. Summarize the manufacturing and characterization of various industrially important polymers

CO-PO-PSO Matrix

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	-	-	2	2	-	-	-	1	2	3	2
CO2	3	3	3	-	-	2	2	-	-	-	1	2	3	3
CO3	3	3	3	-	-	2	2	-	-	-	1	2	3	3
CO4	3	3	3	-	-	2	2	-	-	-	1	2	3	2
CO5	3	3	3	-	-	2	2	-	-	-	1	2	3	2

UNIT - I

Definitions and concepts of terms used in polymer engineering, Classification of polymers; Polymer structures, functionality; polymerization reactions – mechanism of polymerization; stereospecific polymerization, copolymerization. Polymer material structure and Properties: Deformation, flow and melt characteristics. Morphology and order in crystalline polymers. Rheology and the mechanical properties of polymers. Polymer structure and physical properties

UNIT - II

Polymerization reactors, polymerization processes, characterization of polymers, analysis of polymerization reactions, polymer degradation, Condensation polymerization, Addition polymerization, Ionic and coordination polymerization.

UNIT - III

Molecular weight and molecular weight distribution in polymers, properties of polymers – physical, chemical, mechanical and electrical properties of polymers, elementary idea on polymer rheology, polymer blends. Experimental methods for molecular weight determination: cryoscopy, ebulliometry, membrane osmometry, light scattering method, viscometry, intrinsic viscosity measurement, gel permeation chromatography. Structure and Properties: Thermal transitions, Crystallinity, Molecular weight characterization, Nuclear Magnetic Resonance (NMR) and Fourier. Transform Infrared spectroscopy (FTIR) techniques

UNIT – IV

Polymer processing: Molding – compression & transfer, injection & jet; casting; extrusion, calendaring, lamination, spinning & finishing. Processing methods , effect of additives used, plasticizers, colourants, heat stabilizers, antioxidants, ultraviolet absorbers, antistatic agents, flame retardants, blowing agents, fillers etc. Molding techniques for plastics, injection molding, compression molding, calendaring, blow moulding, extrusion, thermoforming, spinning methods for fibres, compounding methods for elastomers, general study of elastomer processing methods.

UNIT - V

Industrial polymers: Manufacturing processes, properties and uses of Polyethylene, Polypropylene, Polyvinylchloride, Polystyrene, Nylon, Polyethylene terephthalate. Hydrocarbon plastics and elastomers. Other carbon chain polymers. Heterochain thermoplastics. Thermosetting resins. Polymer Blends: Types, Compatibility, Thermal and Mechanical Properties. Polymer Composites: Types, Properties, Preparation, Fibre-reinforced composites, In-situ composites. Polymer Nanocomposites: Basic concepts, Processing, Characterization.

Text Books:

1. Text Book of Polymer Science, F. W. Billmeyer, John Wiley, New York, 1962
2. Polymer Science &Technology, P.Ghosh, TMC, 2001

Suggested Reading:

1. The elements of Polymer Science & Engineering, Alfred Rudin, Academic Press, 2nd Edition,1998
2. Introduction to Polymers, R. J. Young, Chapman & Hall, London, 1991

Online Resources

1. https://archive.nptel.ac.in/courses/113/105/113105028/
2. https://www.coleparmer.in/i/polymer-science-and-technology/1545002
3. https://www.accessengineeringlibrary.com/content/book/9780070707047?implicit-login=true

22MEO01 PRINCIPLES OF DESIGN THINKING

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Nil

Course Objectives: This course aims to

1. Create awareness of design thinking approaches
2. Identify a systematic approach for defining/identifying a problem
3. Create design thinking teams and conduct design thinking sessions collaboratively
4. Apply both critical thinking and design thinking in parallel to solve problems
5. Motivate to apply design thinking concepts to their real life scenarios

Course Outcomes: upon completion of this course, the students are able to

1. Understand design thinking and its phases as a tool of innovation
2. Empathize on the needs of the users
3. Define the problems for stimulating ideation
4. Ideate on problems to propose solutions by working as a design thinking team
5. Prototype and test the proposed solutions focusing on local or global societal problems

CO-PO Articulation Matrix

PO/ PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	1	1	1	1	1	2	2	2	2	2	2	2		
CO 2	1	1	2	1	2	2	2	2	1	2	2	2		
CO 3	1	1	2	2	1	2	2	2	1	2	2	1		
CO 4	2	1	2	2	1	2	2	2	1	2	2	2		
CO 5	2	1	2	2	1	2	2	2	1	2	2	2		

UNIT – I

Introduction to Engineering & Thinking: Engineering for social and economic development; impact of science/engineering. Thinking and behaviour; Types of thinking – Linear thinking, lateral thinking, systems thinking, design thinking.

Introduction to Design Thinking: Importance of Design Thinking & Human centric approach – Phases in design thinking process, five-stage model as iterative method, applications of design thinking in various domains.

UNIT – II

Empathize phase: Understanding the unique needs of the user, empathize with the users, steps in empathize phase, developing empathy towards people, assuming a beginner's mind-set (what? why?), steps in immersion activity, body storming; Case studies.

UNIT – III

Define phase: Define the problem and interpret the result, analysis and synthesis, Personas – Four different perspectives on Personas, steps to creating personas, problem statement, affinity diagrams, empathy mapping; Point of View – "How might we" questions, Why-how laddering; Case studies.

UNIT – IV

Ideation phase: What is ideation, need, uses, ideation methods; Brainstorming, rules for brainstorming; Mind maps, guidelines to create mind maps; Ideation games; Six Thinking Hats; Doodling, use of doodling in expressing creative ideas; Case studies.

UNIT – V

Prototyping phase: Types of prototyping, guidelines for prototyping, storytelling, characteristics of good stories, reaching users through stories, importance of prototyping in design thinking; Value proposition, guidelines to write value proposition; Case studies.

Testing phase: Necessity to test, user feedback, conducting a user test, guidelines for planning a test, how to test, desirable, feasible and viable solutions, iterate phase.

Text Books:

1. Tim Brown, Change by Design: How Design Thinking Transforms Organizations and Inspires, 1st Edition, HarperCollins, 2009.
2. Michael Luchs, Scott Swan, Abbie Griffin, Design thinking: New product development essentials from the PDMA. John Wiley & Sons, 2015.
3. Pavan Soni, Design Your Thinking: The Mindsets, Toolsets and Skill Sets for Creative Problem-solv ing, Penguin Random House India Private Limited, 2020.

Suggested Reading:

1. Jeanne Liedtka, Andrew King, Kevin Bennett, Solving problems with design thinking: Ten stories of what works. Columbia University Press, 2013.
2. Bala Ramadurai, Karmic Design Thinking - A Buddhism-Inspired Method to Help Create Human-Centered Products & Services, Edition 1, 2020.

22CAO03

FOUNDATIONS OF DEEP LEARNING
(Open Elective I)

Instruction	3 Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Pre-requisites: Calculus, Probability and Statistics, Python Programming, Machine Learning.

Course Objectives:

1. Provide students with a foundational understanding of the history of deep learning, key concepts, and early neural network models.
2. Equip students with the skills to design and optimize feedforward neural networks using various gradient descent methods and optimization algorithms.
3. Develop students' competence in applying principal component analysis, singular value decomposition, and different types of autoencoders for data representation and regularization.
4. Enable students to design, implement, and apply convolutional neural networks (CNNs) for image and data processing tasks.
5. Enhance students' ability to design and apply recurrent neural networks (RNNs) and attention mechanisms for complex sequence modeling tasks.

Course Outcomes:

1. Demonstrate a comprehensive understanding of deep learning history, key milestones, and foundational concepts.
2. Design, develop, and optimize feedforward neural networks and understand their representation power.
3. Apply principal component analysis, singular value decomposition, and various autoencoder models for data analysis and dimensionality reduction.
4. Develop and implement convolutional neural networks (CNNs) using modern architectures and techniques.
5. Design and utilize recurrent neural networks (RNNs) and advanced attention mechanisms for sequential data processing.

CO-PO Articulation Matrix

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	3	2	2	2	1	1	1	1	2	1	1
CO 2	3	3	3	3	3	1	1	1	1	2	2	2
CO 3	3	3	3	3	3	1	1	1	1	2	2	2
CO 4	3	3	3	3	3	1	1	1	1	2	2	2
CO 5	3	3	3	3	3	1	1	1	1	2	2	2

Unit - I

History of Deep Learning, Deep Learning Success Stories, McCulloch Pitts Neuron, Thresholding Logic, Perceptrons, Perceptron Learning Algorithm Multilayer Perceptrons (MLPs), Representation Power of MLPs, Sigmoid Neurons, Gradient Descent.

Unit - II

Feedforward Neural Networks, Representation Power of Feedforward Neural Networks Feed Forward Neural Networks, Backpropagation Gradient Descent (GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, AdaGrad, RMSProp, Adam, Eigenvalues and eigenvectors, Eigenvalue Decomposition, Basis

Unit - III

Principal Component Analysis and its interpretations, Singular Value Decomposition Auto encoders and relation to PCA, Regularization in auto encoders, Denoising auto encoders, Sparse auto encoders, Contractive autoencoders **Regularization:** Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout

Unit - IV

Convolutional Neural Network: The Convolution Operation, Motivation, Pooling, Convolution and Pooling, Batch Normalization.
Pre-trained models: LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet.

Unit - V

Recurrent Neural Networks, Vanishing and Exploding Gradients, GRU, LSTMs. Encoder Decoder Models, Attention Mechanism, Attention over images.

Text Books:

1. Goodfellow. I., Bengio. Y. and Courville. A., "Deep Learning ", MIT Press, 2016.
2. Rothman, Denis, "Transformers for Natural Language Processing: Build innovative deep neural network architectures for NLP with Python, PyTorch, TensorFlow, BERT, RoBERTa, and more", Packt Publishing Ltd, 2021.
3. Ganguly Kuntal, "Learning generative adversarial networks: next-generation deep learning simplified", Packt Publishing, 2017

Suggested Reading:

1. Bishop, Christopher. Neural Networks for Pattern Recognition. New York, NY: Oxford University Press, 1995. ISBN: 9780198538646.
2. Bishop, Christopher M. Pattern Recognition and Machine Learning. Springer, 2006. ISBN 978-0-387-31073-2
3. Duda, Richard, Peter Hart, and David Stork. Pattern Classification. 2nd ed. New York, NY: Wiley-Interscience, 2000. ISBN: 9780471056690.
4. Mitchell, Tom. Machine Learning. New York, NY: McGraw-Hill, 1997. ISBN: 9780070428072.
5. Richard Hartley, Andrew Zisserman, Multiple View Geometry in Computer Vision, 2004. David Marr, Vision, 1982.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc18_cs41/
2. https://onlinecourses.nptel.ac.in/noc22_cs22/
3. https://onlinecourses.nptel.ac.in/noc19_cs85

22EEO06 **WASTE MANAGEMENT**

(Open Elective I)

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: None.

COURSE OBJECTIVES: This course aims to:

1. Imbibe the concept of effective utilization of any scrap
2. Become familiar with the processes of all disciplines of engineering.
3. Learn the technique of connectivity from waste to utility.

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Categorize the waste based on the physical and chemical properties.
2. Explain the Hazardous Waste Management and Treatment process.
3. Illustrate the Environmental Risk Assessment, methods, mitigation and control.
4. Interpret the Biological Treatment of Solid and Hazardous Waste.
5. Identify the waste disposal options, describe the design and construction, Operation, Monitoring, Closure of Landfills.

CO-PO Articulation Matrix

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO-1	2	1	2	-	-	3	3	2	-	-	-	-			
CO-2	2	1	2	-	-	3	3	2	-	-	-	-			
CO-3	2	1	3	-	2	3	3	2	-	-	-	-			
CO-4	2	3	3	-	1	3	3	2	-	-	-	-			
CO-5	2	3	3	-	2	3	3	2	-	-	-	-			

UNIT I

Introduction to Waste Management and Municipal Solid Waste Management: Classification of waste: Agro based, Forest residue, Industrial waste, e-Waste, Municipal Solid Waste Management: Fundamentals Sources, composition, Generation rates, Collection of waste, Separation, Transfer and Transport of waste, Treatment and Disposal options.

UNIT -II

Hazardous Waste Management and Treatment: Hazardous Waste Identification and Classification, Hazardous Waste Management: Generation, Storage and collection, Transfer and transport, Processing, Disposal, Hazardous Waste Treatment: Physical and Chemical treatment, Thermal treatment, Biological treatment, Pollution Prevention and Waste Minimisation, Hazardous Wastes Management in India.

UNIT -III

Environmental Risk Assessment: Defining risk and environmental risk, Parameters for toxicity quantification, Types of exposure, Biomagnifications, Effects of exposure to toxic chemicals, Risk analysis and Risk matrix, Methods of risk assessment, Mitigation and control of the risk, Case studies.

UNIT -IV

Biological Treatment: Solid and Hazardous Waste Composting, Bioreactors, Anaerobic decomposition of solid waste, Principles of biodegradation of toxic waste, Inhibition, Co-Metabolism, Oxidative and Reductive processes, Slurry phase Bioreactor, In-situ-remediation.

UNIT -V:

Waste Disposal: Key Issues in Waste Disposal, Disposal Options and Selection Criteria: Disposal options, Selection criteria, Sanitary Landfill: Principle, Landfill processes, Landfill Gas Emission: Composition and properties, Hazards, Migration, Control, Leach ate Formation: Composition and properties. Leach ate migration, Control, Treatment, Environmental Effects of Landfill, Landfill Operation Issues, Design and construction, Operation, Monitoring, Closure of Landfills-Landfill Remediation, National and International Waste Management programs.

TEXT BOOKS:

1. John Pichtel, Waste Management Practices CRC Press, Taylor and Francis Group 2005.
2. LaGrega, M.D.Buckingham, P.L. and Evans, J.C. Hazardous Waste Management, McGraw Hill International Editions, NewYork, 1994
3. Richard J. Watts, Hazardous Wastes - Sources, Pathways, Receptors John Wiley and Sons, NewYork, 1997.

SUGGESTED READING:

1. Basics of Solid and Hazardous Waste Mgmt. Tech. by KantiL.Shah 1999, Prentice Hall.
2. Solid and Hazardous Waste Management 2007 by S.C.Bhatia Atlantic Publishers & Dist.

20EGO01

TECHNICAL WRITING SKILLS

(Open Elective -BE/B.Tech - Common to all Branches)

Instruction	3 L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: Language proficiency and the ability to simplify complex technical concepts for a diverse audience.

Course Objectives:

The course will introduce the students to:

1. Process of communication and channels of communication in general writing and technical writing in particular.
2. Learn Technical Writing including sentence structure and be able to understand and use technology specific words.
3. Write business letters and technical articles.
4. Write technical reports and technical proposals.
5. Learn to write agenda, record minutes of a meeting, draft memos. Understand how to make technical presentations.

Course Outcomes:

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

1. Communicate effectively, without barriers and understand aspects of technical communication.
2. Differentiate between general writing and technical writing and write error free sentences using technology specific words.
3. Apply techniques of writing in business correspondence and in writing articles.
4. Draft technical reports and technical proposals.
5. Prepare agenda and minutes of a meeting and demonstrate effective technical presentation skills.

CO-PO Articulation Matrix

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	-	2	1	1	-	1	1	2	3	3	2	3	1	1
CO 2	-	1	-	1	-	-	-	1	2	2	1	2	1	1
CO 3	-	2	-	2	-	1	1	1	2	3	2	2	2	2
CO 4	2	2	1	3	-	2	2	1	3	3	2	2	2	2
CO 5	1	1	1	1	-	1	1	1	3	3	2	2	2	2

Unit - I

Communication – Nature and process.

Channels of Communication – Downward, upward and horizontal communication. Barriers to communication.

Technical Communication – Definition, oral and written communication. Importance and need for Technical communication. Nature of Technical Communication. Aspects and forms of Technical communication. Technical communication Skills – Listening, Speaking, Reading & Writing.

Unit II

Technical Writing – Techniques of writing. Selection of words and phrases in technical writing. Differences between technical writing and general writing. Abstract and specific words. Sentence structure and requisites of sentence construction. Paragraph length and structure.

Unit III

Business correspondence – Sales letters, letters of Quotation, Claim and Adjustment letters.

Technical Articles: Nature and significance, types. Journal articles and Conference papers, elements of technical articles.

Unit IV

Technical Reports: Types, significance, structure, style and writing of reports. Routine reports, Project reports.

Technical Proposals: Definition, types, characteristics, structure and significance.

Unit V

Mechanics of Meetings: Preparation of agenda, participation, chairing and writing minutes of a meeting. Memorandum. Seminars, workshops and conferences.

Technical Presentations: Defining purpose, audience and locale, organizing content, preparing an outline, use of Audio Visual Aids, nuances of delivery, importance of body language and voice dynamics.

Textbooks:

1. Meenakshi Raman & Sangeeta Sharma, "Technical Communications-Principles and Practice", Oxford University Press, Second Edition, 2012.
2. M Ashraf Rizvi, "Effective Technical Communication", Tata McGraw Hill Education Pvt Ltd, 2012.

Suggested Reading:

1. Kavita Tyagi & Padma Misra, "Basic Technical Communication", PHI Learning Pvt Ltd, 2012.
2. R.C Sharma & Krishna Mohan, "Business Correspondence and Report Writing", Tata McGraw Hill, 2003

Web Resources:

1. https://onlinecourses.nptel.ac.in/noc18_mg13/preview
2. https://www.technical-writing-training-and-certification.com/
3. https://academy.whatfix.com/technical-writing-skills

22CHC17 MASS TRANSFER OPERATIONS LAB

Instruction	3P Hours per week
Duration of SEE	3 Hours
SEE	50 Marks
CIE	50 Marks
Credits	1.5

Pre-requisites: MTO I and MTO II

Course objectives: This course will help the students to understand about

1. Estimate the efficiency of simple and steam distillation
2. Plotting the drying curve and estimating total drying time
3. Estimate diffusion co-efficient and mass transfer coefficients
4. Estimate the height of packed bed column.
5. Estimate separation efficiency of VLE, LLE, and leaching.
6. Determine the relationship between vapor and liquid at different temperatures

Course Outcomes: The students able to know

1. Calculate diffusivity coefficient
2. Separation of components by simple and steam distillation
3. Separation components by drying
4. Separation components by liquid- Liquid Extraction and solid-liquid extraction
5. Calculate mass transfer coefficient in wetted wall column.

