**AICTE Scheme and Syllabi**

**B.TECH. (CHEMICAL ENGINEERING)**

**&**

**B.TECH. + M.TECH. (CHEMICAL ENGINEERING)**

**(Effective from the admitted batch of 2019-20)**

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**DEPARTMENT OF CHEMICAL ENGINEERING**

**AU COLLEGE OF ENGINEERING (A)**

**ANDHRA UNIVERSITY**

**VISAKHAPATNAM**

**2/4 B.Tech(Chemical Engineering) - First Semester**

**&**

**2/6 B.Tech + M.Tech (Chemical Engineering) First Semester**

**CHE 1301 Solid Mechanics**

**3 L- 1T- 0P-2C**

**Objectives:**

1. To impart knowledge about the behaviour of elastic bodies subjected to different types of external forces.
2. To impart skills of analysing the statically determinate beams subjected to different types of loads for shear force, bending moment and their corresponding stress distribution.
3. To develop skills to analyse shafts, springs and shells for determining the critical stress distribution..

**Outcomes:**

1. The students are expected to analyse different bodies subjected to different types of loads like axial forces, transverse loads and torsional moment.
2. The students are expected to analyse the statically determinate beams subjected to loads.
3. The students are expected to analyse shafts, springs and shells.

**Syllabus:**

**Axial loads:** Simple stress and strain, Hook’s law, load extension diagram for mild steel, stress in compound assemblies, thermal stresses,

**Transverse loads:** Shear force and bending moment diagrams for a) cantilevers, b) simply supported beams and c) over-hanging beams due to concentrated loads and U D L s only,

**Theory of simple bending:** Relation between i) f and y, ii) M and I, iii) E and R, distribution of shear stress in common shapes of cross-section,

**Principal stresses** and principal planes, maximum shear stress and its plane, Mohar’s circle of stress,

**Torsion** of solid and hollow circular shafts, transmission of horse power, design of flange coupling, closed coil helical spring i) under axial load and ii) under axial twist, riveted joints, design of lap joints,

**Stress** in thin cylindrical shells and spherical shells, stress in thick cylinders, compound cylinders, pressure due to shrink-fitting,

**Text book:**

1. ‘Strength of Materials’ by Ramamrutaham

**Reference book:**

1. ‘Elements of Strength of Materials’ by S.P.Timoshenko and D.H.Young, East West Press, New Delhi

**CHE 1302 Mechanical Engineering**

**3 L- 1T- 0P-2C**

**Objectives:**

* + - To understand the basics in Thermodynamics
		- To get knowledge on applications of steam tables.
		- To understand the principles and applications of turbines and compressors.

**Syllabus:**

**Thermodynamics:** Definitions, systems, classification of thermodynamic systems, cycle, and zeroth law of thermodynamics, first law of thermodynamics, closed system, flow processes, open systems with steady flow process, applications of steady flow energy equation to engineering systems,

**Second law of thermodynamics:** Carnot cycle, inequality of Classius-reversible Carnot cycle, entropy, relation between heat and entropy, general expression for entropy change, entropy change of a perfect gas during various thermodynamic processes, air standard cycles, Otto, diesel, dual combustion cycles,

**Properties of steam and use of steam tables:** Boilers, classification steam boilers, simple vertical, Cocheran locomotive boiler, Babcock and Wilcox boiler, steam generation, Rankine cycle,

**Impulse and reaction turbine:** Classification of steam turbines, velocity diagram and power produced in impulse turbine, performance of steam turbines, reduction of rotor speed,

**I C engines:** Classification-main composition of IC engines, carburetter, fuel pump injector, cooling systems for IC engines, working of 2-stroke and v4-stroke petrol and diesel engines, power and efficiency of IC engines,

**Reciprocating air-compressors:** Single stage, work done during cycle, effect of clearance, two stage compressors, condition for minimum work, effect of inter-cooling, efficiency,

**Drives:** Belts, expression for the ratios of tension on the slack and tight side, power transmitted – V-belts, chain drives, gears – spur, helical, bevel gear, trains simple and compound.

**Text books:**

1. ‘A Text Book of Thermal Engineering’ by R.S.Khurmi and J.K.Gupta
2. ‘Theory of Machines’ by R.S.Khurmi

**Reference books:**

1. ‘Engineering Thermodynamics’ by P.K.Nag
2. ‘Engineering Thermodynamics’ by J.B.Jones and R.E.Dugar
3. ‘Engineering Thermodynamics’ by R.K.Rajput
4. ‘Theory of Machines’ by Balani

**CHE 1303 Organic Chemistry**

**3 L- 1T- 0P-3C**

**Objectives:**

The student will be able to:

1. appreciate the nature and scope of organic chemistry.
2. apply key concepts from general chemistry including electronegativity, bonding (ionic and covalent), hybridization of atomic orbitals, and molecular orbital theory to organic systems.
3. draw skeletal structures for organic compounds.
4. apply acid-base concepts to organic systems; predict ordering of acid or base strength.
5. name alkanes, alkenes, polyenes, alkynes, alkyl halides, aromatic compounds, carbonyl compounds, amines and their various derivatives using systematic (IUPAC) nomenclature.
6. draw reaction mechanisms for some key reactions.
7. recognize stereochemistry and be able to apply the Cahn-Ingold-Prelog system to

designation of stereochemistry (E/Z or R/S).

1. learn many of the reactions of alkanes, alkenes, polyenes, alkynes, aromatic, carbonyl, and amine compounds, and close related species. Be able to predict reactions involving these functional groups.
2. be able to solve problems employing spectroscopic methods including mass spectrometry, infrared and NMR spectroscopy
3. understand the basic chemical and structural features of biomolecules, including lipids, carbohydrates, amino acids and proteins, and nucleic acids

**Outcome:**

 This course enables the students to acquire knowledge, comprehension and application in numerical problems related to organic chemistry, nomenclature and reactions of alkanes, alkenes, alkynes, dienes, electrophilic aromatic substitution, alcohols, acids, aldehydes and ketones, amines, soaps and detergents.

**Syllabus:**

**Chapter 1: Quantitative and Qualitative Organic Analysis:** Determination of percentage composition of carbon, hydrogen and nitrogen, molecular weight determination by depression in freezing point and elevation of boiling point methods, molecular weight of acids by silver salt method; molecular weight of bases by chloroplatinate method, determination of molecular formula of a compound, problems relating to reactions of carboxylic acids, functional derivatives of acids, carbonyl compounds, alcohols, amines, phenols, diazonium salts, alkenes and Functional Group Identification of Organic Compounds

**Chapter 2: Isomerism:** Structural and Optical isomerism, Geometrical isomerism, E-Z configuration, sequence rules, R & S configuration, racemic mixture and their separation, asymmetric synthesis - Fischer projection formula, definitions of axial and equatorial bonds, 1-3-diaxial interaction, enatiomers, diastereomers, mesomers, isomerism in cyclic compounds, chair,boat and twisted boat structures (1-methylcyclohexane, 1, 2-cyclohexane diol)

**Chapter 3: Hydrocarbons**

Hybridisation - sp, sp2 and sp3; Nomenclature, Preparation and chemical reactions of alkanes, alkenes, alkynes, dienes, Wurtz reaction, Clemmensen and Wulf-Kishner reduction, Diels-Alder reaction, Morkovinkov rule, Industrial preparation of ethylene, acetylene; Conformational analysis of ethane, propane and butane; Cyclic aliphatic hydrocarbons - Baeyer's Strain Theory Preparations and their reactions

**Aromaticity and Benzene:** Structure of benzene, aromaticity, nomenclature of benzene derivatives, arenes, Electrophilic and Nucleophilic Aromatic Substitution: Mechanism of nitration, halogenation, sulphonation, Friedel-Craft’s alkylation and acylation reactions, Nucleophilic aromatic substitution; Orientation of disubstituted benzenes

**Chapter 4: Halides, Alcohols and Acids**

**Halides: N**omenclature of alkyl halides, preparation and chemical

reactions, mechanisms of SN1, SN2, E1, E2 reactions, Nomenclature of aryl halides, preparation and chemical reactions: low reactivity of vinyl and aryl halides, Sandmeyer reaction,

**Alcohols:** Nomenclature of alcohols; industrial preparation of ethyl alcohol, preparation and

chemical reactions, Lucas test,

**Carboxylic Acids:** Nomenclature of mono, dicarboxylic acids, industrial preparation of formic, acetic, benzoic, phthalic, salicylic acids, preparation and chemical reactions, mechanism of HVZ reaction and Claisen condensation, nomenclature of functional derivatives of acids, preparation and chemical reactions, mechanism of Hoffmann bromamide reaction, acid and base catalyzed hydrolysis of ester.

