CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY (AUTONOMOUS)

Scheme of Instructions III Sem B.Tech (Chemical Engineering)

As per AICTE Model Curriculum 2020-21

DEPARTMENT OF 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	20MTC08	Mathematics III(PDE & S)	3	1	-	3	40	60	4
2	20CSC06	Basics of Data Structures	2	-	-	3	40	60	2
3	20CHC01	Chemical Engineering Thermodynamics I	3	-	-	3	40	60	3
4	20CHC02	Fluid Mechanics	3	1	-	3	40	60	4
5	20CHC03	Material and Energy Balance Calculations	3	1	-	3	40	60	4
6	20CHC04	Mechanical Unit Operations	3		-	3	40	60	3
PRACTICAL									
7	20CSC07	Basics of Data Structures Lab	-	-	2	3	50	50	1
8	20CHC05	Fluid Mechanics Lab	-	-	3	3	50	50	1.5
9	20CHC06	Mechanical Unit Operations Lab	-	-	3	3	50	50	1.5
10	20CH I01	MOOCs/ Training/ Internship	2-3 weeks/ 90 hours						2
TOTAL			**17**	**03**	**08**	**-**	**390**	**500**	**26**

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

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

NC- Non Credit

20MTC08

PARTIAL DIFFERENTIAL EQUATIONS AND STATISTICS

(For CIVIL/MECH/PROD/CHEM)

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

Course Objectives:

1. To learn Numerical solution of ODE and Engineering problems.
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: On successful completion of this course the students shall be able to

1. Find solution of initial value problems of ODE by Numerical Method.
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

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

UNIT-I: 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.

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, exponential and Growth 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 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, 201

20CSC06

BASICS OF DATA STRUCTURES
(Common for all Programmes except CSE & IT)

Instruction	2 L Hours per week
Duration of Semester End Examination	3 Hours
Semester End Examination	60 Marks
CIE	40 Marks
Credits	2

Prerequisites:
Basic knowledge of programming language such as C or C++ is preferred (but not mandatory) and some mathematical maturity also will be expected.

Course Objectives: To introduce

1. Basic linear and non-linear data structures.
2. Analyzing the performance of operations on data structures.
3. Different sorting and searching techniques and their complexities.

Course Outcomes: The students will be able to

1. Identify various data structures, searching & sorting techniques and their applications.
2. Describe the linear and non-linear data structures, searching and sorting techniques.
3. Apply suitable data structures to solve problems.
4. Analyze various searching and sorting techniques.
5. Evaluate the linear and non-linear data structures.

CO-PO-PSO Matrix

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

UNIT – 1

Introduction: Data Types, Data structures, Types of Data Structures, Operations, ADTs, Algorithms, Comparison of Algorithms- Complexity- Time and space tradeoff.

Recursion: Introduction, format of recursive functions, recursion Vs. Iteration, examples.

UNIT – 2

Linked Lists: Introduction, Linked lists and types, Representation of linked list, operations on linked list, Comparison of Linked Lists with Arrays and Dynamic Arrays.

UNIT – 3

Stacks and Queues: Introduction to stacks, applications of stacks, implementation and comparison of stack implementations. Introduction to queues, applications of queues and implementations, Priority Queues and applications

Searching and Sorting: Linear searching, binary Searching, sorting algorithms- bubble sort, selection sort, quick sort, heap sort

UNIT – 4

Trees: Definitions and Concepts, Operations on Binary Trees, Representation of binary tree, Conversion of General Trees to Binary Trees, Representations of Trees, Tree Traversals, Binary search Tree.

Unit –5

Graphs: Introduction, Applications of graphs, Graph representations, graph traversals, Minimal Spanning Trees

Text Books:

1. NarasimhaKarumanchi "**Data Structures and Algorithms Made Easy**", CareerMonk Publications, 2017
2. E.Horowitz ,S. Sahni and Susan Anderson-Freed, "**Fundamentals of Data structures in C**", Silicon Pr; 2 edition (1 August 2007)
3. ReemaThareja, "**Data Structures using C**",Oxford, 2014

Suggested Reading:

1. https://www.tutorialspoint.com/data_structures_algorithms/index.htm
2. https://www.edx.org/course/foundations-of-data-structures
3. https://sites.google.com/site/merasemester/data-structures/data-structures-1#DS
4. https://www.cs.usfca.edu/~galles/visualization/Algorithms
5. https://www.coursera.org/specializations/data-structures-algorithms

20CHC01 CHEMICAL ENGINEERING THERMODYNAMICS-I

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

1. Understand the fundamental concepts of thermodynamics to engineering applications.
2. Understand the relation between the measurable nature of P, V, T and the un-measurable nature of H,U,A, G
3. Calculate the thermodynamic properties of real gases by using EOS.
4. Understand and analyze the various thermodynamic processes involving ideal gases.
5. Analyze the power cycles; refrigeration cycles, and liquefaction processes.
6. Apply the energy balance equations to Open and Closed systems and also to evaluate the thermodynamic efficiency of nozzles, turbines and compressors.