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	2	3	1	1	0	0	1	3	1
CO2	3	3	3	2	2	2	3	1	1	0	0	1	3	1
CO3	3	3	3	2	2	2	3	1	1	0	0	1	3	1
CO4	2	2	3	2	2	2	3	1	1	0	0	1	3	1
CO5	2	2	3	2	2	2	3	1	1	0	0	1	3	1

List of Experiments:
(Any 10 experiments to be conducted)

1. Estimation of diffusivity coefficient for the gaseous system (CCl_4 - Air).
2. Perform the simple distillation of methanol- water system.
3. Measure the purity of distillate by carrying out Steam Distillation.
4. Calculation of height equivalent to theoretical plate in packed column.
5. Experiment on Liquid - Liquid Extraction.
6. Experiment on Solid-Liquid Extraction (Leaching).
7. Determine Mass transfer coefficient using wetted wall column.
8. Batch Drying
9. Determination of vapor - liquid equilibrium data for the given system.
10. Determination of adsorption of acetic acid from aqueous solution by activated charcoal
11. Determination of yield out the Batch Crystallizer
12. Calculate the property change of mixing
13. To determine the relationship between vapor and liquid at different temperatures
14. To determine the solubility characteristics of given solution at different temperatures
15. Determine distribution coefficient for toluene- acetic acid and chloroform- acetic acid mixture.

Textbooks

1. R.E.Treybal, Mass Transfer Operations, 3rd Edition, McGraw Hill, New Delhi, 1983

22CHC18 PROCESS MODELING AND SIMULATION LAB

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	50 Marks
CIE	50 Marks
Credits	1.5

Course Objectives: This practical course helps the students to understand the:

1. Application of their MATLAB coding and skills learned in previous semesters, as a prerequisite for problem solving.
2. Formulation of a process model leading to ODE.
3. Formulation of process models leading to nonlinear equations.
4. Open-loop simulation through MATLAB coding for simple chemical processes.
5. Steady-state simulation of the process models using ASPEN
6. Application this knowledge of aspen for entire plant design.

Course Outcomes: At the end of the course, students will be able to

1. Dynamically simulate and interpret two heated tanks, using MATLAB
2. Dynamically simulate and analyze continuous reactors in Series using MATLAB
3. Adapt ASPEN software to perform steady-state simulation of valves
4. Apply ASPEN software for the simulation of batch distillation
5. Utilize ASPEN software to design Plug flow reactor

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	3	2	3	-	-	-	1	-	2	2	2
CO2	3	3	2	3	3	1	-	-	-	1	-	3	3	2
CO3	3	3	3	3	3	3	-	-	-	1	-	2	3	3
CO4	3	2	2	3	3	2	-	-	-	2	-	2	3	2
CO5	3	3	3	3	3	2	-	-	-	1	-	2	3	3

Introduction: Software Packages. Understanding the basic concepts and steps involved in developing a process flow sheet. Setting up models for simulation

Part I: Dynamic simulation using MATLAB.

1. Modeling and Simulation of Two-heated Tanks in series.
2. Modeling and Simulation of three CSTRs in series at isothermal constant holdup condition.
3. Modeling and simulation of a Batch Reactor.
4. Modeling of a Vapor Liquid Equilibrium plot.
5. Modeling and Simulation of an Ideal Binary distillation.
6. Modeling and Simulation of a Gas-Phase Pressurized CSTR

Part II: Steady State simulation using ASPEN Plus

1. Simulation of simple units like valves, pumps, flash columns
2. Estimation of thermodynamic properties of the system through simulation
3. Simulation of reactor systems
4. Simulation of Distillation columns
5. Simulation of Heat exchangers
6. Flow-sheeting of chemical processes.

Textbooks:

1. Chemical Process Modeling And Computer Simulation by Amiya K. Jana .2018
2. Manjeet Kaur Bedi, Prof. Vikram Singh, A Textbook Of Simulation And Modeling, Laxmi Publications, 2011.
3. Aspen Plus (R) - Chemical Engineering Applications (English, Hardcover, Al-Malah K)

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

Choice Based Credit System (With effect from 2024-2025)

B.Tech (Chemical Engineering)

Semester VI

S. No	Course Code	Title of the Course	Scheme of Hours per Week			Scheme of Duration of SEE In Hours	Scheme of Maximum		Credits
			L	T	P/D		CIE	SEE	
THEORY									
1	22CHC19	Chemical Reaction Engineering II	3	-	-	3	40	60	3
2	22CHC20	Process Dynamics & Control	3	-	-	3	40	60	3
3	22CHC21	Plant Design & Economics	3	-	-	3	40	60	3
4	22EGM03	Universal Human Values-2	1	-	-	-	50	-	1
5	22CHEXX	Professional Elective III	3	-	-	3	40	60	3
6	22CHEXX	Professional Elective IV	3	-	-	3	40	60	3
7		Open Elective - II	3	-	-	3	40	60	3
PRACTICAL									
8	22CHC22	Chemical Reaction Engineering Lab	-	-	3	3	50	50	1.5
9	22CHC23	Process Dynamics & Control Lab			3		50	50	1.5
10	22CHU02	Upskill Certification course - II	-	-	60	-	-	-	0.5
11	22CHC24	Mini Project	-	-	4	-	50	-	2
	TOTAL		**19**	**-**	**10+60**	**-**	**440**	**460**	**24.5**

S. No	Course Code	**Professional Elective III**
1	22CHE09	Fuel Cell Technology
2	22CHE10	Petrochemical Technology
3	22CHE11	Pharmaceutical Technology
4	22CHE12	Safety and Hazard Analysis

S.No	Course Code	**Professional Elective IV**
1	22CHE13	Biochemical Engineering
2	22CHE14	Corrosion Engineering
3	22CHE15	Nuclear Engineering
4	22CHE16	Nano Science and Technology

S.No	Course Code	**Open Elective II**
1	22EGO02	Gender Sensitization
2	22ITO02	Principles of Internet of Things
3	22MEO06	Principles of Entrepreneurships and Start ups
4	22EEO01	Energy Management System

22CHC19 CHEMICAL REACTION ENGINEERING II

Instructions	3L Hours per week
Duration of End Examination	3 Hours
Semester End Examination	60 Marks
CIE	40 Marks
Credits	3

Pre-requisites: Chemical Reaction Engineering I

Course Objectives This course helps the students to understand

1. Basic Concepts of Catalysis
2. Kinetics and Mechanistic aspects of Catalysts
3. Design and Rating of Catalytic Reactors
4. Design Aspects of Gas-Liquid Reactors

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

1. Identify and characterize solid catalysts.
2. Explain the kinetics for solid catalyzed reactions.
3. Interpret the kinetics of fluid and particle reactions.
4. Identify regions of mass transfer control and reaction rate control in fluid-fluid reactions
5. Apply the concepts to fluid- fluid and fluid-solid reactors.

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1	-	-	-	-	-	1	-	-	-	2	2
CO2	3	2	2	1	1	-	-	1	1	-	-	2	2	2
CO3	3	2	2	1	1	1	1	1	1	-	-	2	2	2
CO4	3	2	2	1	1	1	1	1	1	-	-	1	2	2
CO5	3	2	2	1	1	1	1	1	1	-	-	1	2	2

UNIT – I

Solid Catalysts - Adsorption, adsorption isotherms, surface area, void volume and solid density, pore volume distribution. Theories of heterogeneous catalysis, classification of catalysts, catalyst preparation, promoters and Inhibitors

UNIT – II

Solid Catalyzed Reactions - Introduction; Development of rate expressions from L- H - H - W models for reaction $A + B \leftrightarrow R + S$ under adsorption, surface reaction and desorption controlling condition. Pore diffusion resistance combined with surface kinetics (Single cylindrical pore, first order reaction) Porous catalyst particles, mass and heat transfer within catalyst pellets. Experimental methods for finding rates.

UNIT – III

Kinetics of fluid-particle reactions: selection of a model, PCM, SCM, comparison of models with real situations. Shrinking core model for spherical particles of unchanging size: Diffusion through gas film controls, Diffusion through ash layer controls, chemical reaction controls. Rate of reaction for shrinking spherical particles.

UNIT – IV

Kinetics of fluid - fluid reactions: The rate equation for straight mass transfer of A (absorption). The general rate equation and the rate equation for reaction with mass transfer (infinitely fast to very slow reaction). Clues to the Kinetic Regime from Solubility Data

UNIT V

Fluid- Fluid Reactors: Design of reactors for straight mass transfer and mass transfer plus not very slow reaction cases

Catalytic gas solid reactors: Design of single adiabatic fixed bed catalytic reactor

Textbooks

1. Levenspiel O., "Chemical Reaction Engineering", 3rd Edition, John Wiley & Sons, Singapore, (1999).
2. Smith J. M., "Chemical Engineering Kinetics", 3rd Edition, McGraw Hill, (1981).

Suggested Reading:

1. Fogler H. S., "Elements of Chemical Reaction Engineering", 3rdEdition, Prentice Hall Inc., (1999)
2. Chemical and Catalytic Reaction Engineering, Carberry, J. J., Dover Books on Chemistry, 2001.
3. Chemical Reactor Analysis and Design Gilbert F. Froment, Kenneth B. Bischoff, Juray De Wilde, JohnWiley & Sons, Incorporated, 2010

Online resourses:

1. https://archive.nptel.ac.in/courses/103/101/103101141/

22CH C20

PROCESS DYNAMICS AND CONTROL

Instructions:	3L Hours per week
Duration of End Examination:	3 Hours
Semester End Examination:	60 Marks
CIE:	40 Marks
Credits:	3

PRE REQUISITES: Fluid Mechanics, Process Heat Transfer

Course Objectives: To provide a conceptual and methodological framework to

1. Analyze the transient behavior of simple chemical processes (using mathematical modeling from first principles and Laplace transforms)
2. Feedback control of processes - concepts, terminology, methods, and performance
3. Linearize relative to steady state 4. Obtain solution of linear dynamic problems in the laplace domain
4. Understand advanced control strategies with industrial examples

Course Outcomes: At the end of the course the student will be able to:

1. Characterize and analyze the dynamic behavior of linear systems (1st and 2nd order)
2. Understand the importance of various modes of control
3. Construct block diagrams for simple chemical processes
4. Analyze stability of simple feedback control systems
5. Analyze and tune process controllers to achieve desired performance and explain control valve characteristics

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	-	-	-	-	-	-	-	-	2	-
CO2	3	3	2	2	1	-	-	-	-	-	-	1	1	1
CO3	3	3	3	2	1	1	1	-	-	-	-	-	1	1
CO4	3	3	2	1	1	-	-	-	-	-	-	-	1	1
CO5	3	2	2	2	1	1	1	-	-	-	-	1	1	2

UNIT – I

Introduction: Introduction to process Dynamics and control. Solutions of Ordinary Differential equations using Laplace transform. Inversion by partial fractions. Further properties of Transforms and Partial Fractions. Response of First order system, Transfer Function, Transient response to step, impulse, sinusoidal forcing function. Physical examples of first order systems: liquid level, mixing process, heating process. Concept of time constant. Linearization. Response of first order systems in series: interacting and non-interacting systems

UNIT – II

Response of Second Order Systems: Transient response of under damped, critically damped, over damped systems to step, impulse and sinusoidal forcing functions. Transportation lag

Control Systems: Negative and Positive feedback control systems, Servo and Regulatory control problems, Development of Block diagram, Controllers and final control elements, Ideal transfer functions of P, PI, PD and PID controllers

Second order systems: General form of the transfer function of a second order system, Response of a second order system to pulse, step and sinusoidal inputs.

The Feedback Control System:

Block diagram for a chemical reactor control system, Description of the system. Transfer function representation of the various components in the feedback loop, Transportation lag and its Pade approximation, Set point and regulatory control problems, Closed loop transfer function and block diagram reduction.

UNIT – III

Control system block diagrams and Stability: Reduction of physical control systems to block diagrams. Closed loop transfer functions for servo & regulator problems. Overall Transfer functions for multi loop control systems.
Transient response of simple control systems for servo and regulator problems, measurement lags. Stability of a control system by Routh's Criterion

Transient response of closed loop: Proportional and Proportional-Integral action controllers on the dynamics of the closed loop, Measurement lag and its effect on the closed loop dynamics.

Stability of a closed loop: Derivation of the characteristic equation for a closed loop, Concept of poles and zeros of a transfer function, The role of poles and zeros on the dynamics of a system, Right hand side zeros and the concept of inverse response, Concept of stability, Stability criteria based on the location of closed loop poles, How right hand side zeros limit the stability of a closed loop, Routh test to test the stability of a system.

UNIT – IV

Root Locus: concept of root locus, plotting of the root locus diagram for feedback control systems, Transient response of control system from root locus plot.
Frequency response: Bode diagrams for first order, first order system in series, second order systems and for controllers and transportation lag. Bode stability criterion. Gain margin and phase margin
Introduction to frequency response: Bode plots for common transfer functions, Bode stability criteria, The concept of gain and phase margins, Ziegler-Nicholas tuning rules for controller system design, Cohen-Coon settings for controller design.

UNIT – V

Advanced Control Strategies: Controller Tuning and Process Identification: ISE, ITAE, IAE, Ziegler-Nicholas and Cohen-Coon tuning methods, process identification by step, frequency and pulse testing
Cascade control, Feed forward control, Ratio control, Dead time compensation using Smith predictor, Internal model control.
Control Valves: Control valve construction, Air to open and air to close valve functioning, Valve characteristics, Valve sensitivity, Linear valves, Equal percentage valves, Square root valves.

Text Books:

1. Donald R Coughanowr , Steven E LeBlanc, "Process Systems Analysis and Control", 3rd ed., McGraw Hill Inc, 2013

Suggested Reading:

1. George Stephanopoulos , "Chemical Process Control: An Introduction to Theory and Practice", PHI, 2010
2. Michael L Luyben, William L Luyben, "Essentials of Process Control", McGraw-Hill, 1997
3. Seborg, Edgar, Mellichamp and Doyle, "Process Dynamics and Control", 3rd Edition, Wiley India Pvt. Ltd., 2014
4. Process Control, B.W. Bequette, PHI Learning Pvt. Ltd., New Delhi, 2010

Online Resources:

1. Chemical Process Control by Prof. Sujit S Jogwar, IIT Bombay
   https://archive.nptel.ac.in/courses/103/101/103101142/
2. Process Control and Instrumentation by Dr. A K Jana, Dr. D Sarkar, IIT, Khargpur
   https://nptel.ac.in/courses/103105064

22CH C 21 PLANT DESIGN AND ECONOMICS

Instruction	3Hours per week
Duration of SEE	3 Hours
SEE	60Marks
CIE	40Marks
Credits	3

Prerequisites: MEBC, FM, HT

Course objectives: This course helps the students to:

1. Basics of plant design and plant layout
2. Criteria of selecting process equipment, based on which optimized design can be identified
3. Importance of process economics in process industries

Course Outcomes: At the end of the course students will be able to

1. Understand the basic aspects of plant design and its elements
2. Select a suitable optimized cost-effective equipment for a given process
3. Learn the basics of cost accounting and perform the cost analysis of a plant.
4. Identify methods of estimation of depreciation and profitability studies.
5. Design & Optimize the cost-effective process equipment and plants

CO-PO-PSO Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	-	-	-	-	-	2	-	2	1	2	3
CO2	3	1	1	-	-	-	-	-	2	-	1	1	2	3
CO3	3	2	2	-	-	-	-	-	2	-	1	1	3	3
CO4	3	2	2	-	-	-	-	-	2	-	1	1	3	3
CO5	3	2	2	-	-	-	-	-	2	-	1	1	3	3

UNIT - I

Basic Aspects of Process Design: Introduction – definitions of plant design, process synthesis, process simulation; design factors, design problem and steps; Process flow diagram and Block flow diagram; Mass and energy balances; Piping and Instrumentation diagram; Equipment Design Codes and standards.

UNIT - II

Selection of Process Equipment, Specification and Design; Process Utilities, Utility flow diagram with Examples; Materials choice; Plant location – general site considerations, Site layout and Plant layout, Ethics in Engineering design. Safety factors.

UNIT - III

Process Economics –Cost Accounting – Capital investment, cost index, Equipment cost; Elements of cost; Expenses; Project cost and cost of production, Various components of cost of production and their estimation, Various components of project cost, variable cost, fixed cost, breakeven point and their estimation. Estimation of Working Capital. Balance sheets, Project financing, concept of interest, (Present Worth, Future Worth) time value of money, Margin of Safety

UNIT – IV

Depreciation – Types, Methods of determining Depreciation Profitability Analysis of Projects, Alternatives Investment, Replacements, Payout time and Rate of return, Total annualized cost, cost indices, payback period, discounted cash flow; Sensitivity analysis, Inflation

UNIT - V

Design of Fluid Transport Equipment and costs–Pumps, Pressure vessels. Design of Heat Transport equipment and costs– Heat exchangers, Evaporators Design of Reactors and cost analysis Design of Separation Equipment and costs– Distillation, Absorption, Stripping. Optimization in Design – general procedures.

Text Books:

1. Peters. M.S. and Timmerhaus, K.D., "Plant Design and Economics for Chemical Engineering", 4th Edition, McGraw Hill, Singapore, 1991.
2. Coulson, J.M., Richardson J.E. and Sinnott R.K., "Chemical Engineering", Vol. VI, Pergamon Press, 1991

Suggested Reading:

1. Schweyer. H.E., "Process Engineering Economics", McGraw Hill, 1st edition, New York, 1955.
2. Edgar T.F. and Himmelblau D.M., "Optimization of Chemical Processes" 2nd edition, McGraw Hill, International editions, Chemical Engineering series, 2001.The elements of Polymer Science & Engineering, Alfred Rudin, Academic Press, 2nd Edition,1998.
3. Introduction to Polymers, R. J. Young, Chapman & Hall, London, 1991.
4. C.Vilbrandt and Dryden C.E, "Chemical Engineering Plant Design", 4th Ed, MGH Book Co., Reprints, 2015.