**Chapter 5: Carbonyl Compounds, Ethers, Epoxides and Carbohydrates**

**Carbonyl Compounds:** Nomenclature of aldehydes and ketenes: Industrial preparation of formaldehyde, acetaldehyde, benzaldehyde, salicyaldehyde, acetone; preparation and chemical reactions; mechanisms of Cannizaro, Aldol, Reformatsky and Wittig reactions, reactions without mechanisms -Perkin, Cope, Knoevenagel and Pinacol-Pinacolone reactions, difference between aldehyde and ketone, nomenclature of phenols, industrial preparation of phenol, preparation and chemical reactions, mechanisms of Fries rearrangement, Kobe reaction, Reimer-Tiemann reaction,

**Ethers, Epoxides and Active methylene Compounds:** Nomenclature of ethers and epoxides, industrial preparation of ether and ethylene oxide, preparation and chemical reactions; Williamson’s synthesis, Preparation of malonic, acetoacetic ester and their synthetic applications

**Carbohydrates: C**lassification of carbohydrates, structure of glucose and fructose, reactions of glucose and fructose, Ruff degradation, Wohls degradation, Killiani-Fisher synthesis, Conversion of glucose into fructose, fructose into glucose, glucose to vitamin-C, Mechanism of Osazone formation,

**Chapter 6: Amines, Diazonium Salts and Sulpha Drugs**

**Amines:** Nomenclature of amines, industrial preparation of Aniline, preparation and chemical reactions - exhaustive methylation, mechanism of Hoffmann elimination, Benzidine rearrangement without mechanism, Hinsberg test, differentiation test using nitrous acid

Preparation of diazonium salts and synthetic applications,

**Sulpha Drugs**: Preparation of sulphanilamide, sulphaguanidine, sulphamerazine, sulphapyridene - mode of action of sulpha drugs,

**Chapter 7: Polymers, Soaps and Detergents**

**Polymers:** Preparation of polyethylene, polystyrene, teflon, PVC, polyvinyl cyanide, rubber-vulcanisation, styrene-butadiene rubber, polychloroprene, bakelite, nylon-6 and nylon 6-6, plexiglas, terylene, Ziegler-Natta polymerization, definition of thermoplastics and thermosetting plastics

**Soaps and detergents:** Preparation, Mode of action of soaps, difference between soaps and detergents;

 **Reference books:**

1. ‘Text Book of Organic Chemistry’ by Morrison & Boyd

2. ‘Text Book of Organic Chemistry’ by Bahl&Tuli

3. ‘Text Book of Organic Chemistry’ by M.K.Jain

4. ‘Text Book of Organic Chemistry’ by I. L. Finar (Vols. 1 & 2 as R**eference books**)

**CHE 1304 Material Science & Engineering**

**3L- 1T- 0P-3C**

**Objectives:**

 Materials science and engineering is an important subject to every engineer to understand about the materials’ behavior in different environments. Main objectives of the study are as follows:

1. To understand the structure of atoms
2. To learn something about the crystalline nature of the materials
3. To know about the influence of atoms controlling the properties of materials
4. To know the equivalency of the materials for replacement
5. To learn to prepare alloys, composites for conventional materials
6. To find the relation between arrangement an thermodynamic properties of materials

**Outcome:**

1. To know about the appropriate utility of materials based on their nature.
2. To know the behavior of the materials w.r.t their directions.
3. To know the behaviour of materials exposed to different conditions in different phases.
4. To calculate the stability materials and knew the importance of crystalllinity.
5. Selectivity of the materials for suitable design to manufacture the machines
6. To improve the properties choosing alternative materials suchas alloys, composites instead of conventional materials (to minimize fractures, wear and tear).
7. Leads to prepare some knew semiconductors for important purposes.

**Unit – I**

**Atomic Structure, chemical Bond and Crystal Geometry:** An introduction to materials, classification of engineering materials, brief review of atomic structure and theories, calculation of energy of electron of Bohr’s atomic model, Bonds in materials – classification, properties of ionic, covalent and metallic solids, variation in bonding character and properties. Levels of structure of materials, Crystal Geometry and crystal structure – classification of solids- Single crystals, polycrystalline solids and amorphous solids (non-crystalline), differences between crystalline and non-crystalline materials. Ideal crystal, space Lattice, basis for crystal formation, unit cell, lattice co-ordinates, Bravis lattices for crystal systems, crystal systems and their properties with examples, symmetries in crystals. Atomic packing faction and packing efficiency (SC, BCC, FCC, Diamond cubic and HCP structures), c/a ratio for HCP structure. Miller indices for directions, planes in crystals and their presentation, ligancy and coordination number. Determination of crystal Structure by X-ray diffraction method – Debye method, numerical problems for different cubic structures (SC, BCC and FCC).

**Unit –II**

**Fundamentals of thermodynamics and Crystal imperfections:** Basic thermodynamics functions: – stability and meta-stability of materials, internal energy (E), enthalpy (H), Gibb’s free Energy (G), and thermal entropy and configurational entropy (S). crystal imperfections – classification, point defects- classification and estimation of point defects in the crystals; Imperfections (dislocations) – classification (edge and screw); Berger circuits and Burgers Vector, dislocation reactions, role of dislocations in determining crystal properties; surface defects - types

**Unit -III**

**Mechanical Properties**: Stress –types of stresses; Strain-types of strain; true stress and true strain, engineering stress and engineering strain of the materials, relation between engineering strain and true strain, relation between engineering stress and true stress; Hooke’s Law; Poisson’s Ratio, stress-strain diagram and its uses; different moduli of elasticity – Young’s modulus, shear modulus, and bulk modulus; relation between different moduli of elasticity and strain vs stress relationship diagrams for different materials (metals, non-metals, rubbers and plastics and polmers); elastic deformation and plastic deformation and their differences. Critical Resolved shear stress (CRSS). Relaxation process and viscoelastic behavior. Fracture – types ductile fracture and its mechanism, brittle fracture and its mechanism (Griffith’s criteria), fatigue, mechanism, factors affecting the fatigue, creep and creep failure mechanisms, creep resistance materials.

**Unit –IV**

**Composite materials** – classification, advantages of composite materials over conventional materials, Limitations of composite materials, factors affecting the performance of fibrous composites, factors affecting the performance of matrix in composites, evaluation of Young modulus of composites when axially and transversely loaded.

**Phase Transformationns**- time scale for phase changes, Nucleation and growth, Phase diagrams- phase rule, solid solutions-types, single component systems, Binary phase changes, the lever rule and numerical problems, advantages of phase diagrams, advantages of alloying of metals on the properties of steels, Iron-iron carbide (Fe-Fe3C) phase diagram, limitations of plain carbon steels, types of steels used in chemical industries,

**Unit – V**

**Corrosion of Materials:** Corrosion and prevention: mechanism of oxidation, oxidant resistant materials, corrosion: Erosion and corrosion, principles of corrosion, types of corrosion, polarization, passivation, Galvanic series, formation of Galvanic cells, proper selection of materials, proper design and fabrication procedure, cathodic protection, application of protective coatings, application of inhibitors.

**Text books:**

1. `Materials Science & Engineering’ by V.Raghavan, Prentice Hall of India Ltd, New

 Delhi

2. `Elements of Materials Science & Engineering’, 5th Edition, Lawrence H.VanVlack,

 Addision-Weley Publishing Company.

3. ‘Corrosion Engineering’ by Mars G. Fantana, McGraw Hill Edition

**Reference books:**

1. `Science of Engineering Materials’, Vols.1-3, by Manas Chanda, McMillan Company

 of India, Delhi

2. `Principles of Materials Science & Engineering’, William F.Smith, McGraw-Hill

 Publishing Co.