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	-	-	-	-	-	-	-	-	2	-
CO2	2	1	2	-	-	-	-	-	-	-	-	-	1	-
CO3	-	2	1	2	-	-	-	-	-	-	-	-	-	-
CO4	2	3	1	2	-	-	-	-	-	-	-	-	-	-
CO5	-	3	1	1	-	-	-	-	-	-	-	-	-	2
CO6	2	1	1	-	-	-	-	-	-	-	-	-	-	1

UNIT – I: The First Law of thermodynamics and Other Basic Concepts: Joule's Experiments – Internal Energy - Formulation of the first law of the thermodynamics ,Energy balance closed systems- the thermodynamic state and state functions - Enthalpy - The steady state flow processes; Equilibrium - The phase rule - The Reversible processes - Constant V and constant P processes and Heat capacity.
Volumetric Properties of Pure Fluids: PVT behavior of pure substances, Ideal gas, Virial equations and their use in the calculation of P-V-T Properties; Cubic equations of state (Van der Waals and Redlich-Kwong), generalized correlations for gases.

UNIT – II: The Second law of thermodynamics: Statement of the second law, Heat engines and Heat Pumps, thermodynamic temperature scales, Carnot Engine with Ideal-Gas-State Working Fluid, Entropy, entropy changes of an ideal gas, mathematical statement of the second law, the third law of thermodynamics, entropy from the microscopic view point.

UNTI – III: Thermodynamic properties of fluids; Fundamental property relationships among thermodynamic properties for a homogenous phase of constant composition; Maxwell relations, Residual properties; Residual properties from the virial equations of state, Generalized Property Correlations for Gases, Two-phase systems. Thermodynamic diagrams.

UNIT – IV: Production of Power from Heat: The Steam power plant; Carnot cycle; Rankine cycle; Internal Combustion engines -Otto engine, Diesel engine. **Refrigeration and Liquefaction**: The Carnot refrigerator, the vapor - compression cycle; comparison of Refrigeration cycles; the choice of refrigerant; absorption refrigeration; the heat pump; various processes for liquefaction.

UNIT V: Applications of Thermodynamics to Flow Processes: Energy balances for steady state flow process; Duct flow of compressible fluids, flow processes-Nozzles, turbines, Compressors and Pumps; Entropy balance for Open systems, Calculation of Ideal work and lost work for flow processes.

Text Books:

1. J M Smith and H C Van Ness and M M Abbott, Introduction to Chemical Engineering Thermodynamics (in SI units) , 8th edition, Mc-Graw Hill International Edition, 2018.
2. K.V.Narayanan, A Textbook of Chemical Engineering Thermodynamics, PHI Pvt. Ltd., 2013.

Suggested Reading:

1. Gopinath Halder, Introduction to Chemical Engineering Thermodynamics, 2nd Edition,2009
2. Y V C Rao, Chemical Engineering Thermodynamics, Universities Press, 1997
3. M J Moran, H N Shapiro, D D Boettner and M B Bailey, Principles of Engg. Thermodynamics, 8th Edition, Willey, 2018.

20CHC02 **FLUID MECHANICS**

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

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: At the 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 such as toxic, acidic, slurry type.
6. Identify equipment to be used to measure fluid flow based on their properties

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
CO6	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, stream lines 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

Compressible Fluids and Non Newtonian fluids (with Differential Pressure estimation) 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, Blasius solution, 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- Venturi meter, orifice meter, Pitot tube, Rotameter, Notches and Weirs, Compressors and blowers.

Text Books

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.

20CHC03 **MATERIAL ENERGY BALANCE CALCULATIONS**

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

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. Analysis methods for identifying vapors and liquids
5. Energy balance calculations and its importance.

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

1. Convert physico-chemical quantities from one system of units to another and identify basis of calculation
2. Solve material balance problems without chemical reactions.
3. Solve material balance problems with chemical reactions
4. Solve material balance problems with recycle, purge and bypass
5. Analyze the ideal and real behavior of gases, vapors and liquids
6. Solve energy balance problems with and without chemical reaction

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
CO6	3	3	3	3	3	-	-	-	2	2	1	1	3	2

UNIT-I

Introduction to process calculations: Units and Dimensions - Conversion of Units; Process and process variables – process flow sheet, process unit, process streams, density, specific gravity, specific gravity scales, mass and volumetric flow rates, mole concept, molecular and equivalent weights; Composition of streams; other expressions for concentration

UNIT-II

Material Balance: Introduction, Solubility, dissolution and crystallization (single solute systems) – Solving material balance problems without chemical reaction. Unit operations like absorption, distillation, evaporation, crystallization, leaching, and extraction, drying and mixing units under steady state conditions.