Online Resources:

1. https://archive.nptel.ac.in/courses/103/105/103105166/
2. https://onlinecourses.nptel.ac.in/noc20_ch31/preview
3. https://lib.ui.ac.id/detail.jsp?id=13044
4. http://www.msubbu.in/ln/economics/

22CHE09

FUEL CELL TECHNOLOGY

(Professional Elective III)

Instruction	3L Periods per
Duration of	week 3 Hours
SEE SEE	60 Marks
CIE	40 Marks
Credits	3

Pre-requisites: Engineering Chemistry and CRE

Course Objectives: This course helps the students to:

1. Create awareness about alternate clean fuel available.
2. Evaluate the concepts and chemistry of fuel cell
3. Examine the details of fuel used in fuel cell technology
4. Explain the application of fuel cell in different sectors
5. Evaluate the fuel cell system balance plant and future opportunities

Course Outcomes: At the end of course, students will be able to

1. Apply know-how of thermodynamics, electrochemistry and principle of fuel cell
2. Understand the different types of fuel cell
3. Understand the components of hydrogen-based fuel cell and Evaluate the performance
4. Explain the application of fuel cell in transport, stationary and portable sector
5. Understand the impact of this technology in a global and societal context

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	-	-	2	3	-	-	-	1	2	3	2
CO2	3	3	3	-	-	2	2	-	-	-	1	2	3	3
CO3	3	3	3	-	-	2	2	-	-	-	1	2	3	3
CO4	3	3	3	-	-	2	2	-	-	-	1	2	3	2
CO5	3	3	3	-	2	2	3	-	-	-	1	2	3	2

UNIT - I

Introduction: Electrochemical Systems and Fuel Cell, Fuel Cell Fundamentals and Basic Concepts, Fuel Cell Degradation, Fuel Cell Operation, Types Of Fuel Cell And Its Applications: Direct Carbon Fuel Cell, Solid Oxide Fuel Cell, Polymer Electrolyte Fuel Cell, Alkaline Fuel Cell, Phosphoric Acid Fuel Cell, Molten Carbonate FuelCell, Fuel Cell Thermodynamics - Heat, Work Potentials, Prediction of Reversible Voltage, Fuel Cell Efficiency.

UNIT – II

Fuels and Fuel Processing: Introduction, Feedstock for H2 production: Natural gas, Liquefied petroleum gas, Liquid hydrocarbon Fuels: Gasoline and Diesel, Alcohols- Methanol and Ethanol, Ammonia, Biomass, Fuel processing for fuel cell applications: Desulfurization, fuel reforming, water gas shift reaction, Carbon monoxide Removal.

UNIT – III

Fundamental and Components of Portable Hydrogen Fuel Cell: Introduction, PEM Fuel cell Components and their properties: Membrane, Electrode, Gas diffusion layer, Bipolar plates, Stack design principles, system design, performance analysis, current/voltage, voltage efficiency and power density, ohmic resistance, direct methanol and other non-hydrogen fuel cells, biofuel cell

UNIT – IV

Application of Fuel Cell: Hydrogen fuel cell use in transport, stationary Fuel cell characterization: - in-situ and ex- situ characterization techniques, i-V curve, frequency response analyses; Fuel cell modeling and system integration:
- 1D model - Analytical solution and CFD models.

UNIT – V:

Balance of plant and commercialization issues, Future Opportunities, obstacles and challenges associated in fuel cell systems, impact of this technology in a global and societal context

Text Books

1. Nigel M. Sammes ,Fuel Cell Technology, Reaching Towards Commercialization, Springer London, 2006.
2. David A Berry, Dushyant Shekhawat, J.J. Spivey, Fuel Cells: Technologies for Fuel Processing, Elsevier Science, 2011.

Suggested Readings

1. Shigenori Mitsushima, Viktor Hacker Fuel Cells and Hydrogen, From Fundamentals toApplied Research, Elsevier Science, 2018.

Online Resources

1. https://archive.nptel.ac.in/courses/103/102/103102015/#

22CHE10 **PETROCHEMICAL TECHNOLOGY**

(Professional Elective III)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Course objectives: This course helps the students to understand the

1. Petroleum refineries worldwide.
2. Extraction and production of oil and gas to meet energy needs.
3. Importance of refining crude oil for a wide spectrum of useful products such as petrochemicals, plastics.

Course Outcomes: At the end of the course, the students will be able to

1. Explain the composition, applications and formation theories of crude oil
2. Summarize the refining process of crude oil and the treatment methods for upgrading products.
3. Outline Ethylene derivatives and identify their manufacturing processes.
4. Outline Propylene and C4 derivatives and explain their manufacturing processes.
5. Identify Aromatic derivatives sources and separation methods for aromatics.

CO- PO and PSO Correlation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	-	-	1	2	1	-	-	-	-	1	1	3
CO2	2	1	1	1	1	1	1	-	-	-	-	1	1	2
CO3	2	1	-	1	-	2	1	-	-	-	-	1	2	1
CO4	2	1	-	-	-	1	1	-	-	-	-	2	2	1
CO5	2	3	-	-	-	1	1	-	-	-	-	2	2	1

UNIT−I

Origin and formation of Petroleum: Organic theories, Inorganic theories and biological methods for explaining the formation of Crude oil.

History, Indian and World scenario of Petroleum Industry and Refineries;

Composition of crude oil: Alkanes, Alkenes, Alkynes classification

Petroleum Refining products, properties and testing methods: Overall refining of crude petroleum, Production of Natural gas, gasoline, kerosene and lubricating oils; API Gravity, Aniline point, Octane number, Cetane number, Smoke point, Fire point, Flash point, Diesel Index etc.

UNIT− II

Overview of Refining Processes; Crude pre-treatment methods

Rebuilding of Hydrocarbons and techniques involved:

Cracking: Definition, types, reactions, fluidized bed cracking, description of the reactors. Alkylation:- Hydrofluoric acid process and sulphuric acid process

Isomerization:- Aluminum chloride process and isomerization with platinum catalyst.

Olefin Polymerization: Polymerization in presence of sulphuric acid, polymerizations in presence of phosphoric acid. Reforming; Visbreaking; Coking

UNIT− III

Petrochemicals Overview: Classification of Various Feedstocks and products Manufacture of Methanol from Synthesis gas; Formaldehyde from Methanol

Ethylene Derivatives: Ethylene Industry - Various products with ethylene as the starting materials. Manufacturing and applications of the following: Vinyl Chloride Monomer, Ethyl alcohol by direct hydration and liquid phase hydration methods, Vinyl acetate monomer, Ethylene oxide and Ethanol Amine, Polyethylene.

UNIT – IV

Propylene derivatives: List of propylene derivatives; Manufacturing of the following: Isopropyl alcohol, Acetone, Cumene, Acrylonitrile, Propylene oxide, Isoprene and Oxo-processing of Olefins.

Butylene Derivatives: List of butadiene derivatives, Manufacturing of butadiene from n-butylene and by oxidative dehydrogenation; butylene glycol.

UNIT –V

Derivatives of Aromatics and their Manufacture: Aromatic Industry; BTX and their derivatives; Production of Benzene, Toluene, Xylene and their separation; Phenol, Styrene manufacture by different routes.

Derivative of Higher Paraffins: Manufacturing of Isoprene, olefins of C5 , C6, long chain and straight chain Olefins.

Text Books:

1. W.L.Nelson, “Petroleum refinery engineering” 4th ed., McGraw Hill company, 2013.
2. B.K.Bhasker Rao, “Modern petroleum refining process”, 5th ed., Oxford and IBH, 2008.
3. Uttam Ray Chaudari, “Fundamentals of Petroleum and Petrochemical Engineering”, CRC Press, 2011.

Suggested Reading

1. Ram Prasad, “Petroleum Refining Technology”, Khanna Publishers, 1998.
2. N.K.Sinha, “Petroleum Refining and PetroChemicals”, 1st edition, Umesh publications , 2003.
3. Kirk-Othmer, “Encyclopedia of Chemical Technology”, 3rd Ed..John Wiley and sons.Inc, 2004.
4. Meyers Robert, “HandBook of Petroleum Refining Processes”, 3rd edition McGraw Hill, 2003

Online resources:

Chemical Technology-II
https://nptel.ac.in/courses/103103029
Chemical Technology-I
https://archive.nptel.ac.in/courses/103/107/103107081/
Petroleum Refining Engineering:
https://archive.nptel.ac.in/courses/103/102/103102022/
Chemical Technology - II
https://www.academia.edu/13257922/NPTEL_Chemical_Chemical_Technology_II

22 CHE11 PHARMACEUTICAL TECHNOLOGY

Professional Elective III

Instruction	3 L Hours perweek
Duration of SEE	3Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisites: MEBC, MUO, Chemical Technology

Course Objectives: This course will help the students to understand the:

1. Grade of chemicals, Principles &Various Tests
2. Preparation & testing of Pharmaceuticals & fine chemicals
3. The Concepts & Principles to draw the flow sheets
4. Methods & equipment used for Tablets, Capsules Preparation
5. Sterilization methods.

Course Outcomes: At the end of the course, the students will be able to:

1. Identify the different grades of chemicals, their impurities and limit tests
2. Compare the properties Pharmaceuticals and fine chemicals
3. Apply the testing methods for Pharmaceuticals and fine chemicals
4. Draw flow sheets for manufacturing common Pharmaceuticals & fine chemicals
5. Preparation of tablets and capsules and sterilization methods

CO-PO-PSO Matrix

CO	PO1	PO2	PO3	PO 4	PO5	PO6	PO7	PO8	PO9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	1	2	1	1	-	1	-	-	-	-	-	1	1	1
CO2	1	2	1	1	-	-	-	-	-	-	-	-	2	1
CO3	2	2	1	1	-	-	-	-	-	-	-	-	2	2
CO4	2	1	1	2	-	-	-	-	-	-	-	-	2	2
CO5	2	1	2	2	-	1	-	-	-	-	-	1	1	1

UNIT-I

Introduction and outline of grades of chemicals, sources of impurities in chemicals, principles (without going into details of individual chemicals) of limit test for arsenic, lead, iron, chloride and sulphate in Pharmaceuticals.

UNIT-II

Properties, uses and testing of Pharmaceuticals like sulfacetamide, paracetamol, riboflavin, nicotinamide. Fine chemicals like Methyl orange, fluorescence, procaine hydrochloride, isonicatinic acid hydrazide, para-amino salicylic acid.

UNIT-III

Flowsheet and process description for manufacturing common Pharmaceuticals like aspirin, penicillin, calcium gluconate with uses, properties, flow sheets and testing Methods.

UNIT-IV

Flowsheet and process description for manufacturing of fine chemicals like ferric ammonium citrate, phthalic anhydride. Comparison of phenol fluorobenzene process and benzene sulphate process**.**

UNIT-V

Tablet making, coating, granulation and granulation equipment. Preparation of capsules, extraction of crude drugs. Introduction to sterilization, risk factor, methods of sterilization like heating with bactericide, gaseous and radiation.

Text Books:

1. Ajay Semalty and Mona Semalty Essentials Of Pharmaceutical Technology, 2nd Edition, BS publishers, 2018
2. Dr Shaik Harun Rasheed, A Textbook of Pharmaceutical Technology, Sia publishers, 2017

Suggested Reading:

1. Blently‟s Text Book of Pharmaceutical Chemistry, 8th ed, H A Rawlins, B Tindell and Box,. Oxford University Press, London, 1977.
2. Industrial Chemicals, 3rd ed., Faith, Kayes and Clark, John Wiley &Sons,. 1965.
3. Remington‟s Pharmaceutical Science, 17th ed, Mac publishing company, 1985

Online Resources :

1. https://www.pharmacy.org/
2. https://www.wdl.org/en/
3. https://pharmacylibrary.com/
4. https://libguides.nus.edu.sg/pharmacy/oer
5. https://ispe.org/training/course/pharmaceutical-technology-transfers

22CHE12 **SAFETY AND HAZARD ANALYSIS**

(Professional Elective - III)

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Pre-requisites: Chemical Technology

Course Objectives: This course will help the students to understand the

1. Importance of safety culture in process industry.
2. Disregard for ethical decision making based on numerous case studies.
3. Interaction and implementation of trade-offs concept in chemical plant operation.
4. Examples of problems that can occur with inadequate process design, improper process modification.
5. Different case studies related to industrial processes

Course outcomes: At the completion of this course, students will be able to

1. Analyze chemical incidents and possible consequences to plant facilities, workers, and the general public.
2. Evaluate effect of chemical hazards and risks of toxicants.
3. Understand the safety aspects and safety audit norms for chemical process plant
4. Analyze fire and explosion hazards.
5. Integrate safety concepts into chemical plant design.

CO, PO AND PSO MATRIX

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	2	3	1	1	0	0	1	3	1
CO2	3	3	3	2	2	2	3	1	1	0	0	1	3	1
CO3	3	3	3	2	2	2	3	1	1	0	0	1	3	1
CO4	2	2	3	2	2	2	3	1	1	0	0	1	3	1
CO5	2	2	3	2	2	2	3	1	1	0	0	1	3	1

UNIT-I

Introduction: Process industrial safety –definition, importance. Safety awareness – Safety aspects of site selection, plant planning and layout, check list, inline arrangement of tower drums, exchangers, pumps and main pipelines.
Case studies of major disasters due to safety violations: Chernobyl disaster, Bhopal disaster, recent oil spills. Chemical hazards and workers safety, industrial process case studies.

UNIT – II

Organized labor interest in safety: Involvement of unions in accident prevention, recommendation of occupational health committees. Work Policy of MCA in accident prevention at process industries. Risk assessment procedures (HAZOP) and typical operational practices. Necessary precautionary measures (OSHA). Hazards: Identification and operability studies. Involvement of chemical criminals in process industries and their prevention. DOW Fire and explosion index, calculation of the DOW Fire and EI. Chemical safety data sheets and guides.

UNIT – III

Safety education and training: Training of personnel, on- the- job and job instructed training, meeting and instructional presentations. Effects of toxic Agents, chemicals and smoke on skin, eyes, respiratory tract, digestive tract. Primary protection equipment (PPE) – types, significance and applications. Measuring safety effectiveness: criteria for effective measurement, disabling (Lost-time) injuries, frequency rate, severity rate. Problem related safe-t-score. The technique of safe process design, separation sections, materials handling, storage sections, flow sheet review.

UNIT – IV

Fires and explosions: Types of Explosions, Runaway reactions, Safety valve rupture and risk assessment. Definition of fire, fire triangle, Classification of fires as Class-A, B, C and D. Reaction of fires. Fire extinguishers: Portable fire extinguishers applications and their uses, Construction and working of water, Mechanical foam, CO2, stored powder, ABC powder. Automatic multiple CO2 extinguishers in chemical process industries.

UNIT – V

Emergency preparation and accident investigation: On-site and off-site emergency plan and infrastructure, learning from accidents, layered investigation, equipment aiding in diagnosis. Safety audit: Introduction, essentials, requirements, programs and procedures.

Text Books

1. D. A. Crowl and J.F. Louvar, "Chemical Process Safety", Prentice Hall, New Delhi, 2011.
2. Howard H. Fawcett and W. S. Wood, "Safety & Accident prevention in chemical operations", 2nd Ed., John Wiley and Sons Inc, 1982.

Suggested Reading:

1. Coulson and Richadson, "Chemical Engineering Design", 3rd ed., Vol 6, TMH, 1999.
2. Fulekar M.H, "Industrial Hygiene and Chemical Safety", I.K. International Publisher, 2006.
3. Sanders R.E., "Chemical Process Safety: Learning from case Histories", Butterworth-Heinemann (Elsevier) pub, 2005.

Online Resources:

1. Chemical Process Safety, by Prof. Shishir Sinha, Department of Chemical Engineering IIT Roorkee https://archive.nptel.ac.in/courses/103/107/103107156/
2. Industrial Safety Engineering, by Prof. Jhareswar Maiti, Department of Industrial & Systems Engineering IIT Kharagpur https://archive.nptel.ac.in/courses/110/105/110105094/
3. Safety And Risk Analytics, Prof. Jhareswar Maiti, Department of Industrial & Systems Engineering IIT Kharagpur https://archive.nptel.ac.in/courses/110/105/110105160/

22CH E 13 **BIOCHEMICAL ENGINEERING**
(Professional Elective IV)

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisites: Basics of biology, Mass Transfer, CRE

Course Objectives: This course helps the students to

1. Understand the functions of living cells and apply the principles of Chemical Engineering to bioprocesses.
2. Conduct analysis on the biological factors that are important in the design, operation, performance and/or monitoring of a biological process.
3. Understand the significance of microbes and enzymes.
4. Understand the applications of different bioprocesses.

Course Outcomes: On successful completion of this module, students should be able to

1. Describe the basic structure and function of cells & relate cell function to products and processes useful to man
2. Explain classification, growth concepts and various types of interactions in microbes.
3. Illustrate the significance of enzymes as biocatalysts and immobilized enzymes.
4. Identify and explain the basic features of bioreactors, separation process and down stream processes
5. Summarize the principles of Fermentation technology and products from Industrial biotechnology

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	-	-	-	-	-	-	-	-	-	-	1	1
CO2	2	-	1	-	1	-	-	1	1	-	-	2	2	2
CO3	2	2	2	1	1	1	1	1	1	-	-	2	2	2
CO4	2	2	2	1	1	1	1	-	1	-	-	1	2	2
CO5	1	-	1	-	-	1	-	-	-	-	-	1	1	1

UNIT – I

Introduction to Biochemical Engineering, Molecular Biology& Bio Chemistry

Biochemical Engineering Principles, Biophysics and cell doctrine: Atomic Theory and Cell Theory, Important cell types, structure and functions of a typical cell and their components, Transport across cell membranes: Passive and facilitated diffusion, Active transport Structure and functions of Bio Molecules: Carbohydrates, lipids, Nucleotides to Nucleic Acids – RNA and DNA, Amino acids to Proteins - the building blocks of biochemical life Biosynthesis and Metabolic Pathways: Biosynthesis of Small and Macro Molecules Introduction of metabolic pathways and end products of glucose metabolism.