3. `Essentials of Materials Science’ by A.G. Guy.

4. An introduction to corrosion science and engineering By Herbert Uhilig and R. Winston Revie, Published by John Wiley and sons, New York

**CHE1305 Biology**

**3 L- 1T- 0P-3C**

**Objectives**

Students will be introduced to the basics of biology such as cell structure and functions, inheritance

& evolution, basic concepts of genetics, and an introduction to microbiology

**Contents:**

1. Basics: Diversity of life, prokaryotes and eukaryotes, basic cell constituents and macromolecules.

[6L + 1T]

2. Biochemistry: Metabolism (Catabolism and Anabolism) and Bioenergetics [12L + 3T]

3. Genetics: Basic principles of Mendel, molecular genetics, structure and function of genes and

chromosomes, Transcription and Translation, gene expression and regulation. [12L + 3T]

4. Cell Biology: Macromolecules, membranes, organelles, cytoskeleton, signaling, cell division,

differentiation, motility. [12L + 3T]

5. Microbiology: host-microbe interactions, physiology, ecology, diversity, and virology (6L + 2T)

Total 60 (L + T)

**Course outcomes**

Students will get insight into biology as a science, outlining the diversity, organization and

fundamental principles of living systems.

**CHE 1306 Basic Electrical Engineering**

**3 L- 1T- 0P-3C**

**Objectives:**

* An understanding of basic EE abstractions depends on analysis and design of electric and magnetic circuits and its elements.
* To provide the students with knowledge of fundamental laws in electrical engineering
* To develop the ability of the students to analyze electrical and magnetic circuits using the basic laws of electrical engineering
* To expose the students to the concepts of various types of electrical machines and application of electrical machines.
* To inculcate the understanding about the AC fundamentals
* To prepare the students to have a basic knowledge of transformers
* To acknowledge about three phase induction motor and its operating principle
* To know about the fundamentals of synchronous motors and its working principle

**Outcomes:**

After the completion of the course, the student should be able

* To predict the behavior of any electrical and magnetic circuits.
* student will be able to state and explain the basic laws of electromagnetic induction.
* To impart knowledge on Constructional details, principle of operation, types of Electrical Machines performance Characteristics ,speed control methods and its applications
* Ability to conduct experiments on Ac Machines to find its characteristics.
* Abel to calculate performance characteristics of transformer like regulation and efficiency
* The ability to formulate and then analyze the working of synchronous motors
* Able to solve simple problems on synchronous motors

**Syllabus:**

**Magnetic circuits:** Definitions of magnetic circuit, reluctance, magneto motive force (mmf), magnetic flux, simple problems on magnetic circuits, hysterisis loss (chapter 8, page nos. 155-175),

**Electromagnetic induction:** Faraday’s laws of electromagnetic induction, induced E.M.F., dynamically induced E.M.F, statistically induced EMF, self inductance, mutual inductance (Chapter 9, page nos. 176-190),

**D.C. generators:** D.C generator principle, construction of D.C generator, E.M.F equation of D.C generator, types of D.C generators, armature reaction, losses in D.C generator, efficiency, characteristics of D.C generators, applications of D.C generators (chapter 10, 11, pages 208-238),

**D.C. motors:** D.C motor principle, working of D.C motors, significance of back, E.M.F, torque equation of D.C motors, types of D.C motors, characteristics of D.C motors, speed control methods of D.C motors, applications of D.C motor, testing of D.C machines, losses and efficiency, direct load test and Swinburne’s test (Chapter 12, 13, page Nos. 239-269),

**A.C. circuits:** Introduction to steady state analysis of A.C circuits, single and balanced 3 phase circuits (chapter 16, page nos. 323-348),

**Transformers:** Transformer principle, EMF-equation of transformer, transformer on load, equivalent circuit of transformer, voltage regulation of transformer, losses in a transformer, calculation of efficiency and regulation by open circuit and short circuit tests (Chapter 20, page Nos. 423-455),

**Three phase inductance motor:** Induction motor working principle, construction of 3-phase induction motor, principle of operation, types of 3-phase induction motor, torque equation of induction motor, slip-torque characteristics, starting torque, torque under running condition, maximum torque equation, power stages of induction motor, efficiency calculation of induction motor by direct loading (Chapter 21, page nos. 463-489),

**Altemator:** Altenator working principle, EMF equation of altenator, voltage regulation by Synchronised impedance method (Chapter 23, page nos. 505-515),

**Synchonous motor:** Synchronous motor principle of operation, construction, methods of starting of synchronous motor, (Chapter- 24, page nos. 516-526),

**Text book:**

1. ‘Elements of Electrical Engineering & Electronics’ by V.K. Mehta, S.Chand & Co.

**Reference book:**

‘A first course in Electrical Engineering’ by Kothari.

**CHE 1308 General Engineering Laboratory**

**0 L- 0T- 3P-2C**

**Mechanical Engineering Laboratory:**

1. Find the viscosity of the given sample of oil using Redwood viscometer-1
2. Find the viscosity of the given sample of oil using Redwood viscometer-II
3. Find the flash point of the given sample of oil using Abel’s flash point tester
4. To calibrate pressure gauge using standard pressure and standard weights
5. Draw the valve timing diagram of a 4-stroke diesel engine and port timing diagram of a 2-stroke petrol engine
6. Perform load test at full load, half load, ¼ th load on a 4-stroke Ruston engine and draw the performance curves
7. Find the volumetric efficiency, isothermal efficiency of the given compressor
8. To determine the moment of inertia of a fly-wheel and shaft experimentally and compare the values with the calculated values
9. To determine experimentally the calorific value of a gaseous fuel by using Junkers gas calorimeter
10. To determine the modulus of rigidity of the material of the wire by torsional oscillators

**Electrical Engineering Laboratory:**

1. Study and calibration of ammeter

2. Study and calibration of voltmeter

3. Study and calibration of wattmeter

4. Study and calibration of energy meter

5. Measurement of low resistance (armature)

6. Measurement of medium resistance (field)

7. Measurement of insulation resistance

8. Measurement of filament resistance

9. Verification of KCL and KVC

10. Superposition theorem.

11. Parameters of a choke coil

12. OC and SC tests on transformer

13. Load test D.C. shunt machine

14. OC test on DC,. separately excited machine

15. Swinburne’s test

16. 3-phase induction motor (No load and rotor block tests)

17. Alternator regulation by Syn. impedance method

**CHE 1310 Organic Chemistry Laboratory**

**0 L- 0T- 3P-2C**

**List of Experiments:**

1. Preparation of aspirin
2. Preparation of benzanilide
3. Preparation of m-dinitrobenzene
4. Preparation of benzoic acid
5. Preparation of phthalimide
6. Preparation of methyl orange
7. Preparation of parabenzoquinone
8. Preparation of nerolin
9. Detection of extra elements
10. Analysis of compound -1
11. Analysis of compound -2
12. Analysis of compound -3
13. Analysis of compound -4
14. Analysis of compound -5
15. Analysis of compound -6

**2/4 B.Tech(Chemical Engineering) - Second Semester**

**&**

**2/6 B.Tech + M.Tech (Chemical Engineering) Second Semester**

**CHE 1401** **Particle & Fluid Particle Processing**

**3L- 1T- 0P-3C**

**Objectives:**

 Mechanical Operations is one of the core subjects for chemical engineers, where student can learn some of the unit operations necessary for process industry. Main objects of the inclusion of this subject are:

1. To make the students exposed to different geometrical sizes of raw materials used in the industries, area of calculation of the particles w.r.t their sizes
2. To get familiarity with the different laws of grinding
3. To do the power consumption calculations
4. To learn different separation process on their physical properties
5. To differentiate between the process such as mixing and agitation
6. To know the movement of particles in different liquids (viscous)

**Outcome:**

 By the end of the course, student will be able to know the following things:

1. Separation of materials (useful and gangue) from their physical properties.
2. Selection of Machinery for size reduction of the raw materials
3. Power consumption calculation for crushing and grinding
4. Application of different techniques for separation
5. Minimization of impurities in the raw materials
6. General outlook for transportation of materials in the industry by choosing different conveyers.