UNIT-III

Material Balance with Chemical Reaction: Material Balance with chemical reaction, Concept of stoichiometry and mole balances, examples, including combustion-Proximate and ultimate analysis of coal and analysis of flue gas. Material balances for by-pass, recycle and purge Operations.

UNIT-IV

Gases, Vapours and Liquids: Equations of state, mixture of ideal gases-Dalton's and Amagat's laws, Vapour pressure, Clausius- Clapeyron equation, Cox chart, Duhring's plot, Raoult's law. Humidity and Saturation, humid heat, humid volume, dew point, humidity chart and its use.

UNIT-V

Energy Balances: Thermophysics -Heat Capacity, Calculation of enthalpy changes without and with phase change, Heat of solution and mixing; Energy balances without chemical reactions; Thermochemistry - Energy balances with chemical reactions - Standard heat of reaction, formation and combustion, Hess Law, Effect of temperature; Simultaneous material and energy balances - Adiabatic flame temperature.

Text Books:

1. Himmelblau, D. M., Riggs, J. B. "Basic Principles and Calculations in Chemical Engineering", Eighth Ed., Pearson India Education Services,
2. 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.
4. Felder, R. M.; Rousseau, R. W., "Elementary Principles of Chemical Processes", Third Edition, John Wiley & Sons, 2000

20CHC04 **MECHANICAL UNIT OPERATIONS**

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

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

1. Principles of size reduction using various equipment's.
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: At the end of the course, the students will be able to:

1. Decide the transport of solids based on their properties.
2. Select equipment for industrial application with respect to size reduction.
3. Design equipment for industrial application with respect to separation of solids.
4. Decide the necessary equipment to screen different particles based on their properties.
5. Apply different filtration techniques for industrial application
6. Identify the suitable technique for blending 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
CO6	3	3	2	3	3	1	2	2	1	-	1	1	3	2

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. Critical speed – 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.

Text Books:

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 Reading:

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

20CSC07

Basics of Data Structures Lab
(Common for all Programmes except CSE & IT)

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

Pre-requisites: Any Programming Language

Course Objectives:

1. Design and construct simple programs by using the concepts of Data structures as abstract data type.
2. To have a broad idea about how efficiently pointers can be used in the implement of data structures.
3. To enhance programming skills while improving their practical knowledge in data structures.
4. To strengthen the practical ability to apply suitable data structure for real time applications.

Course Outcomes: The students will be able to

1. Implement the abstract data type.
2. Demonstrate the operations on stacks, queues using arrays and linked lists
3. Apply the suitable data structures including stacks, queues to solve problems
4. Analyze various searching and sorting techniques.
5. Choose proper data structures, sorting and searching techniques to solve real world problems

CO-PO-PSO Matrix

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

List of Experiments

1. Implementation of operations on arrays
2. Implementation of Stack.
3. Implementation of Queue.
4. Implementation of basic operations on Single Linked List.
5. Implementation of Searching techniques.
6. Implementation of Sorting Techniques
7. Case study like Banking System, Students Marks Management, Canteen Management, Library Management etc

Text Books

1. Brian W Kernighan, Dennis Ritchie, C Programming Language, PH PTR, 2nd Edition.
2. Richard M Reese, Understanding and Using C Pointers, O`Reily , 2013.

Web Links

https://nptel.ac.in/courses/106102064/
https://www.udemy.com/algorithms-and-data-structures-in-python/

20CHC05 **FLUID MECHANICS LAB**

Instruction	3 P Hours per week
Duration of SEE	3Hours
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: After the 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
6. Analyze the flow in packed beds.

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
CO6	2	2	-	2	-	-	-	1	2	1	-	1	2	2

List of experiments

(Minimum of 8 experiments in the list are to be performed)

1. Determination of discharge coefficient for Orifice meter and Venturi meter and their variation with Reynolds number
2. Determination of weir meter constant K for V notch / rectangular notch
3. Determination of discharge coefficient for Mouth piece 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

Text Books:

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:

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

20CHC06 **MECHANICAL UNIT OPERATIONS LAB**

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

Course Objectives: This course will

1. Provide students the opportunity to acquire practical skills in mechanical unit operations.
2. Introduce students to the importance and principles 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: At the end of the course, the student will be able to:

1. Understand mechanical unit operations and their role in process industries.
2. Understand the nature of solids, their characterization, handling and the processes involving solids.
3. Analyze the performance of size reduction equipment and calculate the power and efficiency requirements.
4. Understand the principle, construction and operation of various classification equipment.
5. Analyze Solid liquid separation in industrial equipment based on settling, density and centrifugal force.
6. Design and operate filtration equipment.