UNIT – II

Introductory Microbiology

Introduction to Microbiology: Classification and Industrial uses of Microorganisms Growth and Reproduction of Microbes: Growth cycle phases for batch cultivation. Monod's growth kinetics – Growth
Rate dependent classification of Microorganisms.
Microbial Genetics: Recombinant DNA technology and mutant populations. Multiple Interacting Microbial populations: Neutralism, Mutualism, Commensalism, Amesanalism, Predatism and Parasitism

UNIT – III

Enzyme Technology

Enzymology: Enzymes as Biocatalysts - The enzyme substrate complex and enzyme action and Classification of Enzymes based on Functions.

Kinetics of Enzyme Catalyzed Reactions: Simple enzyme kinetics with one and two substrates. Determination of rate constants, substrate activation and inhibition, modulation and regulation of enzyme activity / effect of PH and temp on enzyme activity.

Immobilized Enzyme Technology: Types of Enzyme immobilization, Immobilized enzymes in industrial processes,

Cofactors, Apo-enzymes and Coenzymes utilization and regeneration

UNIT – IV

Bioreactors and Down Stream Techniques - Introduction

Design and Analysis of Biological Reactors: Batch and Continuous Stirred Tank Reactors, Enzyme reactors Ideal Reactors for kinetic measurements: The ideal batch reactor / The ideal continuous flow stirred tank reactor - Alternate bio-reactor configurations

Separation Processes: Filtration, Centrifugation, Adsorption, Reverse osmosis, Dialysis, Electrophoresis, Sedimentation and Extraction Purification Processes: Precipitation, Crystallization, and Chromatography

UNIT – V

Bioprocess Technology

Fermentation Technology: Types of Fermentation, Medium formulation and Culture Propagation, Environmental Biotechnology: Effluent treatment.

Industrial Biotechnology: Commercial enzymes, Antibiotics and single cell protein

Textbooks:

1. James, E Bailey and David F Ollis, “Biochemical Engineering fundamentals”, 2nd Edition, McGraw-Hill International Edition.1986
2. Prof. Shigeo Katoh, Prof. Fumitake Yoshida, “Biochemical Engineering: A Textbook for Engineers, Chemists and Biologists”, First Edition, Wiley- VCH Verlag GmbH & Co.2010

Suggested Reading:

1. Michael L Shuler and Fikret Kargi, “Bioprocess Engineering: Basic Concepts”. Second Edition Prentice Hall, 2002

Online Resources:

1. https://archive.nptel.ac.in/courses/103/105/103105054/

22CHE14 **CORROSION ENGINEERING**

Professional Elective IV

Instruction	3 LHours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisites: MEBC, MUO, Chemical Technology

Course Objectives: This course will help the students to understand the:

1. Definition and classification of corrosion
2. Principles of corrosion, common corrosion forms
3. Different corrosion testing methods
4. Corrosion control methods and material selection for cost reduction
5. Modern theories to explain corrosion

Course Outcomes: At the end of the course, the students will be able to:

1. Explain and predict various corrosion mechanism based on the corrosion theories
2. Distinguish and identify various types of corrosion
3. Explain and apply corrosion testing methods
4. Identify and apply various corrosion prevention techniques
5. Apply modern theories and techniques to predict and prevent corrosion

CO-PO-PSO Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1	1	2	2	1	1	1	1	2	2	2
CO2	2	2	2	2	1	2	2	1	1	1	1	2	2	2
CO3	2	3	2	2	1	2	2	1	1	1	1	3	3	2
CO4	2	3	2	2	1	2	2	1	1	1	1	3	2	3
CO5	2	2	3	2	2	2	2	1	1	1	1	3	3	3

UNIT-I

Introduction: Corrosion principles, Types of Corrosion, Acid Theory, Dry chemical corrosion, Wet theory or Electrochemical Theory, Electro- chemical aspects of Corrosion, environmental effects, Pilling-Bedworth Rule, Metallurgical aspects, corrosion rate expressions, methods of estimation of corrosion rates, Passivity.

UNIT-II

Types of corrosion: Forms of corrosion, uniform attack, galvanic corrosion, Examples of galvanic corrosion, Factors affecting galvanic corrosion, Crevice corrosion, Types of Crevice corrosion, pitting Corrosion: Principle and Theory, inter-granular corrosion, Knife line attack, selective leaching: Dezincification and Graphitization, Cavitation damage, Fretting Corrosion.

UNIT-III

Erosion-corrosion and some case studies, Factors affecting erosion- corrosion, stress corrosion cracking and Factors effecting stress corrosion. Corrosion testing procedures: Introduction, Purpose of Testing, Steps involved in Corrosion testing, Standard expression for corrosion rate, NACE test, Slow stain rate test, Linear Polarization, Paint test, seawater test, In Vivo corrosion test (Field test)

UNIT-IV

Protection against Corrosion: Material selection, alteration of environment, Use of inhibitors, Protection by proper Designing, Modification of the properties of the metal, Cathodic Protection and Anodic Protection Units, Use of protective coatings -organic and inorganic coatings, Methods of application of metallic coatings, cladding.

UNIT-V

Modern Theory: Principle, Thermodynamics: Free energy, Cell Potential, SHE and EMF series, Application of Thermodynamics to corrosion, Pourbaix Diagram. Electrode Kinetics: Exchange current density, Activation Polarization, Concentration Polarization, Combined Polarization, Mixed electrodes, Passivity with modern aspects.
Predicting corrosion behavior: Effect of oxidizers, Velocity effects, galvanic coupling, and Alloy evaluation. Corrosion prevention: Anodic Protection and Noble-Metal Alloying.

Text Books:

1. Corrosion Engineering, 3rd ed., M G Fontana, Tata McGrawHill, 2005.

Suggested Reading:

1. Corrosion and Corrosion Control, H H Uhlig, Wiley, 3rd edition, 2011.
2. Handbook of Corrosion Engineering, Pierre Roberge, McGraw- Hill, New York, 2000.

Online resources

1. https://nptel.ac.in/courses/113108051
2. https://archive.nptel.ac.in/courses/113/104/113104082/

22CHE15 **NUCLEAR ENGINEERING**

(Professional Elective -IV**)**

Instruction	3 L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Course Objectives: This course helps the students to understand:

1. fundamentals of nuclear fission reactions and products.
2. types of nuclear fuel materials, properties, characteristics.
3. non-fuel materials required for design of the reactor structure, cladding and for moderation.
4. different types of reactors, concepts of heat removal, control and safety systems.
5. spent fuel management.

Course Outcomes: Upon completing this course, students will be able to:

1. understand radioactive elements and fission process
2. processing and handling techniques for enrichment of fuel materials
3. properties and radiation effects of non-fuel materials
4. fuel source, heat removal, control and safety needs for operation of nuclear reactors
5. techniques practiced for handling, storage and reprocessing of spent fuel

CO, PO and PSO Correlation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	1	-	-	-	2	-	1	-	-	-	-	2	-
CO2	-	1	2	2	1	2	1	1	-	-	-	-	2	-
CO3	1	1	-	-	-	2	-	1	-	-	-	-	2	-
CO4	-	1	1	-	-	2	-	1	-	-	-	-	2	-
CO5	-	1	2	2	1	-	1	1	-	-	-	-	2	2

UNIT – I: Nuclear fission:

nuclear elements, nuclear stability, nuclear binding energy, radioactive isotopes, radioactive decay - alpha decay, beta decay, gamma rays. Neutron reactions, prompt and delayed fission neutrons, fission products, fission cross-sections, fission rate and reactor power.

UNIT – II: Nuclear fuel materials:

Types of fuel materials, properties and significant characteristics, fuel cycle, pre-reactor fuel operations, isotopic enrichment and separation requirements. Nuclear fuel utilization – breeding ratio, Uranium, Thorium and Plutonium utilization.

UNIT – III: Non-fuel reactor materials

Classification, mechanical properties, radiation effects of materials, corrosion of metals, structural and cladding materials, moderator and reflector materials.

UNIT – IV: Nuclear fission reactors

General features, classification, reactor development for power production. Design features, concepts of heat removal, control and safety systems for: pressurized water reactors (PWR), boiling water reactors (BWR). Heavy water moderated reactors (HWMR) and Fast breeder reactors (FBR).

UNIT – V: Spent fuel management

Characteristics of spent fuel, storage, disposal, reprocessing of spent fuel, Solvent extraction separation process, other possible separation processes.

Text Books:

1. Samuel Glasstone and Alexander Sesonske, "Nuclear Reactor Engineering", 3rd Ed, CBS Publishers and distributors, New Delhi, 1986.

Suggested reading:

1. Benjamin M. MA, "Nuclear reactor materials and applications", Van Nostrand Reinhold Co., New York, 1975.
2. John R. Lamarsh, "Introduction to Nuclear Engineering", Addison-Wesley publishing Co., Philippines, 1975.
3. Raymond L. Murray, "Nuclear Energy", Pergamon Press, New York, 1975.

Online Resources:

1. Introduction to Nuclear Engineering, by Prof. Kannan.N.Iyer, IIT Bombay
   https://nptel.ac.in/courses/112101007

2. Nuclear Reactor Technology, by Dr. K.S. Rajan, School of Chemical & Biotechnology, SASTRA University
   https://archive.nptel.ac.in/courses/103/106/103106101/

3. Fundamentals of Nuclear Power Generation, by Prof. Dipankar N. Basu, IIT Guwahati
   https://archive.nptel.ac.in/courses/112/103/112103243/
   &
   https://onlinecourses.nptel.ac.in/noc21_me54/preview

22CHE16 **NANOSCIENCE AND NANOTECHNOLOGY**
(Professional Elective -IV**)**

Instruction	3 L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Course Objectives This course aims to give some understanding on

1. The introduction and classification of nanoscience and nanomaterials
2. Explain the unique properties of nanomaterials.
3. The various synthesis routes of nanomaterials
4. The tools required for the characterization of nanomaterials.
5. The applications of nanomaterials.

Course Outcomes At the end of the course, the students will be able to

1. Explain the types of nanomaterials and classify them.
2. Understand various defects, and the effect of nano dimensions on the material behavior.
3. Discuss the bottom up and top-down synthesis of nanomaterials.
4. Explain the characterization of nanomaterials using various techniques.
5. Enlist and explain various applications of nanomaterials in diversified fields and areas**.**

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	-	-	1	1	-	-	-	-	2	2	-
CO2	2	1	1	-	-	1	1	-	-	-	-	2	2	-
CO3	2	1	1	-	-	1	1	-	-	-	-	2	2	-
CO4	2	1	1	-	-	1	1	-	-	-	-	2	2	-
CO5	2	1	1	-	-	1	1	-	-	-	-	2	2	-

Unit I: Introduction

History and scope, classification of nanostructured materials, Fascinating nanostructures, applications of nanomaterials

Unit II: Unique properties of nanomaterials

Microstructure and defects in nanocrystalline materials – dislocations, Twins, stacking faults and voids, Grain boundaries, triple junctions and disclinations.

Effect of nano-dimensions on materials behavior – Elastic properties, magnetic properties, electrical properties, optical properties, thermal properties, and mechanical properties.

Unit III: Synthesis Routes

Bottom-up approaches – PVD, CVD, sol-gel process, wet chemical synthesis and self-assembly. Top-down approaches – mechanical alloying, nanolithography

Unit IV: Tools to Characterize Nanomaterials

Scanning electron microscopy, transmission electron microscopy, x-ray diffraction, atomic force microscopy, nanoindentation

Unit V: Applications of Nanomaterials

Nano-electronics, Micro- and Nano-electromechanical systems (MEMS/NEMS), Nano sensors, Nano catalyst, Food and Agriculture Industry, Cosmetics and Consumer Goods, Structure and Engineering, Automotive Industry, Water Treatment and the Environment, Nano-medical Applications, Textiles , Paints, Energy, Defence and SpaceApplications.

Text Book:

1. Murty BS, Shankar P, Baldev Raj, Rath BB, James Murday. Textbook of Nanoscience and Nanotechnology. Bangalore: Springer; 2013.

Online Resources:

1. Nanotechnology, Science and Applications by Prof. Prathap Haridoss, IIT Madras https://onlinecourses.nptel.ac.in/noc22_mm33/preview
2. Introduction to Nanoscience and Nanotechnology, Prof. Dr. Swapna Nair, Central University of Kerala https://onlinecourses.swayam2.ac.in/cec24_cy03/preview

22EGO02

GENDER SENSITIZATION

Instruction	3 L Hours per Week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: No specific prerequisite is required.

Course Objectives

This course will introduce the students to:

1. Sensibility regarding issues of gender in contemporary India.
2. A critical perspective on the socialization of men and women.
3. Popular debates on the politics and economics of work while helping them reflect critically on gender violence.

Course Outcomes

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

1. Understand the difference between "Sex" and "Gender" and be able to explain socially constructed theories of identity.
2. Recognize shifting definitions of "Man" and "Women" in relation to evolving notions of "Masculinity" and "Femininity".
3. Appreciate women's contributions to society historically, culturally and politically.
4. Analyze the contemporary system of privilege and oppressions, with special attention to the ways in which gender intersects with race, class, sexuality, ethnicity, ability, religion, and nationality.
5. Demonstrate an understanding of personal life, the workplace, the community and active civic engagement through classroom learning.

CO-PO-PSO Articulation Matrix

PO/PSO CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	-	-	1	-	-	2	2	1	1	-	-	1	1	1
CO 2	-	-	1	-	-	2	2	1	1	-	-	1	1	1
CO 3	-	-	1	-	-	2	2	2	2	1	1	1	-	-
CO 4	-	-	1	-	-	3	2	2	2	1	1	1	1	2
CO 5	-	-	1	-	-	2	2	2	3	1	1	1	1	2

UNIT – I

Understanding Gender:

Gender: Why Should We Study It? (*Towards a World of Equals*: Unit -1)

Socialization: Making Women, Making Men (*Towards a World of Equals*: Unit -2)

Introduction. Preparing for Womanhood. Growing up Male. First lessons in Caste. Different Masculinities.

UNIT – II

Gender and Biology:

Missing Women: Sex Selection and Its Consequences (*Towards a World of Equals*: Unit -4)

Declining Sex Ratio. Demographic Consequences.

Gender Spectrum: Beyond the Binary (*Towards a World of Equals*: Unit -10)

Two or Many? Struggles with Discrimination.

UNIT – III
Gender and Labour:
Housework: the Invisible Labour (*Towards a World of Equals*: Unit -3)
"My Mother doesn't Work." "Share the Load."
Women's Work: Its Politics and Economics (*Towards a World of Equals*: Unit -7)
Fact and Fiction. Unrecognized and Unaccounted work. Additional Reading: Wages and Conditions of Work.

UNIT-IV
Issues of Violence
Sexual Harassment: Say No! (*Towards a World of Equals*: Unit -6)
Sexual Harassment, not Eve-teasing- Coping with Everyday Harassment- Further Reading: "*Chupulu".*
Domestic Violence: Speaking Out (*Towards a World of Equals*: Unit -8)
Is Home a Safe Place? -When Women Unite [Film]. Rebuilding Lives. Additional Reading:
New Forums for Justice.
Thinking about Sexual Violence (*Towards a World of Equals*: Unit -11)
Blaming the Victim-"I Fought for my Life…." - Additional Reading: The Caste Face of Violence.

UNIT – V
Gender: Co - Existence
Just Relationships: Being Together as Equals (*Towards a World of Equals*: Unit -12)
Mary Kom and Onler. Love and Acid just do not Mix. Love Letters. Mothers and Fathers.
Additional Reading: Rosa Parks-The Brave Heart.

Textbook:

1. Suneetha Uma Bhrugubanda, Duggirala Vasanta, Rama Melkote, Vasudha Nagaraj, Asma Rasheed,
2. Gogu Shyamala, Deepa Sreenivas and Susie Tharu "Towards a World of Equals: A Bilingual Textbook on Gender"**,** Telugu Akademi, Hyderabad, 2015.

Suggested Reading:

1. Menon, Nivedita. "Seeing like a Feminist", Zubaan-Penguin Books, New Delhi, 2012.
2. Abdulali Sohaila, "I Fought For My Life…and Won", Available online at: http://www.thealternative.in/lifestyle/i-fought-for-my-lifeand-won-sohaila-abdulal/

Web Resources:

1. https://aifs.gov.au/publications/gender-equality-and-violence-against-women/introduction
2. https://theconversation.com/achieving-gender-equality-in-india

Note: Since it is an Interdisciplinary Course, Resource Persons can be drawn from the fields of English Literature or Sociology or Political Science or any other qualified faculty who has expertise in this field from engineering departments.

22ITO02 **PRINCIPLES OF INTERNET OF THINGS**

(Open Elective)

Instruction	3 L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Course Objectives:

1. To provide an overview of Internet of Things, building blocks of IoT and real-world applications.
2. To explore various IOT enabling technologies.
3. To facilitate students, understand Python scripts for IoT platform.
4. To identify steps in IOT design Methodology.
5. To introduce the Raspberry Pi device, its interfaces and Django Framework.

Course Outcomes:

Upon completing this course, students will be able to:

1. Comprehend the terminology, protocols and communication models of IoT.
2. Define the various IoT enabling technologies and differentiate between M2M and IoT.
3. Acquire the basics of Python Scripting Language used in developing IoT applications.
4. Describe the steps involved in IoT system design methodology.
5. Design simple IoT systems using Raspberry Pi board and interfacing sensors with Raspberry Pi.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1	1	1	-	1	-	-	-	-	1
CO2	1	2	2	1	-	2	1	-	-	1	-	-
CO3	2	2	2	2	1	2	2	1	1	1	1	1
CO4	2	1	2	2	1	-	2	1	-	1	2	2
CO5	1	2	2	1	-	2	1	-	1	1	-	-

UNIT-I

Introduction & Concepts: Introduction to Internet of Things- Definitions & Characteristics of IoT, Physical Design of IOT-Physical Layer, Network Layer, Transport Layer, Application Layer, Things in IoT, IoT Protocols, Logical Design of IOT-Nonfunctional Blocks, IoT Communication Models-Request response, Publisher-Subscriber, Push-Pull, Exclusive Pair, IoT Communication APIs-REST API, Web socket API.