**Syllabus:**

**Characteristics of solid particles** – shape, size, differential and cumulative screen analysis, specific surface area, particle population, different mean diameters for a mixture of particles,

**Principles of comminution** - Laws of crushing, description and working of size reduction equipment - jaw, gyratory and roll crushers, hammer mills, revolving mills, attrition mills, fluid energy mill, cutting machines, open and closed circuit grinding, wet and dry grinding, grindability index,

**Size separation**, screening, industrial screens - grizzly, gyratory and vibratory screens, revolving screens, trammels, capacity and effectiveness of screens, magnetic separation, electrostatic separation, froth flotation,

**Filtration** - description and working of filtration equipment, plate and frame filter press, shell and leaf filters, rotary drum filter, filter aid, centrifugal filtration, top suspended batch centrifuge, theory of filtration, washing of cakes,

**Motion of particles through fluids**- drag, free and hindered settling, settling velocities, classification, sink and float methods, differential setting methods - jigging and tabling, cyclone separators,

**Batch sedimentation,** thickeners, flocculation, centrifugal sedimentation, gravity and centrifugal decanters,

**Agitation of liquids,** power consumption in agitated vessels, scale up of agitation equipment, mixing equipment for mixing of solids and pastes, mixers for dry powders, mixing index,

**Conveying**, tpes of conveyors – mechanical, belt, chain and screw conveyors, elevators, pneumatic conveyors, size enlargement - need and applications.

**Text books:**

1. ‘Unit Operations of Chemical Engineering’ by W.L. McCabe, J.C. Smith and P.Harriot, McGraw- Hill Book Company

**Reference books:**

1. ‘Chemical Engineering -Vol.2’ by J.H.Coulson and J.F.Richardson, Pergaman press and ELBS
2. ‘Chemical Engineer’s Hand Book’ by R.H.Perry {ed}, McGraw-Hill Book Co.
3. ‘Unit Operations’ by Brown et al., Asian Publishing House
4. ‘Introduction to Chemical Engineering’ by Badger and Banchero, McGraw-Hill Book Company

**CHE 1402 Fluid Mechanics**

**3 L- 1T- 0P-3C**

**The main objectives are to provide:**

1. Knowledge on pressure distribution in static fluids.
2. Knowledge on rheological behavior of fluids, types of fluid flow, boundary layers and basic equations of fluid flow.
3. Knowledge of incompressible & compressible fluid flow in pipes
4. Knowledge on fluid flowing past solid surfaces
5. Knowledge on pipes, fittings, transportation and metering devices.

**Outcome:**

1. Able to estimate the pressure drop.
2. Enhance the flow by reduction by reducing boundary layer separation.
3. Estimating the pumping capacity and friction losses of flowing fluids.
4. Designing fluidized and packed beds.
5. Able to select pumps based on their performance.
6. Able to select proper measuring device and estimate the quantity of flow.

**Syllabus:**

**Dimensional Analysis:** Units and Dimensions, Dimensional Homogeneity, Dimensional Analysis, Buckingham π theorem, Geometric similarity, kinematic similarity, and dynamic similarity.

**Fluid statics and applications:** Nature of fluids, Hydrostatic Equilibrium, Applications of fluid statics – Manometers, continuous gravity decanter and centrifugal decanter.

**Fluid Flow phenomena:** Laminar flow, shear rate, shear stress. Rheological properties of fluids – Newtonian fluids, Non Newtonian fluids, time dependent flow, viscoelastic fluids. Viscosity, Reynolds number, Turbulence - nature of turbulence, deviating velocities, intensity and scale of turbulence, Reynolds stresses and eddy viscosity. Boundary layers - boundary layer formation over flat plate, flow in boundary layers, laminar and turbulent flow in boundary layers, boundary layer formation in straight tubes, boundary layer separation and wake formation.

**Basic Equations of Fluid Flow:** Continuity equation (Mass Balance in a flowing fluid), equation of motion (Differential Momentum Balance), Navier - stokes equations, Euler’s equation, Couette flow, Macroscopic Momentum Balance, layer flow with free surface, Bernoulli equation (Energy equation), corrections for effect of solid boundaries and pump work.

**Incompressible flow in pipes and channels :** Shear Stress and skin friction in pipes, Relation with skin friction and wall shear, Friction factor, relations between skin friction parameters, equivalent diameter, laminar flow in pipes and channels, velocity distribution, average velocity, Kinetic energy correction factor and momentum correction factor for laminar flow, Hagen-Poiseuille equation, laminar flow of non-Newtonian liquids, laminar flow in annulus. Turbulent flow in pipes and channels, Velocity distribution for turbulent flow, universal velocity distribution equations, its limitations, flow quantities for turbulent flow in smooth round pipes, Reynolds number- friction factor law for smooth tubes, effect of roughness, friction factor chart, drag reduction, friction from changes in velocity or direction – sudden expansion, sudden contraction, pipe fittings, friction losses in Bernoulli equation, velocity heads, separation of boundary layer in diverging channel, minimizing losses.

**Flow in compressible fluids:** Definitions and basic equations, processes of compressible flow, isentropic flow through nozzles, Adiabatic friction flow, Isothermal friction flow

**Flow past immersed objects:** Drag and drag coefficients, flow through bed of solids, Motion of particles through fluids - mechanics of particle motion, equation for one-dimensional motion of particles through fluid, terminal velocity, criterion for settling, free and hindered settling. Fluidization – conditions, minimum fluidization velocity, types of fluidizations and its applications.

**Transportation and Metering of Fluids:** Pipes, fittings, valves. Positive displacement Pumps – reciprocating, rotary and peristaltic pumps. Centrifugal pumps - theory, construction, performance, single and multistage pumps. Fans, Blowers and Compressors. Vacuum pumps – jet ejectors.

**Metering of fluids:** Full bore meters – Venturi meter, Orifice meter, Rotameters, Vortex-Shedding meters, Magnetic meters and Coriolis meters. Insertion meters – Pitot Tube, Thermal meters, notches and weirs.

**Text Books:**

1. “Unit Operations of Chemical Engineering” Seventh Edition, by W.L. McCabe, J C Smith and P Harriot, Mc Graw Hill

**Reference Books:**

1. “Chemical Engineering” Volume I by Coulson J.M. and Richardson J.F, Elsevier
2. “Fluid Mechanics” 2nd edition by Noel de Nevers, Mc Graw Hill

**CHE 1403 Thermodynamics-I**

**3L- 1T- 0P-3C**

**Objectives:**

Chemical Engineering Thermodynamics is one of the core subjects of Chemical Engineering Curriculum. Knowledge of thermodynamics helps student compute heat and work requirements of a process. The student would also learn how to estimate data in case of absence of experimental data.

**Outcome:**

1. Identification of system so that application of thermodynamics to real problems would be done
2. Arriving at the limitations of the first law thus enabling a need for second law
3. Application of thermodynamic laws to pipe flow, nozzle flow, expansion, compression, refrigeration and liquefaction.
4. Development of generalized correlations
5. Evolving Gibbs energy as a generating function of all thermodynamic properties

**Syllabus:**

**The first law and other basic concepts:** Joule’s experiments, internal energy, the first law of thermodynamics, thermodynamic state and state functions, enthalpy, the steady-state, steady-flow process, equilibrium, the phase rule, the reversible process, constant-V and constant-P processes, heat capacity.

**Volumetric properties of pure fluids:** PVT behavior of pure substances, virial equations, the ideal gas, application of the virial equations, cubic equations of state, generalized correlations for gases, generalized correlations for liquids, molecular theory of fluids, second virial coefficients from potential functions.

**Heat effects:** Sensible heat effects, internal energy of ideal gases, microscopic view, latent heats of pure substances, standard heat of reaction, standard of heat of formation, standard heat of combustion, temperature dependence of heat effects of industrial reactions.

**The Second law of thermodynamics:** Statement of the second law, heat engines, thermodynamic temperature scales, thermodynamic temperature and ideal-gas scale, entropy, entropy changes of an ideal gas, mathematical statement of the second law, the third law of thermodynamics, entropy from the microscopic view point.