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
CO6	3	3	2	3	2	1	2	3	3	3	2	1	3	3

List of experiments

(Minimum of 8 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.

Text Books:

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, NewYork, 1981.

Suggested Reading:

1. Coulson, J. M., and Richardson, J. F., "Chemical Engineering Series", Vol. 2, 4thEd.,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 (AUTONOMOUS)

Scheme of Instructions IV Sem B.Tech (Chemical Engineering)

As per AICTE Model Curriculum 2020-21

DEPARTMENT OF CHEMICAL ENGINEERING

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	20CHC07	Chemical Reaction Engineering I	3	1	-	3	40	60	4
2	20CHC08	Chemical Technology	3	-	-	3	40	60	3
3	20CHC09	Heat Transfer	3	-	-	3	40	60	3
4	20CHC10	Mass Transfer Operations I	3	-	-	3	40	60	3
5	-----	Professional Elective I	3	-	-	3	40	60	3
6	20EGM01	Indian Constitution & Fundamental Principles	2	-	-	2	-	50	NC
7	20EEM01	Indian Traditional Knowledge	2	-	-	2	-	50	NC
8	20CEM01	Environmental Science	2	-	-	2	-	50	NC
PRACTICAL									
9	20CHC11	Chemical Reaction Engineering Lab	-	-	3	3	50	50	1.5
10	20CHC12	Heat Transfer Lab	-	-	3	3	50	50	1.5
TOTAL			**21**	**01**	**06**	**-**	**300**	**500**	**19**

L: Lecture T: Tutorial P: Practical NC- Non Credit

CIE - Continuous Internal Evaluation SEE - Semester End Examination

S.No	Course Code	Professional Elective I
1	20CHE01	Energy Engineering
2	20CHE02	Food Processing Technology
3	20CHE03	Material Science for Chemical Engineers
4	20CHE04	Pulp and Paper Technology

20CHC07 CHEMICAL REACTION ENGINEERING-I

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

Course Objectives: This course helps the students to

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. Apply the concepts of heat effects on reactions.
5. Understand the concepts of non ideal reactors.

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

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 etc
5. Determine the effect of temperature on reactor performance for adiabatic and non adiabatic operation.
6. Analyze the non ideality of reactors.

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	1	-	1	-	-	-	-	1	1	2
CO2	3	3	3	3	2	-	1	-	-	-	-	1	2	2
CO3	3	3	3	3	1	-	1	-	-	-	-	2	3	3
CO4	3	3	3	3	2	-	-	-	-	-	-	2	3	3
CO5	3	3	3	3	1	-	1	-	-	-	-	-	3	2
CO6	3	3	3	3	1	-	3	-	-	-	-	1	2	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 Stochiometric 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

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 behaviour. 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.

20CHC08

CHEMICAL TECHNOLOGY

Instruction	3 L Hours per week
Duration of SEE	3Hours
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. Estimate the chemical industry growth and opportunities.
2. Differentiate between unit operation and unit processes.
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.
6. Predict the process limitations and propose a model to overcome the limitations.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	2	-	1	1	1	1	-	-	-	-	1	3
CO2	-	1	2	-	-	-	-	-	-	-	-	-	-	-
CO3	-	1	3	2	-	-	-	-	-	-	-	-	2	-
CO4	-	-	1	1	-	1	-	-	-	-	-	-	1	2
CO5	-	-	1	-	-	1	1	-	-	-	-	-	-	-
CO6	-	1	1	2	-	-	-	-	-	-	-	-	-	-

CO-PO-PSO Matrix

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, Methods of Steel making– Steel alloys. Manufacturing of Copper and types of Copper alloys, Manufacturing of Aluminum and types of alloys. Over view of Pharmaceutical Industry with introduction and classification of pharmaceutical chemical forms.

UNIT – II: Manufacturing of H2 by Steam reforming of Hydrocarbons. NH3 Synthesis - methods and manufacturing. Urea manufacturing by various processes. Manufacturing of Mono ammonium Phosphate, Di ammonium Phosphate. Manufacturing of Single super Phosphate and
Triple super Phosphate.

UNTI – 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, Byproducts of sugar industries.

Text Books:

1. George T. Austin, ―Shreve's Chemical Process Industries‖, 5th edition. McGraw Hill Book Company, 1984.
2. 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.

Suggested Reading:

1. 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, NewDelhi, 2009.