UNIT-II

IOT Enabling Technologies: Wireless Sensor Networks, Cloud Computing, Big Data Analytics, Communication Protocols, Embedded Systems, IOT Levels & Deployment Templates. Differences and similarities between IOT and M2M, Domain Specific IoT's – IoT applications for Home Automation, Cities, Environment, Energy, Retail, Logistics, Agriculture, Industry, health and Lifestyle.

UNIT-III

Introduction to Python: Motivation for using Python for designing IoT systems, Language features of Python, Data types- Numbers, Strings, Lists, Tuples, Dictionaries, Type Conversions, Data Structures: Control of flowif, for, while, range, break/continue, pass, functions, modules, packaging, file handling, data/time operations, classes, Exception handling.

UNIT-IV

IoT Platforms Design Methodology: Introduction, IoT Design Methodology Steps-Purpose and Requirements Specification, Process Specification, Domain Model Specification, Information Model Specification, Service Specifications, IoT Level Specification, Functional View Specification, Operational View Specification, Device and Component Integration, Application Development, Case Study on IoT System for Weather Monitoring.

UNIT-V

IoT Physical Devices and End Points: Basic building blocks of an IoT device, Raspberry Pi about the Raspberry Pi board, Raspberry Pi interfaces-Serial, SPI, I2C, Other IoT Devices pcDuino, BeagleBone Black, Cubieboard. Python Web Application Framework: Django Framework-Roles of Model, Template and View

Text Books:

1. Arshdeep Bahga and Vijay Madisetti, "Internet of Things - A Hands-on Approach", Universities Press, 2015.
2. Matt Richardson & Shawn Wallace, "Getting Started with Raspberry Pi", O'Reilly (SPD), 2014.

Suggested Reading:

1. Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle, "From Francis da Costa, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1st Edition, Apress Publications, 2013.
2. Daniel Minoli, "Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications", Willy Publications.

Web Resources:

1. The Internet of Things - Article https://dl.acm.org/citation.cfm?id=1862541
2. Internet of Things - Tutorial
3. http://archive.eurescom.eu/~pub/abouteurescoiem/message_2009_02/Eurescom_message_02_2009.pdf

22MEO06 PRINCIPLES OF ENTREPRENEURSHIP AND STARTUPS

(Open Elective II)

Instruction	3L	Hours per week
Duration of SEE	3	Hours
SEE	60	Marks
CIE	40	Marks
Credits	3	

Prerequisite: Nil

Course Objectives: This course aims to

1. Impart basic concepts and procedure of idea generation.
2. Familiarize the nature of industry and related opportunities and challenges.
3. Familiarize with elements of business plan and its procedure.
4. Learn the project management and its techniques.
5. Know the behavioral issues and time management.

Course Outcomes: Upon completion of this course, the students will be able to

1. Understand the concept and essence of entrepreneurship.
2. Identify business opportunities and nature of enterprise.
3. Analyze the feasibility of new business plan.
4. Apply project management techniques like PERT and CPM for effective planning and execution of projects.
5. Use behavioral, leadership and time management aspects in entrepreneurial journey.

CO-PO Articulation Matrix

PO/PSO CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO 1	1		1	1	1	2	2	2	1	1	1	1	-	-
CO 2	1	1	1	1	1	2	2	2	2	2	3	1	-	-
CO 3	1	1	1	2	2	2	2	2	2	2	3	1	-	-
CO 4	2	1	1	2	2	2	2	2	1	2	3	1	-	-
CO 5	1		1	1	1		2	2	1	1	1	1	-	-

UNIT - I

Entrepreneurship: Definition, Characteristics of an Entrepreneur, Functions of Entrepreneurs, Entrepreneur vs. Intrapreneur, First Generation Entrepreneur, Women Entrepreneurship, Ideas and their Sources, Conception and Evaluation of Ideas.

Behavioral Aspects of Entrepreneurs: Personality: Determinants, Attributes and Models, Leadership: Concepts and Models, Values and Attitudes, Motivation Aspects.

UNIT - II

Indian Industrial Environment: Competence, Opportunities and Challenges, Entrepreneurship and Economic Growth, Small Scale Industry in India, objectives, Linkage among Small, Medium and Heavy Industries, Types of Enterprises, Corporate Social Responsibility.

UNIT - III

Business Plan: Introduction, Elements of Business Plan and its salient features, Business Model Canvas, Technical Analysis, Profitability and Financial Analysis, Marketing Analysis, Feasibility Studies, Executive Summary.

UNIT - IV

Project Management: During construction phase, project organization, project planning and control using CPM, PERT techniques, human aspects of project management.

Time Management: Approaches of Time Management, their strengths and weaknesses. Time Management Matrix, Urgency Addiction.

UNIT - V

Startup: Definition, Startup Ecosystem, Startup Incubator, Need and Importance of Startups and Incubation Centers. Sources of Finance and Incentives for Startups. Innovation, Creativity, Intellectual Property in Entrepreneurial Journey. Business firm Registration Process in INDIA.

Textbooks:

1. Vasant Desai, "Dynamics of Entrepreneurial Development and Management", Himalaya Publishing House, 1997.
2. Prasanna Chandra, "Project-Planning, Analysis, Selection, Implementation and Review", Tata Mcgraw-Hill Publishing Company Ltd, 1995.
3. S.S. Khanka, "Entrepreneurial Development", S. Chand & Co. Pvt. Ltd., New Delhi, 2015.

Suggested Reading:

1. Robert D. Hisrich, Michael P. Peters, "Entrepreneurship", 5th edition, Tata Mc Graw Hill Publishing Company. Ltd., 2005.
2. Stephen R. Covey and A. Roger Merrill, "First Things First", Simon and Schuster Publication, 1994.

22EEO01 **ENERGY MANAGEMENT SYSTEM**
(Open Elective)

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisites: None.

COURSE OBJECTIVES: This course aims to

1. Know the concept of Energy Management.
2. Understand the formulation of efficiency for various Engineering Systems
3. Enable the students to develop managerial skills to assess feasibility of alternative approaches and drive strategies regarding Energy Management

COURSE OUTCOMES: After the completion of this course, the student will be able to

1. Know the current Energy Scenario and importance of Energy Conservation.
2. Understand the concepts of Energy Management, Energy Auditing.
3. Interpret the Energy Management methodology, Energy security and Energy Strategy.
4. Identify the importance of Energy Efficiency for Engineers and explore the methods of improving Energy Efficiency in mechanical systems, Electrical Engineering systems
5. Illustrate the Energy Efficient Technologies in Civil and Chemical engineering systems

CO-PO& PSO Correlation Articulation Matrix:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO-1	1	-	-	1	-	1	2	1	-	-	-	1			
CO-2	2	1	1	1	-	1	2	1	-	-	-	1			
CO-3	2	2	2	1	-	1	2	1	-	-	-	1			
CO-4	2	2	1	2	2	1	2	1	-	-	-	1			
CO-5	1	1	2	1	1	1	2	2	-	-	-	1			

UNIT-I

Various forms of Energy and its features: Electricity generation methods using different energy sources such as Solar energy, wind energy, Bio-mass energy, and Chemical energy such as fuel cells. Energy Scenario in India, Impact of Energy on economy, development, and environment sectors of national and international perspective.

UNIT-II

Energy Management-I: Defining Energy Management, need for Energy Management, Energy management techniques, importance of Energy Management, managing the Energy consumption, Energy Audit and Types, Energy Audit Instruments.

UNIT-III

Energy Management-II: understanding Energy costs, bench marking, Energy performance, matching energy use to requirement, optimizing the input, fuel & Energy substitution, material and Energy balance diagrams, Energy pricing, Energy and Environment, Energy Security

UNIT-IV

Energy Efficient Technologies-I: Importance of Energy Efficiency for Engineers, Energy Efficient Technology in Mechanical engineering: Compressed Air System, Heating, ventilation and air- conditioning, Fans and blowers, Pumps and Pumping Systems,

Energy Efficient Technology in Electrical engineering: Automatic Power Factor Controllers, Energy Efficient Motors, soft starters with energy saver, variable speed drives, energy efficient transformers, electronic ballast, occupancy sensors, energy efficient lighting controls, space cooling, energy efficiency of lifts and escalator, energy saving potential of each technology.

UNIT-V

Energy Efficient Technologies-II: Energy Efficient Technology in Civil Engineering: Intelligent Buildings, And Various Energy Efficiency Rating Systems for Buildings, Green Buildings Energy Efficiency: management of green buildings, importance of embodied energy in selection of sustainable materials, green building design, waste reduction/recycling, rainwater harvesting, maintenance of the green buildings, green building certification, Renewable energy applications.

Energy Efficient Technology in Chemical Engineering: Green chemistry, Low carbon cements, recycling paper.

TEXT BOOKS:

1. Umesh Rathore, 'Energy Management', Kataria publications, 2nd ediiton, 2014.
2. G Hariharaiyer, “Green Building Fundamentals”, Notion press.com
3. K V Shama, P Venkataseshaiah, "Energy management and conservation", I. K. International Publishing agency pvt. ltd., 2011, ISBN: 978-93-81141-29-8

SUGGESTED READING:

1. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-1, General Aspects
2. Hargroves, K., Gockowiak, K., Wilson, K., Lawry, N., and Desha, C. (2014) An Overview of Energy Efficiency Opportunities in Mechanical/civil/electrical/chemical Engineering, The University of Adelaide and Queensland Universityof Technology.
3. Success stories of Energy Conservation by BEE, New Delhi (www.bee-india.org)

22CHC22 CHEMICAL REACTION ENGINEERING LAB

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	50 Marks
CIE	50 Marks
Credits	1.5

Course Objectives: This course helps the students to understand to

1. Familiarize students with the main type of chemical reactors.
2. Analyze the experimental data to obtain the reaction rate expression (reaction order and specific reaction rate constant).
3. Compare the conversion of reactants for a specific reaction in various types of reactor.
4. Understand the concept of residence time distribution in reactor systems.
5. Determine mass transfer coefficient of systems with and without chemical reaction.

Course Outcomes: At the end of the course students will be able to:

1. Develop rate law for use in reactor design based on reaction data from a reactor.
2. Find the conversion of reactants for a particular reaction in different reactors.
3. Interpret the kinetics of an exothermic reaction.
4. Analyze laboratory reactors through residence time distributions.
5. Determine mass transfer coefficient of Solid-Liquid and Liquid-Liquid systems.

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	1	-	1	-	2	-	-	-	3	2
CO2	3	2	1	1	1	-	1	-	2	-	-	1	3	3
CO3	3	2	1	1	1	-	1	-	2	-	-	2	2	2
CO4	3	2	1	1	1	-	1	-	2	-	-	-	2	3
CO5	3	2	1	1	1	-	1	-	2	-	-	1	2	2

List of Experiments

(Minimum of 10 Experiments in the list are to be performed)

1. Studies in Batch Reactor: To find the Arrhenius form of temperature dependency of reaction.
2. Studies in Mixed Flow Reactor (CSTR): To find kinetics from reactor performance of CSTR.
3. Studies in Tubular Reactor: To determine the rate constant and to verify the order of reaction.
4. Mass Transfer with Chemical Reaction (Liquid – Liquid Reaction System): To find out the mass transfer coefficient in a stirred cell with chemical reaction and without chemical reaction.
5. Mass Transfer with Chemical Reaction (solid – Liquid Reaction System): To find the mass transfer coefficient with chemical reaction and without chemical reaction.
6. R.T D Studies in Packed bed reactor: To determine the axial mixing (axial dispersion) in the packed column.
7. R T D Studies in Tubular Column: To determine the variance of residence time distribution and the dispersion number in a tubular column.
8. Studies in Batch Reactor: With Equimolar Feed (M = 1): To determine the rate constant and to verify the order of reaction by differential & integral methods of analysis.

9. Studies in Batch Adiabatic Reactor: To determine the kinetics of an exothermic reaction from the temperature of the reaction system.

10. Studies in Mixed Flow Reactors in series: To compare the actual & ideal performances of a reaction system.

11. Studies in Packed bed: To determine the rate constant and to verify the order of reaction from performance of the reactor.

Text Books:

1. Octave Levenspiel, Chemical Reaction Engineering, Wiley India Pvt. Ltd, New Delhi, 3rd Ed, 2006.
2. H. Scott Fogler, Elements of Chemical Reaction Engineering, Prentice Hall, 3rd Edition, 2002.

Suggested Reading:

1. J. M. Smith, Chemical Engineering Kinetics, McGraw – Hill, Third Edition, 1981.
2. L. D. Schmidt, The Engineering of Chemical Reactions, Oxford Press, 2nd Edition, 2004.

Online Resources:

1. https://archive.nptel.ac.in/courses/103/103/103103153/
2. https://archive.nptel.ac.in/courses/103/101/103101141

22CHC23 **PROCESS DYNAMICS & CONTROL LAB**

Instruction	3P Hours per week
Duration of SEE	3 Hours
SEE	50 Marks
CIE	50 Marks
Credits	1.5

Prerequisites: Instrumentation, Process Dynamics and control, MEBC, FM

Course Objectives: This course helps the students to understand to

1. Dynamic response of first and second order processes
2. The difference between interacting and non-interacting systems
3. Characteristics of various modes of control
4. Controller tuning methods
5. Control valve characteristics

Course Outcomes: After completing this course, students will be able to:

1. Calibrate and evaluate the performance of a first and second order systems
2. Analyze the response of simple feedback control systems
3. Determine the frequency response of control systems
4. Analyze the behavior of a control system using different modes of controller
5. Estimate the tuning parameters for closed loop and open loop process

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	3	1	3	1	1	3	1	3	1	3	2
CO2	2	1	1	2	1	3	1	1	3	1	3	1	3	2
CO3	2	1	1	1	1	3	1	1	3	1	3	1	3	2
CO4	2	2	1	2	1	3	1	1	3	1	3	1	3	2
CO5	2	2	1	1	1	3	1	1	3	1	3	1	3	2

List of Experiments

(Minimum of 10 Experiments in the list are to be performed)

1. Determination of dynamics of interacting system
2. Determination of dynamics of non-interacting system
3. Determination of dynamics of second order system (U-tube manometer)
4. Differential Pressure Transmitter for level control system
5. Control valve characteristics
6. Step response on Level control trainer
7. Frequency response on Level control trainer
8. Modes of control on Pressure control trainer
9. Zeigler-Nichols's controller tuning on Flow control trainer
10. Cohen-Coon controller tuning on Temperature control trainer
11. Multi-loop control system cascade control
12. Multi-loop control system ratio control

Text Books:

1. Donald R Coughanowr, Steven E LeBlanc, Process Systems Analysis and Control, 3rd edition, McGraw Hill Education (India) Edition2013.
2. D Patranabis, Principles of Industrial Instrumentation, , 2nd ed., Tata McGraw Hill Edu. (India) Pvt. Ltd.,

Online Resources:

1. https://learncheme.com/screencasts/process-controls/
2. https://in.mathworks.com/matlabcentral/fileexchange/116500-process-dynamics-and-control-course
3. http://vlabs.iitkgp.ac.in/cpd/index.html
4. https://uorepc-nitk.vlabs.ac.in/Introduction.html
5. https://www.vlab.co.in/ba-nptel-labs-chemical-engineering

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

Choice Based Credit System (With effect from 2024-2025)

B.Tech (Chemical Engineering)

Semester VII

S.No	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours per Week			Duration of SEE in Hours	Maximum Marks		
			L	T	P/ D		CI E	SEE	
THEORY									
1	22 CHC25	Artificial Intelligence in Chemical Engineering	2	-	-	3	40	60	2
2	22 CHC26	Material Science in Chemical Engineering	3	-	-	3	40	60	3
3	22 CHC27	Transport Phenomena	3	-	-	3	40	60	3
4	22 CHEXX	Professional Elective -V	3	-	-	3	40	60	3
PRACTICAL									
6	22EGC03	Employability Skills	-	-	2	2	50	50	1
7	22CHC28	Artificial Intelligence in Chemical Engineering Lab	-	-	3	3	50	50	1.5
8	22CHC29	Plant Design Lab	-	-	3	3	50	50	1.5
9	22CHC30	Project Part I	-	-	4	-	50	-	2
TOTAL			**11**	-	**12**	**-**	**360**	**390**	**17**
Clock hours per week 23									

S.no	Course Code	**Professional Elective V**
1	22CHE17	Computational Fluid Dynamics
2	22CHE18	Design and Analysis of Experiments
3	22CHE19	Optimization of Chemical Processes
4	22CHE20	Process Intensification

22CHC25 ARTIFICIAL INTELLIGENCE IN CHEMICAL ENGINEERING

Instruction	2 Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	2

Course Objectives

This course aims to give some understanding on

1. The general introduction to artificial intelligence
2. The Fundamental of machine learning
3. The concepts of deep learning
4. The methods used to solve using algorithms
5. The fundamentals of artificial neural networks

Course Outcomes

At the end of the course, the students will be able to

1. Explain various phases in artificial intelligence in chemical engineering
2. Classify and discuss the types of machine learning algorithms
3. Understand the basic concepts of deep learning.
4. Understand different types of evolutionary algorithms and their applications
5. Explain the types of artificial neural networks, their classification and applications.

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	1	-	2	1	-	-	-	1	-	-	2	2	2
2	2	1	1	2	1	-	-	-	1	-	-	2	2	2
3	2	1	1	2	1	-	-	-	1	-	-	2	2	2
4	2	1	2	2	1	-	-	-	1	-	-	2	2	2
5	2	1	1	2	1	-	-	-	1	-	-	2	2	2

Unit I: Introduction

Background, Phases of AI in Chemical Engineering: Past Work, Phase 0: Early attempts, Phase I: Expert systems era (~1983 to ~1995), Phase II: Neural networks era (~1990 to ~2008), Lack of impact of AI during Phases I and II, Phases of AI in Chemical Engineering: Current, Phase III: Deep learning and the data science era (~2005 to present), AI in Chemical Engineering: Recent Trends and Future Outlook, Beyond data science: Phase IV—Emergence in large scale systems of self-organizing intelligent agent.