**Thermodynamic properties of fluids:** Property relations for homogeneous phases, residual properties, two-phase systems, thermodynamic diagrams, generalized property correlations for gases.

**Thermodynamics of flow processes:** Equations of balance, duct flow of compressible fluids, turbines (expanders), compression processes.

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

***Textbook:***

1. `Introduction to Chemical Engineering Thermodynamics’ by J.M.Smith, H.C.Van Ness and M.M.Abbott, 6th Edition, McGraw-Hill International Editions, 2000.

***Reference Books:***

1. `Chemical Engineering Thermodynamics’ by B.F.Dodge, McGraw-Hill Book Co.,

2. `Schaum Outline of Theory and Problems of Thermodynamics’ by Michael M. Abbott and Hendrick C.VanNess, McGraw-Hill International Book Co., Singapore, 1981.

**CHE 1404 Material & Energy Balance**

**3L- 1T- 0P-3C**

**Objective**: To give intensive quantitative training in the practical applications of the principles of physical chemistry to the solution of complicated industrial problems and in methods of predicting missing physicochemical data from generalized principles.

**Outcome**: 1. Able to solve the problems based on stoichiometry, ideal gas and vapor pressure.

 2. Able to write and solve material and energy balances for a process.

**Syllabus**:

**Stoichiometry and composition relationships**- the gram-mole and pound-mole, limiting reactant, excess reactant, degree of completion, basis of calculation, weight percent, volume percent and mole percent, density and specific gravity- Baume and API gravity scales,

**Behavior of ideal gases**- application of the ideal-gas law, Dalton and Amagat laws to gaseous mixtures, composition of gases on dry basis and on wet basis,

**Vapor pressures**- Effect of temperature on vapor pressure, Antoine equation, reference substance vapor pressure plots, vapor pressure of immiscible liquids, ideal solutions and Raoult’s law, non-volatile solutes,

**Humidity -** Percentage saturation, relative saturation or relative humidity, dew point, vaporization, condensation, wet and dry bulb temperatures, adiabatic vaporization and adiabatic saturation temperature,

**Material balances-** Tie substance, yield, conversion, processes involving chemical reactions, material balance- calculations involving drying, dissolution, and crystallization, processes involving recycle, bypass and purge,

**Heat capacities of gases and gaseous mixtures-** effect of temperature on heat capacity of gas, mean heat capacity of gas, Kopp’s rule, latent heats, heat of fusion, heat of vaporization, Trouton’s rule, Kistyakowsky equation for non-polar liquids, estimation of latent heat of vaporization using Classius-Clayperon equation, enthalpy of humid air and humid heat capacity,

**Standard heat of reaction -** Standard heat of formation, laws of thermochemistry, standard heat of combustion, calculation of heat of formation from heats of combustion, calculation standard heat of reaction from heats of formation and from heats of combustion, standard integral heat of solution, effect of temperature on heat of reaction, Kirchoff’s equation, adiabatic and non-adiabatic reactions, theoretical and actual flame temperatures.

**Text book:**

1. ‘Chemical Process Principles, Part-I - Material and Energy balances’ by Olaf A Hougen, K.M. Watson and R.A.Ragatz, CBS Publishers and Distributors (1995)

**Reference books:**

1. ‘Basic principles and Calculations in Chemical Engineering’ by David M. Himmelblau, Prentice Hall of India Pvt Ltd, 1995
2. ‘Stoichiometry’ by B.I. Bhatt and S.M. Vora, 3rd Edition, Tata McGraw Hill Publishing Company Limited, New Delhi (1996)
3. ‘Stoichiometry for Chemical Engineers’ by Williams and Johnson, McGraw Hill Publishers.

**CHE 1304 Materials Science & Engineering**

**3L- 1T- 0P-3C**

**Objectives:**

 Materials science and engineering is an important subject to every engineer to understand about the materials’ behavior in different environments. Main objectives of the study are as follows:

1. To understand the structure of atoms
2. To learn something about the crystalline nature of the materials
3. To know about the influence of atoms controlling the properties of materials
4. To know the equivalency of the materials for replacement
5. To learn to prepare alloys, composites for conventional materials
6. To find the relation between arrangement an thermodynamic properties of materials

**Outcome:**

1. To know about the appropriate utility of materials based on their nature.
2. To know the behavior of the materials w.r.t their directions.
3. To know the behaviour of materials exposed to different conditions in different phases.
4. To calculate the stability materials and knew the importance of crystalinity.
5. Selectivity of the materials for suitable design to manufacture the machines
6. To improve the properties choosing alternative materials such as alloys, composites instead of conventional materials (to minimize fractures, wear and tear).
7. Leads to prepare some knew semiconductors for important purposes.

**Unit – I**

**Atomic Structure, chemical Bond and Crystal Geometry:** An introduction to materials, classification of engineering materials, brief review of atomic structure and theories, calculation of energy of electron of Bohr’s atomic model, Bonds in materials – classification, properties of ionic, covalent and metallic solids, variation in bonding character and properties. Levels of structure of materials, Crystal Geometry and crystal structure – classification of solids- Single crystals, polycrystalline solids and amorphous solids (non-crystalline), differences between crystalline and non-crystalline materials. Ideal crystal, space Lattice, basis for crystal formation, unit cell, lattice co-ordinates, Bravis lattices for crystal systems, crystal systems and their properties with examples, symmetries in crystals. Atomic packing faction and packing efficiency (SC, BCC, FCC, Diamond cubic and HCP structures), c/a ratio for HCP structure. Miller indices for directions, planes in crystals and their presentation, ligancy and coordination number. Determination of crystal Structure by X-ray diffraction method – Debye method, numerical problems for different cubic structures (SC, BCC and FCC).

**Unit –II**

**Fundamentals of thermodynamics and Crystal imperfections:** Basic thermodynamics functions: – stability and meta-stability of materials, internal energy (E), enthalpy (H), Gibb’s free Energy (G), and thermal entropy and configurational entropy (S). crystal imperfections – classification, point defects- classification and estimation of point defects in the crystals; Imperfections (dislocations) – classification (edge and screw); Berger circuits and Burgers Vector, dislocation reactions, role of dislocations in determining crystal properties; surface defects - types

**Unit -III**

**Mechanical Properties**: Stress –types of stresses; Strain-types of strain; true stress and true strain, engineering stress and engineering strain of the materials, relation between engineering strain and true strain, relation between engineering stress and true stress; Hooke’s Law; Poisson’s Ratio, stress-strain diagram and its uses; different moduli of elasticity – Young’s modulus, shear modulus, and bulk modulus; relation between different moduli of elasticity and strain vs stress relationship diagrams for different materials (metals, non-metals, rubbers and plastics and polmers); elastic deformation and plastic deformation and their differences. Critical Resolved shear stress (CRSS). Relaxation process and viscoelastic behavior. Fracture – types ductile fracture and its mechanism, brittle fracture and its mechanism (Griffith’s criteria), fatigue, mechanism, factors affecting the fatigue, creep and creep failure mechanisms, creep resistance materials.

**Unit –IV**

**Composite materials** – classification, advantages of composite materials over conventional materials, Limitations of composite materials, factors affecting the performance of fibrous composites, factors affecting the performance of matrix in composites, evaluation of Young modulus of composites when axially and transversely loaded.

**Phase Transformationns**- time scale for phase changes, Nucleation and growth, Phase diagrams- phase rule, solid solutions-types, single component systems, Binary phase changes, the lever rule and numerical problems, advantages of phase diagrams, advantages of alloying of metals on the properties of steels, Iron-iron carbide (Fe-Fe3C) phase diagram, limitations of plain carbon steels, types of steels used in chemical industries,

**Unit – V**

**Corrosion of Materials:** Corrosion and prevention: mechanism of oxidation, oxidant resistant materials, corrosion: Erosion and corrosion, principles of corrosion, types of corrosion, polarization, passivation, Galvanic series, formation of Galvanic cells, proper selection of materials, proper design and fabrication procedure, cathodic protection, application of protective coatings, application of inhibitors.