20CHC09 **HEAT TRANSFER**

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

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 completing this course, students will be able to:

1. Distinguish between different types of heat transfer
2. Calculate heat transfer coefficients for forced and natural convection
3. Analyze and understand the concepts of Heat exchangers
4. Analyze the heat transfer phenomena in fluids involving phase changes
5. Identify the type of evaporator required for a specific purpose and design it
6. Explain the impact of radiation shields and laws of radiation.

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
CO6	3	2	2	1	1	2	3	-	2	2	1	1	3	2

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

Text Books:

1. W.L.McCabe, 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 Reading:

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

20CHC10 **MASS TRASFER OPERATIONS - I**

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

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. Write the rate equations for mass transfer operations
3. Estimate the mass transfer coefficients of mixtures
4. Design Absorber/Stripper by equilibrium methods
5. Design the cooling tower with the concept of humidification.
6. Interpret the drying mechanism by estimating total drying period

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	-	-	-	2	-	-	-	2	3	3	2
CO2	3	3	3	-	2	-	2	-	-	-	2	3	3	3
CO3	3	3	3	2	1	2	2	-	-	-	-	3	3	3
CO4	3	3	3	-	2	-	2	-	2	-	2	3	3	2
CO5	3	3	3	-	2	-	2	-	2	-	2	3	3	2
CO6	3	3	3	-	1	-	2	-	2	-	2	3	3	2

UNIT – I Diffusion Mass Transfer

Introduction of Mass transfer operations & their applications, 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) - Correlation's for mass transfer coefficients and Reynolds & Colburn analogies.

UNIT – II Mass Transfer coefficients & Interphase Mass Transfer

Mass transfer coefficients concepts and classifications, 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, packing for packed columns – Liquid distribution. Mass transfer coefficients in packed columns, Flooding in packed and plate columns, Ideal stage, Murphree, point and overall column efficiency, Comparison of packed and plate columns.

UNIT - III Absorption and Stripping

Introduction to absorption, Equilibrium in gas-liquid system, and minimum liquid rate, Design of packed column

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. Kremser – 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, 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.

Text Books:

1. R.E. Treybal, "Mass Transfer operations", 3rd Edition, McGraw Hill Book Co., 1981
2. Christie John Geonkoplis "Transport Processes and Separation Process Principles",4th edition. PHI, New Delhi.

Suggested Reading:

1. J Coulson and Richardson,"Fluid Flow, Heat and Mass Transfer", Volume 1, 6th Edition, Pergoman Press, 2009
2. W.L.McCabe, Julian C. Smith, Peter Harriott, Unit Operations of Chemical Engineering, 7th Edition, 2005.

20EGM01 **INDIAN CONSTITUTION AND FUNDAMENTAL PRINCIPLES**

(BE/BTech III/IV Semester - Common to all branches)

Instruction	2 Hours per week
Duration of Semester End Examination	2 Hours
Semester End Examination	50 Marks
CIE	0 marks
Credits	Non-credit course

Course Objectives

The course will introduce the students to:

1. History of Indian Constitution and how it reflects the social, political and economic perspectives of the Indian society.
2. Growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
3. Various Organs of Governance and Local Administration.

Course Outcomes

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

1. Understand the making of the Indian Constitution and its features.
2. Identify the difference among Right To equality, Right To freedom and Right to Liberty.
3. Analyze the structuring of the Indian Union and differentiate the powers between Union and States.
4. Distinguish between the functioning of Lok Sabha and Rajya Sabha while appreciating the importance of Judiciary.
5. Differentiate between the functions underlying Municipalities, Panchayats and Co-operative Societies.

CO-PO-PSO Matrix

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

Unit-I

Constitution of India: Constitutional history-Govt of India Act 1909, 1919 and 1935, Constitution making and salient features. Directive Principles of State Policy - Its importance and implementation.

Unit-II

Scheme of the Fundamental Rights & Duties: The Fundamental Rights - To Equality, to certain Freedom under Article 19, to Life and Personal Liberty Under Article 21. Fundamental Duties - the legal status.

Unit III

Union Government and its Administration - Structure of the Indian Union: Federalism, distribution of legislative and financial powers between the Union and the States.

Parliamentary form of government in India: Executive-President's role, power and position.

Unit IV

Legislature and Judiciary: Central Legislature-Powers and Functions of Lok Sabha and Rajya Sabha.

Judiciary: Supreme Court-Functions, Judicial Review and Judicial Activism

Unit V

Local Self Government - District's Administration Head (Collector): Role and Importance. Municipalities: Introduction, Mayor and Role of Elected Representative, CEO of Municipal Corporation. Panchayati Raj: Introduction, Zilla Panchayat, Elected Officials and their roles, CEO Zilla Panchayat: Position and Role. Block level: Organizational Hierarchy (Different departments). Village level: Role of Elected and Officials.