Unit II: Fundamentals of ANN

Introduction to Artificial Neural Networks, overview, types of ANNs, ANN algorithms: gradient descent, backpropagation algorithm, Application of ANN in chemical engineering – CSTRs using ANN.

Unit III: Fundamentals of Deep Learning

Fundamentals of deep learning - theoretical discussion on DNN architecture, training, and fine-tuning. Applications of DNN in chemical engineering, introduction to Convolution neural networks and recurrent neural networks

Unit IV: Evolutionary algorithms

Genetic Algorithm, Differential evolution, simulated annealing, ANT colony, tabu search applications to chemical engineering problems (Qualitative)

Unit V: **Fundamentals of Machine Learning**

Introduction to machine learning algorithms, Data pre-processing, and feature engineering, model selection for machine learning, Types of Learning problems: Supervised learning, unsupervised learning, and semi-supervised learning.

Text Books:

1. Bhagat P. An introduction to neural nets. Chemical Engineering Progress 1990;86:55–60.
2. Müller AC, Guido S. Introduction to machine learning with Python: a guide for data scientists. First edition. Sebastopol, CA: O'Reilly Media, Inc; 2017.

References:

1. Venkatasubramanian V. The promise of artificial intelligence in chemical engineering: Is it here, finally? AIChE Journal 2019;65:466–78. https://doi.org/10.1002/aic.16489.
2. Venkateswarlu C, Jujjavarapu SE. Stochastic global optimization methods and applications to chemical, biochemical, pharmaceutical and environmental processes. Amsterdam, Netherlands ; Oxford ; Cambridge, MA: Elsevier; 2020.

Online resources

1. An Introduction to Artificial Intelligence, Prof. Mausam, IIT Delhi, https://onlinecourses.nptel.ac.in/noc20_cs42/preview
2. Fundamentals Of Artificial Intelligence, Prof. Shyamanta M. Hazarika, IIT Guwahati, https://onlinecourses.nptel.ac.in/noc22_ge29/preview

22CHC26 MATERIAL SCIENCE IN CHEMICAL ENGINEERING

Instruction	3 L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Course Objectives: This course helps the students to understand the

1. Introduction to different types of engineering materials and alloys
2. Alloying elements and factors for material selection
3. Significant properties of engineering materials
4. Specific requirements of materials for high and low temperature applications.
5. Possible and latest alternatives available for standard engineering materials.

Course outcomes: Upon completing this course, students will be able to:

1. Classify different engineering materials as ferrous and non-ferrous alloys.
2. Compare mechanical and thermal properties of engineering materials
3. Select materials for high and low temperature applications.
4. Identify new or alternate materials for development and operation of the process industry.
5. Understand the significance and applications of Biomaterials

CO, PO and PSO Correlation Matrix

	Program Outcomes												Program Specific Outcomes	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	3	3	2	1	1	0	-	-	-	-	3	3
CO2	3	3	3	3	3	2	0	1	-	-	-	-	3	2
CO3	3	3	3	3	3	2	3	1	-	-	-	-	3	2
CO4	3	3	3	3	3	3	3	1	-	-	-	-	3	1
CO5	3	3	3	3	3	3	3	2	-	-	-	-	3	3

UNIT-I Introduction to Engineering Materials: Classification – metals, non-metals, alloys; Criteria for material selection. Ferrous metals and alloys - types of steels like mild, carbon and stainless steel, common grades of steel – 304 and 316; Non-Ferrous metals and alloys of Aluminium, Copper and Nickel;

UNIT-II General Properties of Engineering Materials: Mechanical Properties: Stress-strain diagram, Elastic, Plastic, Anelastic and Viscoelastic behavior. Creep, Fatigue and Fracture strengthening mechanisms; **Thermal Properties:** Conductivity, Expansion, Protection, Diffusivity, Stresses and Shock resistance;

UNIT-III Materials for High and Low Temperature Applications: Classification, advantages, general properties and applications of engineering materials like Refractories, Ceramics, Super alloys, Composites

UNIT-IV New materials: Nano-materials: carbon nanotubes, fullerene, nanosensors; **Nanocomposites,** role of reinforcement-matrix interface strength on composite behaviour
Smart materials: Piezoelectrics, shape memory alloys, Magneto-strictive, electro-rheological materials, 3D printing.

UNIT-V Biomaterials: Biomaterials: Biocompatibility, advantages, properties, uses, Types - Nearly inert, surface active, resorbable.

Text Books

1. Materials Science and Engineering an Introduction, William D. Callister, Jr. 5thEd., John Wiley and Sons, Inc. 2002.

Suggested Readings:

1. Fundamentals of Smart Materials, Mohsen Shahinpoor, The Royal Society of Chemistry Publishing, U.K, 2020.B. S. Mitchell An Introduction to Materials Engineering and Science for Chemical and Materials Engineers, John Wiley & Sons, 2004.
2. S. Upadhyaya and A. Upadhyaya, Material Science and Engineering, Anshan Publications, 2007.

Online Resources:

1. Nature And Properties of Materials, by Prof. Bisakh Bhattacharya, Department of Mechanical Engineering IIT Kanpur
   https://archive.nptel.ac.in/courses/112/104/112104203/

22 CHC27 **TRANSPORT PHENOMENA**

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Pre-requisites: Basic knowledge of FM, HT, and MTO

Course Objectives: This course introduces the students to

1. Fundamentals to solve flow problems involving transport of momentum, mass and energyusing a unified approach
2. The analogy between momentum, mass and energy transport.
3. The common mathematical structure of transport problems.
4. The turbulent phenomena and the methods of characterizing the turbulent fluxes.
5. Equations of change for isothermal and non-isothermal systems and multi-component mixtures.

Course Outcomes: At The end of the course students will be able to

1. Identify analogy between momentum, mass and energy transport and Develop expressions for velocity profiles using shell balances
2. Develop expressions for temperature profiles using shell balances
3. Develop expressions for concentration profiles using shell balances
4. Apply equations of change to solve flow problems
5. Understand transport mechanism in turbulent flows

CO-PO-PSO MATRIX

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	-	2	1	-	-	-	-	-	3	3
CO2	3	3	3	2	-	-	-	-	-	-	-	-	3	3
CO3	3	3	3	2	-	-	-	-	-	-	-	-	3	3
CO4	3	3	3	2	-	-	-	-	-	-	-	-	3	3
CO5	3	3	3	2	-	-	-	-	-	-	-	-	3	3

UNIT – I

Introduction - Mechanism of molecular transport of momentum, heat and mass transfer. Flux equations - Newton's, Fourier's and Fick's laws - Similarities and differences- Temperature and pressure dependence of viscosity, thermal conductivity and Diffusivity.

Velocity distributions in laminar flow - shell momentum balances -flow of a falling film - flow of fluids through circular tubes, annulus and immiscible fluids between parallel plates.

UNIT – II

Temperature distributions in solids and in laminar flow – shell balances - Heat conduction with electrical, Nuclear, viscous and chemical heat source, Heat conduction through composite walls and cooling fin, Forced convection and free convection

UNIT – III

Concentration distributions in solids and in laminar flow - shell mass balances, diffusion through a stagnant gas film, Diffusion with homogenous chemical reaction and heterogeneous chemical reaction. Diffusion into a falling liquid film (Absorption), chemical reaction inside a porous catalyst

UNIT – IV

Equations of change for isothermal systems – Equation of continuity, Equation of Motion, Equations of change in curvilinear coordinates, use of equations of change to set up steady flow problems. Equations of change for non- isothermal systems – Equation of energy, Equation of change for a binary mixture

UNIT – V

Velocity distributions in turbulent flow-Turbulence -Introduction to Time smoothed equations of change, Reynolds stresses; Semi empirical expressions for turbulent -momentum, energy and mass fluxes

Text Books:

1. R B Bird, W E Stewart, and E N Lightfoot, Transport Phenomena, Revised 2nd Edition, John Wiley & Sons Inc., 2007

Suggested Reading:

1. R S Broadkay, Introduction to Transport Phenomena, McGraw Hill Publications, 1980
2. J R Welty, C E Wicks and R E Wilson, Fundamentals of Momentum, Heat and Mass Transfer, 3rd Ed., 1984
3. Geankoplis, Transport Processes and Separation Processes Principles. 4th Edition, Prentice Hall, 2003

Online Resources :

1. https://archive.nptel.ac.in/courses/103/102/103102024/# [NPTEL-IIT Delhi]
2. https://archive.nptel.ac.in/courses/103/105/103105128/ [NPTEL-IIT Kharagpur]

22CH E17 **COMPUTATIONAL FLUID DYNAMICS**
(Professional Elective V)

Instruction	3 L Hours per week 3 Hours
Duration of SEE SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisites: Basic knowledge of Mathematics, FM, HT, and MTO

Course Objectives: This course helps the students to

1. Recall the basic fluid and heat transfer governing equations.
2. Utilize basic aspects of discretization for grid generation.
3. Estimate fluid flow and heat transfer problems.

Course Outcomes: At the end of the course, the students will be able to:

1. Understand and select the governing equations of fluid flow and heat transfer.
2. Make use of discretization techniques for derivatives and differential equations to solve numerically.
3. Examine general transformation equations for grid generation.
4. Recommend suitable explicit, implicit and semi-implicit methods of finite difference scheme for given problems.
5. Solve fluid flow field and temperature field to design any process equipment using some popular CFD techniques.

CO-PO-PSO MATRIX

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	3	3	-	3	-	-	3	-	-	-	2	1
CO2	3	2	3	3	-	3	-	-	3	-	-	-	2	1
CO3	3	3	3	3	-	3	-	-	3	-	-	-	2	1
CO4	3	3	3	3	-	3	-	-	3	-	-	-	2	1
CO5	3	3	3	3	-	3	-	-	3	-	-	-	2	1

Unit-I

Overview of CFD: Introduction of CFD, Applications of CFD, Problem-solving in CFD, Components of CFD Software. Comparison between numerical, analytical, and experimental approaches, modeling versus experimentation

Unit-II

Principle of conservation: Fundamental principles of conservation, Reynolds transport theorem, conservation of mass, conservation of linear momentum: Navier-Stokes equation, conservation of energy,general scalar transport equation, turbulence modeling

Unit-III

Classification of Partial Differential Equations: Mathematical classification of partial differential Equation, physical and mathematical classifications of PDEs, systems of partial differential equations, Boundary value problems, boundary conditions,

Finite difference method: Discretization principles, truncation and round-off error, explicit and implicit approaches, basic of finite difference method, treatment of boundary conditions, finite difference applications in heat conduction and convection: solution of Navier-Stokes equation for incompressible flows using SIMPLE algorithm.

Unit-IV

Finite Volume Method: Discretization methods, the four basic rules, one-dimensional steady and unsteady diffusion problems, two- and three-dimensional situations, convection and diffusion for one-dimensional steady problems, various discretization schemes.

Unit-V

Solution Algorithms and Techniques: LU decomposition, approximate factorization, Relaxation algorithms, Hybrid Schemes. **Grid Generation:** Structured Grid generation, Unstructured Grid generation, Adaptive Grid generation. **CFD Methods For Navier-Stokes Equations:** Upwind Techniques.

Textbooks:

1. Computational Fluid Dynamics by J. D. Anderson, McGraw-Hill.
2. Computational Fluid Mechanics and Heat Transfer by J.C. Tannehill, D.A. Anderson, R.H. Pletcher,Taylor and Francis.
3. Computational Fluid Dynamics by T. J. Chung, Cambridge University Press

Suggested Reading:

1. Numerical Heat Transfer and Fluid Flow, by Suhas V. Patankar
2. An Introduction to CFD by H K Versteeg and W. Malalasekera

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc21_me126/preview [NPTEL-IIT-Kharagpur]
2. https://archive.nptel.ac.in/courses/112/106/112106186/ [NPTEL-IIT Madras]

22CHE18 **DESIGN AND ANALYSIS OF EXPERIMENTS**

(Professional Elective V)

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Course objectives: This course helps the students to:

1. Understand the fundamental principles and concepts of experimental design.
2. Learn to apply appropriate experimental designs for different research questions and objectives.
3. Develop skills in conducting hypothesis tests and analyzing variance for various experimental designs.
4. Gain proficiency in interpreting experimental results and drawing valid conclusions.
5. Acquire practical experience in designing experiments and analyzing data using statistical software.

Course Outcomes: At the end of the course, the students will be able to

1. Demonstrate a comprehensive understanding of experimental design principles and their applications.
2. Select and justify appropriate experimental designs based on research objectives and constraints.
3. Proficiently conduct hypothesis tests and perform analysis of variance for different experimental designs.
4. Interpret experimental results accurately, considering the assumptions and limitations of the chosen designs.
5. Gain practical experience in designing experiments and interpret response surface plots statistical software.

CO, PO and PSO Correlation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	3	1	-	-	1	1	1	1	1	2	1
CO2	2	2	1	3	1	-	-	1	1	1	1	1	1	1
CO3	2	2	1	3	1	-	-	1	1	1	1	1	2	1
CO4	2	2	1	3	1	-	-	1	1	1	1	2	2	1
CO5	3	3	2	3	2	-	-	1	1	1	1	2	3	1

UNIT−I

Basic concepts of design of experiments.
Types of experiments: Completely randomized, randomized complete block, factorial designs
Principles of randomization and replication; Introduction to factorial designs: 2k factorial design, 2k-p fractional factorial design; Practical examples and applications

UNIT− II

Completely Randomized Designs (CRD): Completely randomized design (CRD): Definition and characteristics**;** Analysis of variance (ANOVA) for CRD**;** Assumptions of ANOVA**;** Post hoc tests and multiple comparison procedures**;** Interpretation of results and drawing conclusions.

UNIT− III

Factorial and Fractional Factorial Designs: Factorial designs: Definition, main effects, and interaction effects; Two-level factorial designs; Confounding and resolution in fractional factorial designs; Design resolution and its impact on efficiency.

UNIT − IV

Regression model for factorial analysis : Fitting Regression Models, Introduction, Linear Regression Models, estimation of the Parameters in Linear Regression Models, Hypothesis testing in multiple regression, Confidence intervals in multiple regression

UNIT V

Introduction to response surface methodology (RSM); Design and analysis of central composite designs (CCD);optimization techniques in RSM; Interpretation of response surface plots; Practical applications and case studies. Introduction to MINITAB software, and some basic practical exercises

Text Books:

1. Montgomery, Douglas C. "Design and Analysis of Experiments."
2. Box, George EP, Hunter, William G., and Hunter, J. Stuart. "Statistics for Experimenters: Design, Innovation, and Discovery."

Suggested Reading

1. Wu, C. F. Jeff, and Hamada, Michael. "Experiments: Planning, Analysis, and Optimization." John Wiley & Sons, 2011.
2. Myers, Raymond H., Montgomery, Douglas C., and Anderson-Cook, Christine M. "Response Surface Methodology: Process and Product Optimization Using Designed Experiments." John Wiley & Sons, 2016.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc21_mg48/preview

22 CHE19 **OPTIMIZATION OF CHEMICAL PROCESSES**

(Professional Elective IV)

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisites: Mathematics, Mass Transfer, Plant Design and Economics

Course objectives: This course helps the students to

2. learn problem formulation of optimization,
3. realize the numerical methods of un-constrained optimization
4. learn linear programming and its applications

Course Outcomes: At the end of the course, student will be able to

1. Formulate and analyze the elementary optimization problem.
2. Solve single variable optimization problems using different methods and can suggest a suitable technique for a given problem.
3. Solve multivariable optimization problems using various methods and can assess the suitability of those methods to a given problem.
4. Perform the optimization calculations of various unit operations.
5. Solve linear programming problems.

CO-PO-PSO MATRIX

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	2	-	-	-	-	-	-	1	1	2	2
CO2	3	3	2	1	-	-	-	-	-	-	-	-	2	2
CO3	3	3	2	1	-	-	-	-	-	-	-	-	2	2
CO4	3	3	3	1	-	-	-	-	-	-	1	1	2	2
CO5	3	3	2	1	-	-	-	-	-	-	-	-	2	2

UNIT- I

Nature and organization of optimization problems: introduction to optimization scope and hierarchy of optimization, examples of applications of optimization, essential features of optimization problems, general procedure for solving optimization problems, Optimization of a manufacturing problem with a stepwise procedure, obstacles of optimization, constraints in optimization, examples and formulation of constrained optimization problems.

Basic concepts of optimization: Continuity of functions, unimodal versus Multi modal functions. Convex and Concave functions, Convex region, Necessary and sufficient conditions for an extremum of an unconstrained function.

UNIT- II

Optimization of unconstrained single variable functions: Region elimination methods: Fibonacci search, Golden section search. Polynomial approximation methods - Sequential search. Methods specifying optimum by a point: Newton's method, Secant method, Quadratic interpolation. Applications of one-dimensional search methods to chemical engineering problems.

UNIT- III

Unconstrained multivariable optimization: *Random search methods*: grid search, uni-variate search, multivariable Newton's method, steepest descent method, Conjugate search directions, Conjugate gradient method.

UNIT- IV

Optimization of Unit operations: Optimal pipe diameter, minimum work of compression, optimizing recovery of waste heat, optimization of multiple effect evaporator, shell and tube heat exchanger.

UNIT- V

Linear programming and applications: Basic concepts in linear programming, graphical solution, artificial variable technique, exceptional cases in LPP, non-existing feasible solution, degeneracy, duality in linear programming, dual simplex method, revised simplex method.

Text Books:

1. Optimization of Chemical Processes, T.F. Edgar and D.M. Himmelblau, McGraw-Hill, New York, 2001.
2. Optimization for Engineering Design, Kalyan Moy Deb, PHI Pvt. Ltd., New Delhi, 2000.