**Text books:**

1. `Materials Science & Engineering’ by V.Raghavan, Prentice Hall of India Ltd, New

 Delhi

2. `Elements of Materials Science & Engineering’, 5th Edition, Lawrence H.VanVlack,

 Addision-Weley Publishing Company.

3. ‘Corrosion Engineering’ by Mars G. Fantana, McGraw Hill Edition

**Reference books:**

1. `Science of Engineering Materials’, Vols.1-3, by Manas Chanda, McMillan Company

 of India, Delhi

2. `Principles of Materials Science & Engineering’, William F.Smith, McGraw-Hill

 Publishing Co.

3. `Essentials of Materials Science’ by A.G. Guy.

4. An introduction to corrosion science and engineering By Herbert Uhilig and R. Winston Revie, Published by John Wiley and sons, New York

**CHE 1405 Managerial Economics**

 **(Common for all 1/4 B.Tech and 1/6 B.Tech + M.Tech Branches)**

**3L- 1T- 0P-3C**

**Unit -I**

**Significance of Economics and Managerial Economics:**

**Economics:** Definitions of Economics- Wealth, Welfare and Scarcity definition Classification of Economics- Micro and Micro Economics. **(Two periods)**

**Managerial Economics:** Definition, Nature and Scope of Managerial Economics, Differences between Economics and Managerial Economics, Main areas of Managerial Economics, Managerial Economics with other disciplines. **(Four periods)**

**Demand Analysis :** **Demand -** Definition, Meaning, Nature and types of demand, Demand function, Law of demand - Assumptions and limitations. Exceptional demand curve. **(Two periods)**

**Elasticity of demand** - Definition, Measurement of elasticity, Types of Elasticity ( Price, Income, Cross and Advertisement), Practical importance of Price elasticity of demand, Role of income elasticity in business decisions, Factors governing Price Elasticity of demand. **(Four periods)**

**Demand Forecasting -** Need for Demand forecasting, Factors governing demand forecasting, Methods of demand forecasting: Survey methods- Experts' opinion survey method and consumers Survey methods. **(Four periods)**

**Utility Analysis:** Utility- Meaning, Types of Economic Utilities, Cardinal and Ordinal Utility, Total Utility, Marginal Utility, The law of Diminishing Marginal Utility and its Limitations**. (Two periods)**

**Unit -II**

**Theory of Production and Cost analysis:**

**Production -** Meaning, Production function and its assumptions, use of production function in decision making; Law of Variable Proportions: three stages of the law.         **(Four periods)**

**Cost analysis -** Nature of cost, Classification of costs - Fixed vs. Variable costs, Marginal cost, Controllable vs. Non - Controllable costs, Opportunity cost, Incremental vs. Sunk costs, Explicit vs. Implicit costs, Replacement costs, Historical costs, Urgent vs. Postponable costs, Escapable vs. unavoidable costs, Economies and Diseconomies of scale. **(Four periods)**

**Unit -III**

**Market Structures** : Definition of Market, Classification of markets; Salient features or conditions of different markets - Perfect Competition, Monopoly, Duopoly , Oligopoly, Importance of kinked demand curve ;Monopolistic Competition. **(Four periods)**

**Unit -IV**

**Pricing Analysis** : Pricing - Significance: Different Pricing methods- Cost plus pricing, Target pricing, Marginal cost pricing, Going -rate pricing, Average cost pricing, Peak load pricing , Pricing of joint Products, Pricing over the life cycle of a Product, Skimming pricing Penetration pricing, Mark- up and Mark- down pricing of retailers.

 **(Four periods)**

**Unit -V**

**Business cycles, Inflation and Deflation:**

**Business cycles** - Definition , Characteristics , Phases, Causes and Consequences; Measures to solve problems arising from Business cycles. **(Four periods)**

**Inflation -**Meaning, Types, Demand- pull and Cost push inflation, Effects of Inflation, Anti- inflationary measures. **(Four periods)**

**Deflation-** Meaning, Effects of Deflation, Control of Deflation, Choice between Inflation and Deflation. **(Two periods)**

**Text Books:**

1. Sankaran,S., **Managerial Economics,** Marghan Publications, 2015, Chennai.

2. Aryasri, A.R., **Managerial Economics and Financial Analysis,** MC Graw Hill

 Education, New Delhi,2015.

**Reference Books:**

1. Dwivedi, D.N., **Managerial Economics,** Vikhas Publishing House Pvt. Ltd. 6th

 Edition, New Delhi,2004.

2. Dewett, K.K., **Modern Economic Theory**, S.Chand & Company Ltd., New Delhi,

 2005.

**CHE 1406 Numerical Methods in Chemical Engineering**

**2L- 0T- 3P-2C**

**Objectives:**

The objective of this course is to provide student with

* a sufficient background regarding the applications of computers in Chemical Engineering problems.
* The Knowledge of numerical integration, numerical differentiation, function approximations, solution of linear equations using matrix methods, solution of ordinary differential equations, initial value problems, boundary value problems and solution of partial differential equations by solving number of problems.

**Outcome:**

* Enables students to learn the applications of computers in solving chemical Engineering problems
* Students will be able to solve/write programs for Chemical Engineering problems

**Syllabus:**

**Roots of algebraic and transcendental equations:** Iteration methods, Regula-Falsi method, Newton Rapson method, roots of simultaneous sets of transcendental and algebraic equations,

System of linear equations and their solution by different techniques, numerical differential and integration, regression analysis, least squares and orthogonal polynomial approximation,

Numerical solution of ordinary differential equations,

Numerical solution of partial differential equations (simple case studies),

**Application of the above techniques to problems of interest in Chemical Engineering.**

Hand on experience on *MATLAB* software to solve liner algebraic equations, matrix methods, non liner algebraic equations, ordinary differential equations etc.

Hand on experience on *simulink* software

***Text book:***

1. ‘Digital computation for chemical engineers’ by Leaon Lapidus, McGraw Hill Book Company

***Reference books:***

1. ‘Applied Numerical Methods’ by Camehanet, McGraw Hill Book Co.
2. ‘Applied Numerical Methods with Personal Computers, by Constantinides, McGraw Hill Book Co, New York

**CHE 1407 Environmental Science**

**3L- 0T- 0P-0C**

**OBJECTIVE** : The aim of this course is to make the students better understand the changes in the environment and be given a greater voice and planning conservation through an interdisciplinary environmental science curriculum that is design to enhance scientific enquiry and to strengthen competence.

**OUTCOME** :

1. Understanding various types of pollution regulations and their scientific bases.
2. Apply knowledge for the protection and improvement of the environment.
3. Finally the students can recognize all the major concepts in environmental science and demonstrating in-depth of the environment

**Syllabus:**

**Introduction:** Definition, scope and importance, measuring and defining environmental development – indicators,

**Ecosystems:** Introduction, types, characteristic features, structure and functions of ecosystems – forest, grassland, desert, aquatic (lakes, rivers and estuaries),

**Environmental and natural resources management:** Land resources- land as a resource, common property resources, land degradation, soil erosion and desertification, effects of modern agriculture, fertilizer-pesticide problems,

Forest resources- use and over-exploitation, mining and dams –their effects on forest and tribal people,

Water resources – use and over utilization of surface and ground water, floods, droughts, water logging and salinity, dams-benefits and costs, conflicts over water,

Energy resources- Energy needs, renewable and non-renewable energy sources, use of alternate energy sources, impact of energy use on environment,

**Bio-diversity and its conservation:** Value of bio-diversity- consumptive and productive use, social, ethical, aesthetic and option values, bio-geographical classification of India - India as a mega diversity nation, threats to biodiversity, hot spots, habitat loss, poaching of wild life, loss of species, seeds etc., conservation of biodiversity - in-situ and ex-situ conservation,

**Environmental pollution- local and global issues**: Causes, effects and control measures of air pollution, indoor air pollution, water pollution, soil pollution, marine pollution, noise pollution, solid waste management, composting, vermiculture, urban and industrial wastes, recycling and re-use, nature of thermal pollution and nuclear hazards, global warming, acid rain , ozone depletion,