Text Books:

1. **Indian Government & Politics**, Ed Prof V Ravindra Sastry, Telugu Akademy, 2nd edition, 2018.
2. **Indian Constitution at Work,** NCERT, First edition 2006, Reprinted- January 2020.

Suggested Reading:

1. **The Constitution of India**, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar, **Framing of Indian Constitution**, 1st Edition, 2015.
3. M. P. Jain, **Indian Constitution Law**, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu**, Introduction to the Constitution of India**, Lexis Nexis, 2015.

Online Resources:

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

20EEM01 **INDIAN TRADITIONAL KNOWELDGE**

Instruction	2 Hours per week
Duration of Semester End Examination	2 Hours
Semester End Examination	50 Marks
CIE	02 Mid sem assignments [Optional]
Credits	No Credits

Course Objectives:

1. To get a knowledge in Indian Culture
2. To Know Indian Languages and Literature and the fine arts in India
3. To explore the Science and Scientists of Medieval and Modern India

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

1. Understand philosophy of Indian culture
2. Distinguish the Indian languages and literature
3. Learn the philosophy of ancient, medieval and modern India
4. Acquire the information about the fine arts in India
5. Know the contribution of scientists of different eras.

CO-PO-PSO Matrix

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

UNIT-I

Culture and Civilization: Culture, civilization and heritage, general characteristics of culture, importance of culture in human literature, Cultural diversity, Aesthetics, Women seers, Indus culture, Indian cuisine, Martial arts

UNIT-II

Education system: Education in ancient, medieval and modern India, aims of education, subjects, languages, Science and Scientists of Ancient India, Science and Scientists of Medieval India, Scientists of Modern India

UNIT-III

Linguistic Wealth: Indian Languages and Literature: the role of Sanskrit, Paleography, Significance of scriptures to current society, Indian semantics and lexicography, Bhakti literature, Darsanas

UNIT-IV

Art, Technology& Engineering: Sculpture, Painting and Handicrafts, Indian Music, Dance Drama and Theatre, Introduction to Mayamatam, Iron and steel technology, Use of metals in medicinal preparations

UNIT-V

Science and Logic: Helio-centic system, Sulbasutras, Katapayadi, Hindu calendar, 6 pramanas in Indian logic, Scientific method applied to therapeutics, Fallacies, Tarka – Induction&Deduction, Ayurvedic biology, Definition of health

Essential Readings:

1. Kapil Kapoor, Text and Interpretation: The Indian Tradition, ISBN: 81246033375, 2005

2. Samskrita Bharati,Science in Samskrit, ISBN-13: 978-8187276333, 2007
3. Satya Prakash, Founders of sciences in Ancient India, Govindram Hasanand, ISBN-10: 8170770009, 1989
4. Brajendranath Seal, The Positive Sciences of the Ancient Hindus, Motilal Banarasidass, ISBN-10: 8120809254, 1915

Suggested Readings:

1. Swami Vivekananda, *Caste, Culture and Socialism*, Advaita Ashrama, Kolkata ISBN-9788175050280
2. Swami Lokeswarananda, *Religion and Culture*, Advaita Ashrama, Kolkata ISBN-9788185843384
3. Kapil Kapoor,*Language, Linguistics and Literature: The Indian Perspective*, ISBN-10: 8171880649, 1994.
4. Karan Singh, *A Treasury of Indian Wisdom: An Anthology of Spiritual Learn*,ISBN: 978-0143426158, 2016
5. Swami Vivekananda, *The East and the West*, Advaita Ashrama, Kolkata 9788185301860
6. Srivastava R.N., *Studies in Languages and Linguistics*, Kalinga Publications ISBN-13: 978-8185163475
7. Subhash Kak and T.R.N. Rao, Computation in Ancient India, Mount Meru Publishing ISBN-1988207126
8. R.N Misra, *Outlines of Indian Arts Architecture, Painting, Sculpture, Dance and Drama,* IIAS, Shimla & Aryan Books International, ISBN 8173055149
9. S. Narain, *Examinations in ancient India*, Arya Book Depot, 1993
10. M. Hiriyanna, Essentials of Indian Philosophy, Motilal Banarsidass Publishers, ISBN-13: 978-8120810990, 2014
11. Ravi Prakash Arya, Engineering and Technology in Ancient India, Indian Foundation for Vedic Science, ISBN-10: 1947593072020

SWAYAM/Nptel:

1. History of Indian Science and Technology - https://onlinecourses.swayam2.ac.in/arp20_ap35/preview
2. Introduction to Ancient Indian Technology – https://onlinecourses.nptel.ac.in/noc19_ae07/preview
3. Indian Culture & Heritage - https://onlinecourses.swayam2.ac.in/nos21_sc11/preview
4. Language and Society - https://nptel.ac.in/courses/109/106/109106091/
5. Science, Technology & Society - https://nptel.ac.in/courses/109/103/109103024/
6. Introduction to Indian Philosophy - https://nptel.ac.in/courses/109/106/109106059/
7. Introduction to Indian Art - An appreciation - https://onlinecourses.nptel.ac.in/noc20_hs09/preview

20CEM01

ENVIRONMENTAL SCIENCE

Instruction	2 L Hours per week
Duration of SEE	2 Hours
SEE	50 Marks
CIE	0 Marks
Credits	Non-credit course

Course Objectives: To enable the student

1. Identify environmental problems arising due to over utilization of natural resources and understand the importance of use of renewable energy sources
2. Become aware about the importance of eco system and interlinking of food chain.
3. Identify the importance of biodiversity in maintaining ecological balance.
4. Learn about various attributes of pollution management and waste management practices.
5. Contribute for capacity building of nation for arresting and/or managing environmental disasters.

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

1. Identify the natural resources and realise the importance of water, food, forest, mineral, energy, land resources and affects of over utilisation.
2. Understand the concept of ecosystems and realise the importance of interlinking of food chains.
3. Contribute for the conservation of bio-diversity.
4. Suggest suitable remedial measure for the problems of environmental pollution and contribute for the framing of legislation for protection of environment.
5. Follow the environmental ethics and contribute to the mitigation and management of environmental disasters.

CO-PO-PSO Matrix

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

UNIT- I:

Environmental Studies: Definition, Scope and importance, need for public awareness.

Natural resources: Use and over utilization of Natural Resources - Water resources, Food resources, Forest resources, Mineral resources, Energy resources, Land resources.

UNIT – II:

Ecosystems: Concept of an ecosystem, structure and function of an ecosystem, role of producers, consumers and decomposers, energy flow in an ecosystem, food chains, food webs, ecological pyramids, Nutrient cycling, Bio-geo chemical cycles, Terrestrial and Aquatic ecosystems.

UNIT – III:

Biodiversity: Genetic, species and ecosystem biodiversity, Bio-geographical classification of India, India as a Mega diversity nation. Values of biodiversity, hot-spots of biodiversity, threats to biodiversity, endangered and endemic species of India, methods of conservation of biodiversity.

UNIT – IV:

Environmental Pollution: Cause, effects and control measures of air pollution, water pollution, marine pollution, soil pollution, noise pollution and Solid waste management, nuclear hazards

Environmental Legislations: Environment protection Act, Air, Water, Forest & Wild life Acts, issues involved in enforcement of environmental legislation, responsibilities of state and central pollution control boards

UNIT – V:

Social issues and the environment: Water conservation methods: Rain water harvesting and watershed management, Environmental ethics, Sustainable development and Climate change: Global warming, Ozone layer depletion, forest fires, and Contemporary issues.

Text Books:

1. Y. Anjaneyulu, "Introduction to Environmental Science", B S Publications, 2004.
2. Suresh K. Dhameja, "Environmental Studies", S. K. Kataria& Sons, 2009.

Suggested Reading:

1. C. S. Rao," Environmental Pollution Control Engineering", Wiley, 1991.
2. S. S. Dara, "A Text Book of Environmental Chemistry &Pollution Control", S. Chand Limited, 2006

20CHE01 **ENERGY ENGINEERING**

(Professional Elective I)

Instruction	3 L Hours per week
Duration of SEE	3Hours
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, bio fuels 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. Classify and explain energy sources
2. Summarize the basic principles and fundamentals of non-conventional energy sources
3. Summarize the basic principles and fundamentals of conventional energy sources
4. Outline the production and future perspectives of bio fuels
5. Relate the importance of future energy resources
6. Demonstrate the need for energy auditing and conservation

CO-PO-PSO Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	2	1	-	-	3	-	-	-	-	-	-	-	-
CO2	-	2	1	-	-	3	-	-	-	-	-	-	-	-
CO3	-	2	1	-	-	3	3	-	-	-	-	-	2	2
CO4	-	2	1	-	-	3	3	-	-	-	-	-	2	2
CO5	-	2	1	-	-	3	3	-	-	-	-	-	2	1
CO6	-	2	1	-	-	3	3	-	-	-	-	-	2	1

UNIT-I

Introduction:

Introduction to conventional and non conventional energy sources, alternative energy sources, their significance & availability, consumption patterns in India. Energy survey and policies for India

UNIT-II

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-III

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-IV

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-V

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 bio-diesel, bio-butanol and bio-ethanol, Second generation bio-fuel feed stocks

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

Text Books:

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

Suggested Reading:

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 Butterwolferand 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 techniques in food processing
3. Design process equipment to achieve the desired quality of food.
4. Develop novel food processes that have a minimal effect on food quality
5. Select control strategies to maintain food quality
6. Apply the scientific method to food science problems.

