With effect from AY 2023-24

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: Upon completion of this course, students 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 Ed, OReilly, 2018
2. Michael T.Goodrich, Roberto Tamassia, Michael H. Goldwasser, “Data Structure and Algorithms in Python”, Wiley, 2013.
3. 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-algorithms3.
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

(For CIVIL/MECH/CHEM)

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

Course Objectives:

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 fit the hypothetical data using probability distribution.
5. To learn fitting of distribution and predicting the future values.

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

1. Calculate the Euler's coefficients for Fourier series expansion of a function.
2. Solve Linear and Non-Linear PDE's.
3. Solve One-Dimension Wave and Heat equations and Two Dimension Laplace equation.
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-PSO Matrix

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 Non-linear Partial Differential Equation(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.

Textbooks:

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 Readings:

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.

22CH C01

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 will help the students to understand the:

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: Upon completion of this course, students 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.
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 will help the students to understand the

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: Upon completion of this course, students 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 will help the students to understand the:

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: Upon completion of this course, students 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 helps the students to understand the

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: Upon completing this course, students 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: Upon completion of this course, students 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.

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

	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

20CHC05

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 will help the students 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: Upon completion of this course, students 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 will help the students 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: Upon completion of this course, students 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.

With effect from AY 2023-24

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									

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

Professional Elective I	
22CHE01	Energy Engineering
22CHE02	Food Processing Technology
22CHE03	Material Science for Chemical Engineers
22CHE04	Pulp and Paper Technology

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 will help the students to understand about

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 for miscible binary mixtures.
5. Methodology adopted to determine equilibrium constant.

Course Outcomes: Upon completion of this course, students 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 will help the students to understand the:

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: At the completion of this course, students 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 will help the students to understand the

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: Upon completion of this course, students 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. Smirh 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

22CH C10

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 helps the students to understand

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 helps the students 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: Upon completing this course, students 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 helps the students 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: Upon completing this course, students will be able to:

1. Explain the conventional and non-conventional energy sourcesand 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 bio fuels 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

20CHE02

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 helps the students to understand the

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: Upon completing this course, students 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

MATERIAL SCIENCE FOR CHEMICAL ENGINEERS

(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 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, thermal and optical properties of engineering materials
3. Select materials for high and low temperature applications.
4. Identify new or alternate materials for development and operation of process industry.
5. Understand the significance of Biomaterials in engineering

CO- PO and PSO Correlation Matrix

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

UNIT-I

Introduction to Engineering Materials: Classification – metals, non-metals, alloys; 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; Criteria for material selection.

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; Optical behavior: Light & electro-magnetic spectrum, Luminescence, stimulated emission of Radiation, Lasers, Optical fibres.

UNIT-III

Materials for High and Low Temperature Applications: Classification, advantages, general propertiesand applications of engineering materials like Refractories, Ceramics, Super alloys, Composites;

UNIT-IV

New materials: Nano-materials: nanosensors, nanocomposites, role of reinforcement-matrix interface strength on composite behaviour. Smart materials: Piezoelectrics, Magneto-strictive, shape memory alloys, electro-rheological materials, 3D printing.

UNIT-V

Biomaterials: Biomaterials: Biocompatibility, advantages, properties, uses, Types- Nearly inert ceramics, surface active ceramics, resorbable ceramics.

Textbooks

1. Materials Science and Engineering an Introduction, William D. Callister, Jr. 10thEd., John Wiley and Sons, Inc. 2017.

Suggested Readings:

1. Fundamentals of Smart Materials, Mohsen Shahinpoor, The Royal Society of Chemistry Publishing, U.K, 2020.
2. An Introduction to Materials Engineering and Science for Chemical and Materials Engineers, B. S. Mitchell, John Wiley & Sons, 2004.
3. Material Science and Engineering, S. Upadhyaya and A. Upadhyaya, Anshan Publications, 2007.

22CHE04

PULP AND PAPER 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 helps the students to understand

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: At the end of the course students 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.

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 Upon completion of this course, students 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.

Text Books:

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.

Online Resources:

1. http://www.nptel.ac.in/courses/103107084/Script.pdf

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 helps the students to understand 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 completing this course, students 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, 7thEd., 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 helps the students to understand the

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 completing this course, students 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, Cengage Learning, 2018.
3. Principles of industrial instrumentation, D. Patranabis, 2nd ed., Tata McGraw Hill Edu. (India) Pvt. Ltd., New Delhi, 2013.