**Environmental problems in India**: Drinking water, sanitation and public health, effects of activities on the quality of environment, urbanization, transportation, industrialization, green revolution, water scarcity and ground water depletion, controversies on major dams – resettlement and rehabilitation of people: problems and concerns, rain water harvesting, cloud seeding and watershed management,

**Economy and environment**: The economy and environment interaction, economics of development, preservation and conservation, sustainability: theory and practice, limits to growth, equitable use of resources for sustainable lifestyles, environmental impact assessment,

**Social issues and the environment**: Population growth and environment, environmental education, environment movements, environment versus development,

**Institutions and governance**: Regulation by Government, monitoring and enforcement of environmental regulation, environmental Acts, water (prevention and control of pollution) act, air (prevention and control of pollution) act, environment .protection act, wild life protection act, forest conservation act, coastal zone regulations, institutions and policies relating to India, environmental governance,

 **International conventions**: Stockholm conference-1972, Earth summit-1992, World commission for environmental development (WCED),

**Case studies**: Chipko movement, Narmada bachao andolan, Silent valley project, Madhura refinery and Taj mahal, Industrialization of Pattancheru, Nuclear reactor at Nagarjuna sagar, Tehri dam, Ralegaon siddhi (Anna Hazare), Kolleru lake-aquaculture, Fluorosis in Andhra Pradesh,

**Field work**: Visit to a local area to document and mapping environmental assets –river/forest/grass land / hill/ mountain, study of local environment-common plants, insects, birds, study of simple ecosystems – pond, river hill, slopes etc, visits to industries- water treatment plants, effluent treatment plants.

TEXT BOOK:

* 1. Environmental Studies by Anubha Kaushik & C.P. Kaushik

Second Edition, New Age International (P) Limited.

**CHE 1410 Particle & Fluid Particle Processing Lab**

**0L- 0T- 3P-2C**

**List of Experiments:**

1. To take a representative sample from a bulk by two methods, viz. Riffle and cone & quartering and to find out the average size (volume-surface mean diameter) of the samples
2. To determine the grindability index {GI} of coal by hard groove machine
3. To determine the time of grinding in a ball mill for producing a product with 80% passing a given screen
4. To verify the laws of crushing using any size reduction equipment like crushing rolls, ball mill or vibrating mill and to find out the work Index {WI} of the material
5. To compare open circuit and closed circuit grinding by means of a ball mill
6. To determine the optimum time of sieving for a given sample of material
7. To find the effectiveness of hand screening of a given sample by a given screen
8. To find the screen effectiveness of a trommel
9. To separate a mixture of coal into two fractions using sink and float method
10. To separate a mixture of coal into two fractions using froth flotation technique
11. To find the size analysis of a given fine sample using beaker decantation method
12. To separate a mixture of particles by jigging
13. To concentrate a given material by means of tabling
14. To obtain batch sedimentation data and to calculate the minimum thickener area under given conditions
15. To determine the specific cake resistance and filter medium resistance of a slurry in plate and frame filter press.

**CHE 1412 Fluid Mechanics Laboratory**

**0L- 0T- 3P-2C**

 **List of Experiments:**

1. Identification of laminar and turbulent flows (Reynolds apparatus)

2. Measurement of point velocities (Pitot tube)

3. Verification of Bernoulli equation

4. Calibration of rotameter

5. Variation of orifice coefficient with Reynolds number

6. Determination of venturi coefficient

7. Friction losses in fluid flow in pipes

8. Pressure drop in a packed bed for different fluid velocities

9. Pressure drop and void fraction in a fluidized bed

10. To study the coefficient of contraction for a given open orifice

11. To study the coefficient of discharge in a V - notch

12. To study the characteristics of a centrifugal pump

 **3/4 B.Tech(Chemical Engineering) - First Semester**

**&**

**3/6 B.Tech + M.Tech (Chemical Engineering) First Semester**

**CHE 1501 General Chemical Technology**

**3L- 1T- 0P-3C**

**Objectives:**

* To provide the student understanding of importance of chemical process industries over the other manufacturing industries.
* To provide the brief introduction of chemical process equipments, the application of thermodynamics, the chemical process principles, the equipment design and also the corrosion and the safety aspects to consider in the chemical manufacturing processes.
* To provide basic inorganic chemistry background required for the undergraduate students of engineering.
* To provide an overview of chemical properties of inorganic chemicals and the manufacturing processes.
* To provide an overview of applications of materials which the engineers are likely to use during their professional career.

**Outcome:**

* The student learnt the importance of chemical process industries over the other manufacturing industries.
* The student had a brief introduction of chemical process equipments, the application of thermodynamics, the chemical process principles, the equipment design and so on.
* Provided the basic inorganic chemistry background required for the undergraduate students of engineering.
* Provided an overview on chemical process industries.
* Learn the topics “The Fuel and Industrial Gases”.
* Enabled the students to get knowledge on metallurgy.

**Syllabus:**

Water: Sources of water, hardness, treatment for different end uses, municipal water conditioning, industrial waste water treatment.

Sulphur and sulphuric acid: Sources of sulphur-sulphuric acid, different processes of manufacturing-contact process, DCDA process for sulphuric acid manufacture.

Nitrogen industries: Manufacture of ammonia, nitric acid, urea and ammonium nitrate.

Phosphorous and phosphoric acid industries: Methods for production of phosphorous and phosphoric acid, manufacture of super phosphate and triple super phosphate.

Chloro-alkali industries: - Manufacture of soda ash, caustic soda and chlorine.

Cement: Types of cement, manufacture of ordinary portland cement [opc], slag cement.

Fuel and industrial gases: Production of water gas, producer gas and coke oven gas,

production of acetylene, oxygen and nitrogen.

Metallurgy: Manufacture of pig iron, cast iron, methods of making steel, open hearth process, production of aluminium by electrolytic process.

**Textbooks:**

1. “Dryden’s Outlines of Chemical Technology” by M.Gopala Rao & Marshall Sitting (Editors). Affiliated East West Press Pvt. Ltd.
2. “Shreve’s Chemical Process Industries” by G.T.Austin, McGraw Hill Books

**Reference Books:**

1. “ Encyclopedia of Chemical Technology” by R.E.Kirk & D.F.Othmer (Editors)

 Interscience.

**CHE 1502** **Mass Transfer –I**

**3L- 1T- 0P-3C**

**Objectives:**

* To explain the students with the basic principles of mass transfer operations and other separation processes with examples.
* To impart knowledge on how certain substances undergo the physical change with diffusion/mass transfer of components from one phase to other phases.
* To describe the students with equipment used in operations involving mass transfer and other separation processes and their advantages and disadvantages.
* To focus on absorption and distillation operations and the process design aspects of the same operations.
* To provide the knowledge on humidification and dehumidification operations and their applications in real situations

**Outcome:**

* An ability to define the basic principles of mass transfer operations and other separation processes
* An ability to identify the basic techniques for measurement of diffusivity, mass transfer coefficient, evaporation rate,
* An ability to understand the importance of mass transfer phenomena in the design of process equipment in distillation operation
* An ability to understand the VLE concepts and application to different distillations
* An ability to identify the major parts of various mass transfer equipment
* An ability to understand the design of sizing of packed columns in absorption and plate columns in distillation
* An ability to understand the importance of humidification and dehumidification processes and their industrial applications

**Syllabus:**

**Introduction**: Mass transfer Operations.

**Molecular diffusion in fluids:** Binary solutions, Fick’s law, equation of continuity, Steady state equimolal counter current diffusion, Stefan’s diffusion, estimation of diffusivity of gases and liquids, application of molecular diffusion.

**Mass transfer coefficients**: Mass transfer coefficients in turbulent flow, theories of mass transfer, analogy between momentum, heat and mass transfer in laminar and turbulent flow, correlations for mass transfer coefficients in simple situations, diffusion in solids.

**Interphase mass transfer:** Concept of equilibrium, diffusion between phases, two resistance theory, material balances in steady state co-current and counter-current stage processes, Murphy stage efficiency.