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	3	2	2	1	2
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	3	2	2	1	1	-	-	3	3	3
CO6	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, Quality and nutritive aspects, Product and Process development, 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, Size reduction, Mixing and forming, Separation and concentration of food components, Centrifugation, 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: Coating or enrobing, Theory and Types of packaging materials, Printing, Interactions between packaging and foods, Environmental considerations.

Text Books:

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, 200

20CHE03 **MATERIAL SCIENCE FOR CHEMICAL ENGINEERS**

(Professional Elective I)

Instruction	3 L Hours per week
Duration of SEE	3Hours
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.
6. Material characterization

Course outcomes: Upon completing this course, students will be able to:

1. Classify different engineering materials as ferrous and non-ferrous alloys.
2. Select materials for design and fabrication of process equipment.
3. Understand the significance of mechanical, thermal and optical properties of engineering materials
4. Select materials for high and low temperature applications.
5. Identify new or alternate materials for development and operation of process industry.
6. Characterize material using different experimental techniques.

CO-PO-PSO Matrix

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

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 properties and applications of engineering materials like Refractories, Ceramics, Super alloys, Composites; Nano-materials: carbon nanotubes, fullerene, nanosensors; Nanocomposites, role of reinforcement-matrix interface strength on composite behaviour

UNIT-IV

New materials: Biomaterials: Biocompatibility, advantages, properties, uses, Types- Nearly inert ceramics, surface active ceramics, resorbable ceramics. Smart materials Piezoelectrics, shape memory alloys, Magneto-strictive, electro-rheological materials, 3D printing.

UNIT-V

Material characterization: Study of material characterization using X-ray diffraction (XRD), Nuclear Magnetic Resonance (NMR) spectroscopy, Scanning electron microscopy (SEM), transmission electron microscopy (TEM).

Text Books

1. Materials Science and Engineering an Introduction, William D. Callister, Jr. 5thEd., John Wiley and Sons, Inc. 2002.
2. Materials Characterization - Introduction to Microscopic and Spectroscopic Methods, Yang Leng, 2nd ed., Wiley Publishers, USA, 2013.

Suggested Readings:

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

20CHE04 **PULP AND PAPER TECHNOLOGY**

(Professional Elective I)

Instruction	3 L Hours per week
Duration of SEE	3Hours
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. Design the operation, maintenance and safety aspects for paper making
2. Identify the factors that drive industry trends
3. Evaluate different grades of paper and boards based on testing methods
4. Select appropriate bleaching technique for required paper quality
5. Distinguish the important wood and fiber properties that affect paper quality
6. Identify, formulate and solve design problems pertaining to pulp digester

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
CO6	3	2	3	2	2	-	1	-	-	-	-	3	3	3

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 & 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 & newsprint specifications; BIS and ISO standards of paper. Paper properties dependence on paper making processes.
Paper recycling process, Effluent treatment processes with environmental considerations.

Text Books:

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 Reading:

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, Ultrastructure, 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.

20CHC11 CHEMICAL REACTION ENGINEERING LAB

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

Course Objectives: This course helps the students to understand to

1. Familiarize students with 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. Compare the performance of ideal reactors.
2. Develop rate law for use in reactor design based on reaction data from a reactor.
3. Find the conversion of reactants for a particular reaction in different reactors.
4. Interpret the kinetics of an exothermic reaction.
5. Analyze laboratory reactors through residence time distributions.
6. 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
CO6	3	2	1	1	1	-	1	-	2	-	-	-	2	2

List of Experiments

(Minimum of 8 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.

20CHC12 **HEAT TRANSFER LAB**

Instruction	3P 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. 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: Upon completing this course, students will be able to:

1. Demonstrate and evaluate heat transfer by conduction in solids for steady state conditions
2. Determine thermal conductivity of different materials of varying geometries
3. Estimate heat transfer coefficients and determine effectiveness of pin fin for free and forced convection
4. Determine surface emissivity of a test plane and Stefan-Boltzmann's constant and compare with theoretical values
5. Determine critical heat flux in pool boiling
6. 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	3	-	-	-	-	-	-	-	-	-	-	3	1
CO2	3	3	-	-	-	-	-	-	-	-	-	-	3	2
CO3	3	3	-	-	-	-	-	-	-	-	-	-	3	3
CO4	3	3	-	-	-	-	-	-	-	-	-	-	1	1
CO5	3	3	-	-	-	-	-	-	-	-	-	-	1	1
CO6	3	3	-	-	-	-	-	-	-	-	-	-	3	3

List of Experiments

(Minimum of 8 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

Text Books:

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