Reference Books:

1. S. S. Rao, Engineering Optimization Theory and Practice, 3rd edition, New Age International Publishers, India.

Online references:

1. https://archive.nptel.ac.in/courses/103/105/103105139/

2CHE20 **PROCESS INTENSIFICATION**

(Professional Elective V)

Instruction	3L hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisites: Mass Transfer and CRE

Course objectives: This course helps the students to:

1. Understanding of the concept of Process Intensification.
2. Application of intensification techniques to a range of various separation processes.
3. Understanding of basic operating principles of a variety of intensified process.
4. Analyse the range of potential applications of intensified equipment.

Course Outcomes: At the end of the course, the student will be able to:

1. Identify the scope for process intensification in chemical processes.
2. Implement methodologies for process intensification
3. Understand scale up issues in the chemical process.
4. Describe the impact of process intensification on heat transfer
5. Solve process challenges using intensification technologies.

CO-PO-PSO Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	3	1	3	2	1	3	-	-	-	-	-	-	2	2
2	2	-	3	2	-	3	-	-	-	-	-	-	2	2
3	2	1	3	2	1	3	-	-	-	-	-	-	2	-
4	2	-	3	2	-	3	-	-	-	-	-	-	-	2
5	2	-	2	2	-	2	-	-	-	-	-	-	2	2

UNIT-I

Introduction: 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.

UNIT-II

Process Intensification through micro reaction technology: Effect of miniaturization on unit operations and reactions, Batch to continuous reactions, Implementation of Micro reaction Technology, From basic Properties to Technical Design Rules, Inherent Process Restrictions in Miniaturized Devices and Their Potential Solutions, Micro fabrication of Reaction and unit operation Devices - Wet and Dry Etching Processes

UNIT-III

Scales of mixing, Flow patterns in reactors, mixing in stirred tanks: Scale up of mixing. Mixing in intensified equipment, Nebulizers, Ejectors, Tee mixers, Impinging jets, Rotor stator mixers, Design Principles of static Mixers Applications of static mixers, Higee reactors.

UNIT-IV

Combined chemical reactor heat exchangers and reactor separators: Principles of operation; Applications, Reactive absorption, Reactive distillation, Applications of RD Processes, Fundamentals of Process Modeling, Reactive Extraction Case Studies: Absorption of NO_x Coke Gas Purification.

UNIT-V

Enhanced fields: Energy based intensifications, Sono-chemistry, Basics of cavitation, Cavitation Reactors, Flow over a rotating surface, Hydrodynamic cavitation applications, Cavitation reactor design, Nusselt-flow model and mass transfer, The Rotating Electrolytic Cell, Microwaves, Electrostatic fields, Sono crystallization, Reactive separations, Supercritical fluids.

Textbooks:

1. Stankiewicz, A. and Moulijn, (Eds.), Reengineering the Chemical Process Plants, Process Intensification, Marcel Dekker, 2003.
2. Reay D., Ramshaw C., Harvey A., Process Intensification, Butterworth Heinemann, 2008.
3. Kamelia Boodhoo (Editor), Adam Harvey (Editor), Process Intensification Technologies for Green Chemistry: Engineering Solutions for Sustainable Chemical Processing, Wiley, 2013.

Suggested Reading:

1. Segovia-Hernández, Juan Gabriel, Bonilla-Petriciolet, Adrián (Eds.) Process Intensification in Chemical Engineering Design Optimization and Control, Springer, 2016.
2. Reay, Ramshaw, Harvey, Process Intensification, Engineering for Efficiency, Sustainability and Flexibility, Butterworth-Heinemann, 2013

Online Resources:

1. https://archive.nptel.ac.in/courses/103/103/103103152/ [NPTEL-IIT Guwahati]

22EGC03

EMPLOYABILITY SKILLS

Instruction	2P Hours per week
Duration of SEE	3 Hours
SEE	50 Marks
CIE	50 Marks
Credits	01

Prerequisite: Basic Knowledge of Soft skills in the professional setting.

Course Objectives: To help the students

1. Learn the art of communication, participate in group discussions and case studies with confidence and to make effective presentations.
2. With- resume packaging, preparing them to face interviews.
3. Build an impressive personality through effective time management, leadership qualities, self-confidence and assertiveness.
4. Understand professional etiquette and to make them learn academic ethics and value system.
5. To be competent in verbal aptitude.

Course Outcomes: By the end of the course**,** the students will be able to

1. Become effective communicators, participate in group discussions with confidence and be able to make presentations in a professional context.
2. Write resumes, prepare and face interviews confidently.
3. Be assertive and set short term and long term goals, learn to manage time effectively and deal with stress.
4. Make the transition smoothly from campus to work, use media with etiquette and understand the academic ethics.
5. Enrich their vocabulary, frame accurate sentences and comprehend passages confidently.

CO-PO-PSO Articulation Matrix

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO 1	-	1	-	-	-	1	-	2	3	3	1	3	-	1
CO 2	-	-	-	-	-	-	-	1	-	2	-	1	-	-
CO 3	-	-	-	-	-	1	-	1	2	1	1	3	-	1
CO 4	-	1	1	-	-	1	-	2	3	3	1	3	-	2
CO 5	-	-	-	-	-	-	-	1	2	2	1	3	-	-

UNIT I

Verbal Aptitude: Error Detection, Articles, Prepositions, Tenses, Concord and Transformation of Sentences- Jumbled Words/Sentences- Vocabulary, Synonyms, Antonyms, One Word Substitutes, Idioms and Phrases, Word/Sentence/Text Completion- Reading Comprehension.

UNIT II

Group Discussion & Presentation Skills: Dynamics of Group Discussion-Case Studies- Intervention, Summarizing, Modulation of Voice, Body Language, Relevance, Fluency and Accuracy, Coherence. Elements of Effective Presentation – Structure of a Presentation – Presentation tools – Body language - Preparing an Effective PPT.

UNIT III

Behavioural Skills: Personal strength analysis-Effective Time Management- Goal Setting- Stress management- **Corporate Culture** – Grooming and etiquette-Statement of Purpose (SOP).

UNIT IV

Mini Project: Research-Hypothesis-Developing a Questionnaire-Data Collection-Analysis-General and Technical Report - Writing an Abstract –Technical Report Writing-Plagiarism-Project Seminar.

UNIT V

Interview Skills: Cover Letter and Résumé writing – Structure and Presentation, Planning, Defining the Career Objective, Projecting ones Strengths and Skill-sets – Interviews: Concept and Process, Pre-Interview Planning, Opening Strategies, Answering Strategies, Mock Interviews.

Text Books:

1. Leena Sen, "Communication Skills", Prentice-Hall of India, 2005.
2. Gulati and Sarvesh, "Corporate Soft Skills", New Delhi: Rupa and Co., 2006.
3. Edgar Thorpe and Showick Thorpe, "Objective English", 2nd edition, Pearson Education, 2007.
4. Ramesh, Gopalswamy, and Mahadevan Ramesh, "The ACE of Soft Skills", New Delhi: Pearson, 2010.

Suggested Reading:

1. Van Emden, Joan, and Lucinda Becker, "Presentation Skills for Students", New York: Palgrave Macmillan, 2004.
2. R.S. Aggarwal, "A Modern Approach to Verbal & Non-Verbal Reasoning", 2018.
3. Covey and Stephen R, "The Habits of Highly Effective People", New York: Free Press, 1989.
4. Shalini Verma, "Body Language - Your Success Mantra", S Chand, 2006.

22CHC28 ARTIFICIAL INTELLIGENCE IN CHEMICAL ENGINEERING LAB

Instruction	3P Hours per week
Duration of SEE	3 Hours
SEE	50 Marks
CIE	50 Marks
Credits	1.5

Prerequisites – AI in chemical engineering,

Course Objectives

This course aims to give some understanding on

1. Fundamentals of python programming scripts
2. Applications of python programming in loops, predictive modeling, genetic algorithm and fault diagnosis

Course Outcomes At the end of the course, the students will be able to

1. Write the script in python programming.
2. Apply the conditional loops in python programming.
3. Apply modeling and optimization in the chemical reaction process.
4. Optimize the process using python script.
5. Apply artificial intelligence knowledge for fault diagnosis.

CO-PO-PSO Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
1	2	1	2	2	1	1	1	-	2	1	-	2	2	2
2	2	1	1	2	1	1	1	-	2	1	-	2	2	2
3	2	1	1	2	1	1	1	-	2	1	-	2	2	2
4	2	1	2	2	1	1	1	-	2	1	-	2	2	2
5	2	1	1	2	1	1	1	-	2	1	-	2	2	2

LIST OF EXERCISES (A minimum of 10 experiments in the list are to be performed)

1. Write a basic python code
2. Conditional loops in python -1
3. Conditional loops in python -1
4. Process Optimization for Batch Reactors
5. Predictive Modeling of Chemical Reaction Kinetics
6. Prediction of Temperature and pressure in the Distillation column
7. Catalyst performance optimization
8. GA-based code for chemical engineering problems -1
9. GA-based code for chemical engineering problems -2
10. Fault Diagnosis

22CHC29 **PLANT DESIGN LAB**

Instruction	3P Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Pre-requisites: MEBC, Thermodynamics, FM, CRE, MTO

Course Objectives: This course will

1. Provide students the opportunity to acquire simulation skills in Chemical Plant equipment design.
2. Introduce students to the importance and principles of design of a plant
3. Provide an overall view of design concepts of various unit operations and processes.
4. Demonstrate the overview of plant layout, and flow sheeting and perform economic evaluation and sensitivity analysis of the plant
5. Help students develop simulation skills using various chemical Engineering software like Aspen Plus,Aspen Hysys software, DWSIM, MATLAB etc.

Course Outcomes: At the end of the course, the student will be able to:

1. Understand and apply the design concepts to various unit operations and processes.
2. Design various Heat and mass transfer equipment.
3. Design pumps, pressure vessels and reactors.
4. Analyze the performance of a process plant using economic evaluation and sensitivity analysis.
5. Perform simulation of design case studies in Aspen Plus/Aspen Hysys/DWSIM software.

CO-PO-PSO Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO11	PO12	PSO11	PSO12
CO1	3	2	2	2	2	-	-	-	2	-	-	2	3	2
CO2	3	2	2	2	2	-	-	-	2	-	-	2	3	2
CO3	3	2	2	2	2	-	-	-	2	-	-	2	3	2
CO4	3	2	2	2	2	-	-	-	2	-	-	2	3	2
CO5	3	2	2	2	2	-	-	-	2	-	-	2	3	2

LIST OF EXERCISES (A minimum of 10 experiments in the list are to be performed)

1. Symbols for Piping and Instrumentation, Flow sheet symbols for unit operations.
2. Design and analysis of pumps and pressure vessels.
3. Design of Heat Transfer Equipment - Shell and Tube Heat Exchanger
4. Design of Heat Transfer Equipment - Condensers/Evaporators
5. Design of Reactors - 1
6. Design of Reactors - 2
7. Design of Mass Transfer Equipment - 1
8. Design of Mass Transfer Equipment - 2
9. Economic Evaluation Analysis in Aspen Plus - Case Study 1
10. Economic Evaluation Analysis in Aspen Plus - Case Study 2
11. Performing Sensitivity Analysis in Aspen Plus - Case Study 1
12. Performing Sensitivity Analysis in Aspen Plus - Case Study 2
13. Overall Plant Layout and Design - Case Study

Text Books

1. Joshi, M.V. “Process Equipment Design”, 2nd Ed., McMillan Co. of India Limited, Madras, 1976.
2. Bachurst, J.R. and Harker, J.A. “Process Plant Design”, Heiman Education Books, London, 1973.
3. Peters. M.S. and Timmerhaus, K.D., “Plant Design and Economics for Chemical Engineering”, 4th Edition, McGraw Hill, Singapore, 1991
4. Chemical Process Design and Simulation: Aspen Plus and Aspen Hysys Applications, Juma Haydary,AICHE, Wiley Pub.

22CHC30 **PROJECT: PART I**

Instruction	4P Hours per week
Duration of SEE	--
SEE	--
CIE	50 Marks
Credits	2

Course Outcomes: At the end of the course, the student will be able to:

1. Summarize the literature review to identify and formulate engineering problems
2. Design the experiments/ process /mathematical model by selecting the engineering tools/components for solving the identified problem
3. Develop skills of problem solving, interpreting analysis and evaluation
4. Illustrate written and oral communication skills through project report and presentation
5. Demonstrate the knowledge, skills, attitude and ethics of a professional engineering graduate by working as a team.

CO-PO-PSO Matrix

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	2	2	1	2	2	1	1	1	1	2	2	2
CO2	2	3	3	3	1	2	2	1	1	1	1	2	2	2
CO3	3	3	2	3	2	2	2	1	1	3	1	2	3	2
CO4	2	3	2	2	1	2	2	1	1	1	1	2	2	3
CO5	2	1	1	1	1	2	1	3	2	2	1	2	3	3

The objective of Project Part -1 is to enable the student take up investigative study in the broad field of Engineering / Technology, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the department on an individual basis or two/three students in a group, under the guidance of a supervisor. This is expected to provide a good initiation for the student(s) towards R&D.

The work shall include:

1. Survey and study of published literature on the assigned topic;
2. Working out a preliminary Approach to the Problem relating to the assigned topic;
3. Conducting preliminary Analysis/Modeling/Simulation/Experiment/Design/Feasibility;
4. Preparing a Written Report on the Study conducted for Presentation to the Department;
5. Final Seminar, as oral Presentation before departmental committee.

Guidelines for the award of marks in CIE: (Max. Marks: 50)

Evaluation by	Max Marks	Evaluation criteria/parameter
Supervisor	20	Project status/review
	5	Report
Department committee	5	Relevance of the topic
	5	PPT preparation
	5	Presentation
	5	Question and Answers
	5	Report Preparation

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (A)

Choice Based Credit System (With effect from 2025-2026)

B.Tech (Chemical Engineering)

Semester VIII

S. No	Course Code	Title of the Course	Scheme of Instruction			Scheme of Examination			Credits
			Hours per Week			Duration of SEE in Hours	Maximum Marks		
			L	T	P/D		CIE	SEE	
THEORY									
1.	22XXOYY	Open Elective III	3	-	-		40	60	3
PRACTICAL									
2	22CHC31	Technical Seminar	-	-	2		50	-	1
3	22CHC32	Project Part II	-	-	8		100	100	4
TOTAL			**03**		**10**	**-**	190	160	**8**

S. No	Course Code	**Open Elective III**
1	22CEO02	Disaster Risk Reduction and Management
2	22BTO04	Bioinformatics
3	22ADO02	Data Science using Python
4	22EEO07	Fundamentals of Electric Vehicles

22CE O02

DISASTER RISK REDUCTION AND MANAGEMENT

Instruction	3L Hours per week
Duration of Semester End Examination	3 Hours
Semester End Examination	60 Marks
Continuous Internal Evaluation	40 Marks
Credits	3

Course Outcomes: Upon completion of this course, the student will be able to,

1. Explain the fundamental concepts of disaster management.
2. Demonstrate the principles and practices of disaster risk reduction management.
3. Identify stress and its management during disaster.
4. Outline institutional frame work at different levels of administration.
5. Evaluate disaster management study including data search, analysis and presentation as a case study.

CO-PO Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	-	-	-	-	2	3	-	-	-	-	1	-	-
CO2	2	-	-	-	-	2	3	-	-	-	-	1	-	-
CO3	2	-	-	-	-	2	3	-	-	-	-	1	-	-
CO4	2	-	-	-	2	2	3	-	-	-	-	1	-	-
CO5	2	-	-	-	-	2	3	-	-	-	-	1	-	-

UNIT I

Fundamental concepts in disaster management: Hazard and disaster-concepts, vulnerability and risk, Hazard and disaster type – Natural, Water- related, pandemic and Human induced hazards disasters. Causes and Impacts of disasters – Impacts on natural eco systems: physical, psychological and social impact. Disaster and financial resilience. Disaster vulnerability profile of India –Specific to geographical regions and states (as per regional significance)

UNIT II

Disaster Management Cycle: Rescue, Relief, Rehabilitation, Prevention, Mitigation and Preparedness. Disaster risk reduction (DRR). Community based DRR, institutions concerned with safety, disaster mitigation and construction techniques as per Indian standards and Early warning systems

UNIT III

Disaster Impacts Management: Trauma and stress management, First aid and emergency procedures Awareness generation strategies for the community on safe practices in disaster (as per regional significance)

UNIT IV

Institutional framework of disaster management in India: NDMA-SDMA, NDRF, civic volunteers, and NIDM. Phases of disaster/risk management and post-disaster responses. Compensation and insurance Applications of remote sensing & GIS in disaster management. Components of disaster management. Preparedness of rescue and relief, mitigation, rehabilitation & reconstruction. Institutional frame work of disaster management in India

UNIT V

Capacity building for disaster/damage mitigation: Structural and Nonstructural measures forcapacity building for disaster/damage mitigation. Disaster risk reduction strategies and national disaster management guidelines. Disaster management Act -2005. Regional issues as per regional requirement/university can take minimum two topics as per high powered committee

Text Books:

1. Singh, R. (2017), "Disaster management Guidelines for Earth quakes, Landslides, Avalanches andTsunami". Horizon Press publications.
2. Taimpo (2016), "Disaster management and preparedness". CRC Press Publications

Suggested Reading:

1. Nidhi, G.D. (2014), "Disaster management preparedness" .CBS Publications Pvt. Ltd.
2. Gupta, A.K.,Nair, S.S., Shiraz, A. and Dey, S. (2013), "Flood Disaster Risk Management-CBSPublications Pvt Ltd.
3. Singh, R. (2016), "Disaster management Guidelines for Natural Disasters" Oxford University PressPvt. Ltd

E Resources:

1. https://nptel.ac.in/courses/124107010
2. https://onlinecourses.swayam2.ac.in/cec19_hs20/preview

22BTO04 **BIOINFORMATICS**
(Open Elective III)

Instruction	3L Hours per week
Duration of Semester End Examination	3 Hours
Semester End Examination	60 Marks
Continuous Internal Evaluation	40 Marks
Credits	3

Prerequisites: The school level basic knowledge in Fundamental science is required

Course Objectives:

The objectives of this course are

1. To provide elementary knowledge in biology and bioinformatics and biological information available to a biologist on the web and learn how to use these resources on their own.
2. To learn the fundamentals of biological databases, Sequence analysis, data mining, sequence alignment and phylogenetics
3. To learn methods for determining the predicting gene and protein

Course Outcomes:

At the end of the course, the students are able to

1. Explain the basic concepts of biology and bioinformatics
2. Identify various types of biological databases used for the retrieval and analysis of the information
3. Explain the sequence analysis and data mining
4. Discuss the methods used for sequence alignment and construction of the phylogenetic tree
5. Describe the methods used for gene and protein structure prediction

Mapping of Course Outcomes with Program Outcomes:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	0	0	0	0	0	0	0	0	1	0	1	0	0
CO2	1	1	0	1	1	0	0	0	0	1	0	1	0	0
CO3	2	0	0	1	1	0	0	0	0	1	0	1	0	0
CO4	2	0	0	1	1	0	0	0	0	1	0	1	0	0
CO5	2	1	0	1	1	0	0	0	0	1	0	1	0	0

UNIT-I

Introduction And Basic Biology: Bioinformatics- Introduction, Scope and Applications of Bioinformatics; Basics of DNA, RNA, Gene and its structure, Protein and metabolic pathway; Central dogma of molecular biology; Genome sequencing, Human Genome Project.

UNIT-II

Biological Databases: Introduction to Genomic Data and Data Organization, types of databases, biological databases and their classification, Biological Databases - NCBI, SWISS PROT/Uniport, Protein Data Bank, Sequence formats; Information retrieval from biological databases; Data mining of biological databases

UNIT-III

Sequence Analysis and Data Mining: Scoring matrices, Amino acid substitution matrices- PAM and BLOSUM; Gap, Gap penalty; Database similarity searching - BLAST, FASTA algorithms to analyze sequence data, FASTA and BLAST algorithms comparison; Data Mining- Selection and Sampling, Pre-processing and Cleaning, Transformation and Reduction, Data Mining Methods, Evaluation, Visualization, Designing new queries, Pattern Recognition and Discovery, Text Mining Tools

UNIT-IV

Sequence Alignment And Phylogentics: Sequence Alignment – Local and Global alignment; Pairwise sequence alignment – Dynamic Programming method for sequence alignment - Needleman and Wunsch algorithm and Smith Waterman algorithm. Multiple sequence alignment - Methods of multiple sequence alignment, evaluating multiple alignments, applications of multiple sequence alignment. Concept of tree, terminology, Methods of phylogenetic analysis, tree evaluation – bootstrapping, jack knifing

UNIT-V.

Macromolecular Structure Prediction:

Gene prediction, - neural networks method, pattern discrimination methods, conserved domain analysis; Protein structure basics, protein structure visualization, Secondary Structure predictions; prediction algorithms; Chou-Fasman and GOR method, Neural Network models, nearest neighbor methods, Hidden-Markov model, Tertiary Structure predictions; prediction algorithms; homology modeling, threading and fold recognition, ab initio prediction.

Text Books:

1. David Mount, "Bioinformatics Sequence and Genome Analysis", 2nd edition, CBS Publishers and Distributors Pvt. Ltd., 2005
2. Rastogi SC, Mendiratta N and Rastogi P, "Bioinformatics: Methods and Applications Genomics, Proteomics and Drug discovery", 3rdedition, PHI Learning Private Limited, New Delhi, 2010

Suggested Reading:

1. Baxebanis AD and Francis Ouellette BF, "Bioinformatics a practical guide the analysis of genes and proteins", 2ndedition, John Wiley and Sons, Inc., Publication, 2001
2. Vittal R Srinivas, "Bioinformatics: A modern approach. PHI Learning Private Limited", New Delhi, 2009
3. JiXiong, "Essential Bioinformatics", Cambridge University Press, 2006

22ADO02

DATA SCIENCE USING PYTHON

(Open Elective III**)**

Instruction	3 Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Course Objectives:

1. To familiarize the data scientists, work environment like IPython and Jupyter.
2. To understand ndarray object for efficient storage and manipulation of dense data arrays in python using NumPy.
3. To understand DataFrame object for efficient storage and manipulation of labelled / columnar data in python using Pandas.
4. To perform data visualizations in python using Matplotlib.
5. To practice machine learning algorithms in python using Scikit-Learn.

Course Outcomes:

1. Apply advanced IPython features including shell commands, magic commands, and debugging techniques.
2. Analyze NumPy functionalities such as data types, arrays, and computations, and implement them in data manipulation tasks.
3. Evaluate Pandas capabilities for data manipulation, aggregation, and grouping, and apply them to real-world datasets.
4. Create visualizations using Matplotlib, customize plots, and interpret various types of plots for effective data communication.
5. Implement machine learning algorithms using Scikit-Learn, validate models, and apply them to real-world problems.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	3	2	2	2	2	2	2	3
CO2	3	2	2	2	3	2	2	2	2	2	2	3
CO3	3	2	2	2	3	3	2	2	2	2	2	3
CO4	3	3	3	3	3	3	2	2	2	3	3	3
CO5	3	3	3	3	3	3	2	2	2	2	2	3

UNIT-I

Ipython: Beyond Normal Python

Shell and Notebook, Help and Documentation in IPython, Keyboard Shortcuts in the IPython Shell, IPython Magic Commands, Input and Output History, IPython and Shell Commands, Errors and Debugging Profiling and Timing Code.

UNIT-II

Introduction To Numpy

Understanding Data Types in Python, The Basics of NumPy Arrays, Computation on NumPy Arrays: Universal Functions, Aggregations, Computation on Arrays, Comparisons, Masks, and Boolean Logic, Fancy Indexing, Sorting Arrays, Structured Data.

UNIT-III

Data Manipulation with Pandas

Installing and Using Pandas, Introducing Pandas Objects, Data Indexing and Selection, Operating on Data in Pandas, Handling Missing Data, Hierarchical Indexing, Combining Datasets, Aggregation and Grouping, Pivot Tables, Vectorized String Operations, Working with Time Series, High-Performance Pandas.

UNIT-IV

Visualization with Matplotlib

General Matplotlib Tips, Simple Line Plots, Simple Scatter Plots, Visualizing Errors, Density and Contour Plots, Histograms, Binnings, and Density, Customizing Plot Legends, Customizing Colorbars, Multiple Subplots, Text and Annotation, Customizing Ticks, Customizing Matplotlib, Three-Dimensional Plotting in Matplotlib, Geographic Data with Basemap, Visualization with Seaborn.

UNIT-V

Machine Learning with Scikit-Learn

Machine Learning- Introducing Scikit-Learn, Hyperparameters and Model Validation, Feature Engineering, Naive Bayes Classification, Linear Regression, Support Vector Machines, Decision Trees and Random Forests, Principal Component Analysis, k-Means Clustering, Gaussian Mixture Models, Application: A Face Detection Pipeline.

Text Books:

1. Jake VanderPlas, ―Python Data Science Handbook: Essential Tools for Working with Data‖, O'Reilly, 2017.

Suggested Reading:

1. Wes McKinney, ―Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython‖, O'Reilly, 2nd Edition,2018.
2. Python for data science for dummies 2nd Edition, John Paul Mueller, Luca Massaron, Wiley

22EEO07

FUNDAMENTALS OF ELECTRIC VEHICLES

(Open Elective III)

Instruction	3L Hours per week
Duration of SEE	3 Hours
SEE	60 Marks
CIE	40 Marks
Credits	3

Prerequisite: None.

COURSE OBJECTIVES: This course aims to know
1. Basics of Electric Vehicle history and components.
2. Various types of Electric Vehicles.
3. Different storage methods.

COURSE OUTCOMES: After the completion of this course, the student will be able to
1. Understand the basics of electric vehicle and environmental impact.
2. Understand the various types of Electric Vehicles and their properties
3. Understand the functioning of BEV.
4. Understand the difference between HEV and FCEV.
5. Understand the various methods of energy storage.

CO-PO Articulation Matrix

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2
CO-1	1	1	1	-	-	2	3	-	2	1	2	1		
CO-2	1	1	1	-	-	2	3	-	2	1	2	1		
CO-3	1	1	1	-	-	2	3	-	2	1	2	1		
CO-4	1	1	1	-	-	2	3	-	2	1	2	1		
CO-5	1	1	1	-	-	2	3	-	2	1	2	1		

UNIT-I

Introduction to Electric vehicles: Present scenario of electric vehicles, Need of Electric Vehicles, Economic and environmental impacts of using Electrical vehicles. Challenges faced by electric vehicles to replace ICE. Major requirements of electric vehicles.

UNIT-II

Types of Electric Vehicle and their challenges: Types of Electric Vehicle - Pure Electric Vehicle (PEV): Battery Electric Vehicle (BEV), Fuel Cell Electric Vehicle (FCEV), and Hybrid Electric Vehicle (HEV). Challenges of Battery Electric Vehicle, Hybrid Electric Vehicle and Fuel Cell Electric Vehicle

UNIT -III

Battery Electrical Vehicle: Components of BEV drive train, The electric propulsion subsystem - Driving wheels , Suspension system, Driveshaft, Mechanical transmission , Electric Motor. The energy source subsystem -Battery pack with Battery Management System, On board charger, The auxiliary subsystem -Power steering unit, Common parts between ICE drive train and EV drive train, Differences (modifications/parts to be removed/added) between ICE and EV drive train.

UNIT-IV

Hybrid Electrical Vehicle and Fuel Cell Electric Vehicle: Hybrid Electric vehicle (HEV) -Basic architecture of hybrid drive trains, Components of HEV drive train system. Classification of HEV: Grid -Able HEV (Plug in hybrid, Range extended).Fuel efficiency in HEV. Fuel Cell Electric Vehicle (FCEV) - Basic architecture of FCEV. Components of FCEV drive train system.

UNIT-V

Energy Storage: Battery based energy storage, Overview of batteries, Battery Parameters, Battery Charging, regenerative braking, alternative novel energy sources-solar photovoltaic cells, fuel cells, super capacitors, and flywheels.

TEXT BOOKS:

1. A.K. Babu, “Electric & Hybrid Vehicles” , Khanna Publishing House, New Delhi, 2018.
2. Iqbal Hussain, “Electric & Hybrid Vehicles – Design Fundamentals” , CRCPress, Second Edition, 2011.

SUGGESTED READING:

1. James Larminie, “Electric Vehicle Technology Explained”, John Wiley & Sons, 2003.
2. Mehrdad Ehsani,Yimin Gao, Ali Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals”, CRC Press, 2010.
3. Sandeep Dhameja, “Electric Vehicle Battery Systems”, Newnes, 2000.

20CHC31 **TECHNICAL SEMINAR**

Instruction	2 P Hours per week
Duration of SEE	-
SEE	-
CIE	50 Marks
Credits	1

Course Objective:
The goal of a seminar is to introduce students to critical reading, understanding, summarizing, explaining and preparing report on state of the art topics in a broad area of his/her specialization. Seminar topics may be chosen by the students with advice from the faculty members and the student shall read further relevant articles in the domain.

Course Outcomes: At the end of the course, the students will be able to:

1. Summarize the literature review in order to identify and formulate the engineering problem.
2. Show preparedness to study independently and apply acquired technical skills to variety of real time problem scenarios.
3. Develop the required critical thinking ability and analytical skills for evaluation of the selected problem.
4. Illustrate the written and oral communication skills through a seminar report and presentation.
5. Demonstrate the required knowledge, skills, attitude and ethics as a professional engineering graduate by working as a team

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	1	1	-	-	3	2	3	3	3	2
CO2	1	2	2	2	1	1	-	-	3	2	3	3	3	2
CO3	2	2	2	2	1	1	-	-	3	2	3	3	3	2
CO4	3	2	2	2	1	1	-	-	3	2	3	3	3	2
CO5	3	2	2	2	1	1	-	-	3	2	3	3	3	2

The seminar must be clearly structured and the power point presentation shall include following aspects:

1. Introduction to the field
2. Literature survey
3. Consolidation of available information
4. Summary and Conclusions
5. References

Each student is required to:

1. Submit a one page synopsis of the seminar talk for display on the notice board.
2. Deliver the seminar for a maximum duration of 30 minutes, where the presentation should be for 20 minutes in PowerPoint, followed by Question and Answers session for 10 minutes.
3. Submit the detailed report of the seminar in spiral bound in a précised format as suggested by the department.

Seminars are to be scheduled from 3rd week to the last week of the semester and any change in schedule shall be discouraged. For the award of sessional marks students are judged by three (3) faculty members and are based on oral and written presentations as well as their involvement in the discussions during the oral presentation.

Note: Topic of the seminar shall be preferably from any peer reviewed recent journal publications

Guidelines for awarding marks		
S.No.	**Description**	**Max .marks**
1	Contents and relevance	**10**
2	Presentation skills	**10**
3	Preparation of PPT slides	**5**
4	Questions and answers	**5**
5	Report in a prescribed format	**20**

20CH C 32 **PROJECT: PART II**

Instruction	8 P Hours per week
Duration of SEE	-
SEE	100 Marks
CIE	100 Marks
Credits	4

Course Outcomes: At the end of the course, the student will be able to:

1. Summarize the literature review to identify and formulate engineering problems
2. Design the experiments/ process /mathematical model by selecting the engineering tools/components for solving the identified problem
3. Develop skills of problem solving, interpreting analysis and evaluation
4. Illustrate written and oral communication skills through project report and presentation
5. Demonstrate the knowledge, skills, attitude and ethics of a professional engineering graduate by working as a team

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	2	2	1	2	2	1	1	1	1	2	2	2
CO2	2	3	3	3	1	2	2	1	1	1	1	2	2	2
CO3	3	3	2	3	2	2	2	1	1	3	1	2	3	2
CO4	2	3	2	2	1	2	2	1	1	1	1	2	2	3
CO5	2	1	1	1	1	2	1	3	2	2	1	2	3	3

The object of 'Project: Part-2' is to enable the student extend further the investigative study taken up, either fully theoretical/practical or involving both theoretical and practical work, under the guidance of a Supervisor from the Department alone or jointly with a Supervisor drawn from R&D laboratory/Industry. This is expected to provide a good training for the student(s) in R&D work and technical leadership. The assignment to normally include:

1. In depth study of the topic assigned;
2. Review and finalization of the Approach to the Problem relating to the assigned topic;
3. Preparing an Action Plan for conducting the investigation, including team work;
4. Detailed Analysis/Modeling/Simulation/Design/Problem Solving/Experiment as needed;
5. Final development of product/process, testing, results, conclusions and future directions;
6. Preparing a paper for Conference presentation/ Publication in Journals, if possible;
7. Preparing a Dissertation in the standard format for being evaluated by the Department.
8. Final Seminar presentation before Departmental Committee

Guidelines for the award of marks in CIE: (Max. Marks: 100)

Evaluation by	Max Marks	Evaluation criteria/parameter
Department committee	10	Review I
	15	Review II
	25	Submission
Supervisor	10	Regularity and Punctuality
	10	Work Progress
	10	Quality of the work which may lead to publications
	10	Report Preparation
	10	Analytical / Programming / Experimental Skills

Guidelines for the award of marks in SEE: (Max. Marks: 100)

Evaluation by	Max Marks	Evaluation criteria/parameter
External and Internal Examiners together	20	Power point presentation
	40	Thesis evaluation
	20	• Quality of the project • Innovations • Applications • Live Research Projects • Scope for future study • Application to society
	20	Viva-Voce

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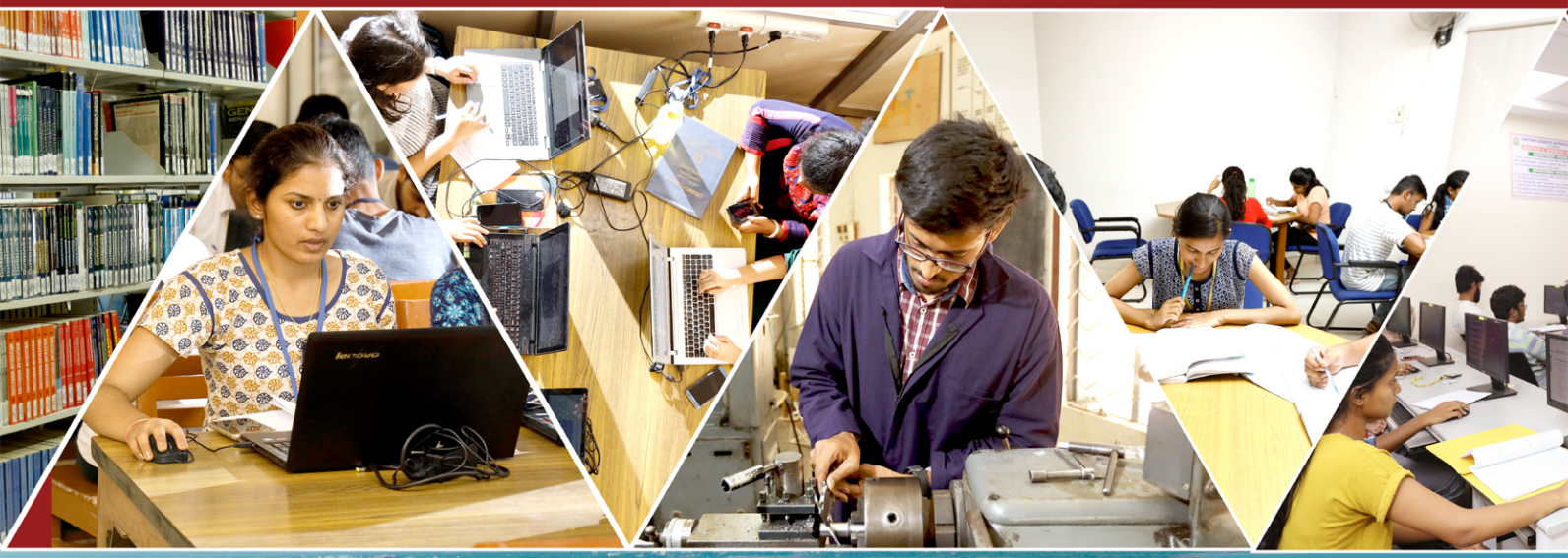

CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY

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