**Equipment for gas-liquid operations:** Sparged vessels, mechanically agitated vessels for single phase liquids and gas-liquid mixtures, tray towers, sieve tray for absorption and distillation, venturi scrubbers, spray towers and spray chambers, packed towers for absorption and distillation, tray towers versus packed towers.

**Humidification** **operations:** Definition of fundamental terms, Psychrometric charts, theory of adiabatic saturation and wet bulb temperature, Lewis relation, gas-liquid contact operations, water cooling with air, dehumidification of air-water-vapor mixture, cooling towers, evaporative cooling.

**Absorption: S**olubility’s of gases in liquids, two component systems, multi-component systems, ideal and non-ideal solutions, choice of solvent for absorption, single component absorption material balances, counter current multistage operations, dilute gas mixtures, on-isothermal operation, tray efficiency, continuous contact equipment, HETP, HTU, NTU concepts for single operation absorption with chemical reaction.

**Distillation:** Principles of VLE for binary systems, phase diagrams, relative volatility, ideal solutions, azeotropes, enthalpy concentration diagrams, flash vaporization, partial condensation, differential distillation, steam distillation, continuous distillation, McCabe-Thiele method, Ponchon-Savarit method, tray efficiencies, introduction to multi-component distillation, azeotropic and extractive distillations.

**Text book:**

1. Mass transfer Operations, Robert E. Treybal, 3rd edition, McGraw-Hill Book Co.,

**Reference books:**

1.”Unit Operations in Chemical Engineering” by McCabe,W.L.,Smith,J.C.and Harriot,P., 5th Edition, McGraw-Hill Book Co.,

2. “Chemical Engineering Hand Book” by J.H. Perry.

**CHE 1503 (A) Paper Technology (Core Elective – I)**

**3L- 1T- 0P-3C**

**Objectives:**

To understand the growth prospects of Indian paper mills, history of paper industry, different types, composition and uses of paper, raw materials for paper making, preparation of raw materials, classification of fibers, recovery of cooking chemicals from spent cooking liquors, Pulping processes, manufacture of paper and Testing of different properties of pulp and paper and the types of pollutants from paper industry and their treatment.

**Outcome:**

* Able to know about the history of development of paper industry in India and Importance of paper industry, historical background of paper making.
* Able to learn growth prospects of Indian Paper mills.
* Able to design the equipment used for the manufacture of paper.
* Able to reduce the paper wastes, by proper choice of the equipment, modifications in the design and process parameters to improve the production rate and recovery of use full chemicals.

**Syllabus:**

**History:** Importance of paper industry, historical background of paper making, development of paper industry in India, **Different types and uses of paper**: Different types and uses of papers and paper boards, composition, method of making different types of papers and boards, **Raw materials for paper making:** Classification of fibres, characteristics and composition of some important vegetable fibers (hard woods, softwoods, bagasse, straws, rags and paper stock)**Preparation of raw materials**: Wood preparation – pulp wood measurement, barking, chipping, screening and conveying of chips)**Pulping processes:** Mechanical pulping, alkaline pulping (Soda and Kraft), sulfite pulping, semi-chemical pulping, recovery of cooking chemicals from spent cooking liquors, **Pulp bleaching:** Bleaching agents, bleaching methods – single stage and multi stage bleaching, **Stock preparation**: Beating and refining, sizing and loading (filling),**Manufacture of paper**: Paper machines (Fourdrinier and Cylinder), making of paper – forming section, press section, dryer section, calendaring section, **Testing of different properties of pulp and paper**: Testing and evaluation of pulp, various properties of pulp and paper and their testing.

***Text books:***

*1.*‘Handbook of Pulp and Paper Technology’ by Kenneth W.Britt, Vols.I&II

2.‘Modern Pulp and Paper Making’ edited by John B.Calkin

3***.*** `Pulp and Paper: Science and Technology - Vols.I&II’ by E.Libby, McGraw Hill

 Books Co.

4.‘Pulp and Paper Manufacture- Vols. I & II’ by R.C.McDonald & Others, McGraw Hill

 Books Company.

**CHE 1503 (B) Fertilizer Technology (Core Elective – I)**

**3L- 1T- 0P-3C**

**Objectives:**

* + To introduce various nutrients and their role in growth of a plant
* To introduce different types of the nitrogenous, phosphatic, potassic and compound fertilizers
* To introduce different fertilizer production methods

**Outcome:**

1. Able to know different raw material availability
2. Able to know the beneficiation of rock phosphate
3. Able to know the production of all types of fertilizers
4. Able to formulate different fertilizer mixtures

**Syllabus:**

**Details about indigenous fertilizer production** – raw materials, details of various nutrients with their importance, sources of nitrogen and hydrogen, steam reforming of hydrocarbons, partial oxidation of fuel cells with gas purification including high and low temperature shift conversion, carbondioxide removal processes and methanation.

**Coal gasification,** ammonia synthesis, thermodynamic principles associated with ammonia synthesis, ammonia reactors, nitric acid and sulfuric acid.

**Urea** – total recycle and stripping processes, process details of ammonium sulfate, ammonium chloride, ammonium nitrate, calcium ammonium nitrate.

**Phosphate rock** – availability and beneficiation methods for upgrading, bone meal, basic slag, single super phosphate, triple super phosphate, phosphoric acid by wet process and furnace process, AMI process with hydrochloric acid, complex fertilizers like mono and di-ammonium phosphates, urea ammonium phosphate.

**Text book :**

1. ‘Hand Book of Fertilizers’ published by fertilizer Association of India, New Delhi

**Reference Books :**

1. ‘Chemistry and Technology of Fertilizers’ by V. Sauchelli, Reinhold Publications
2. ‘Fertilizers Manual, a UNIDO Publication from International Fertilizer Development Centre, Alabama, USA.
3. ‘Chemical Technology-II’ published by IIT, Madras.

**CHE 1503 (C) Petroleum Refinery Engineering (Core Elective – I)**

**3L- 1T- 0P-3C**

 **Objective:**

To introduce the basics of refinery engineering subject for petroleum specialization students to gain knowledge of the overall refinery operations, refinery products and its test methods. To learn various primary and secondary cracking process available to produce normal and value added products. Further, to learn the treatment process available to remove the impurities in the crude and finished products and its test methods for quality check.

**Outcome:**

Student gains very basic knowledge which every petroleum specialization student should know to work in the refinery field. Student will learn the importance of quality check and different methods available for quality check. Student learns about various treatment processes available to increase the quality of the product. Student is able to gain complete knowledge on the process available including operating conditions, reaction kinetics, catalyst, products, etc. This knowledge is very helpful for the student to have primary and basic knowledge of the process in advance before delivering the duty as process engineer.

 Origin and formation of Petroleum. Reserves and deposits of the world, Composition of crudes, Refinery introduction and Indian petroleum refining industry scenario.

 Refinery products and test methods, Evaluation of crudes, Crude pretreatment-Dehydration and desalting, Pipe still heater. Atmospheric and Vacuum distillation of crude oil.

 Thermal Conversion Process- Vis Breaking, Delayed Coking.

 Catalytic Conversion Process- Fluid Catalytic Cracking, Hydrocracking, Hydrotreating, Alkylation, Isomerization, Polymerization and Reforming.

 Lube Oil Process – Solvent deasphalting, solvent Extraction, Solvent Dewaxing and Hydro finishing.

 Treatment of kerosene, additives, blending of gasoline, Asphalt and air blown asphalt.

 Textbooks:

1. Petroleum Refining Technology by Dr. Ram Prasad
2. Modern Petroleum Refinery Engineering by B K Bhaskar Rao
3. Gary, J.H., Handwerk, G.E. and Kaiser, M.J. (2007) Petroleum Refining: Technology and Economics. 5th Edition, CRC Press, Boca Raton, 488 p.
4. Petroleum Refining. Vol. 3 Conversion Processes, Pierre Leprince (Editor).

**CHE 1503 (D) Ceramic Raw Materials (Core Elective – I)**

**3L- 1T- 0P-3C**

Ceramic Raw Materials is a vital subject to the Ceramic technology students. It is life and back-bone of the ceramic engineers to become a skilled technician. This will provide knowledge regarding the raw materials which are used in the ceramic industry. Important objectives beyond the incorporation of the paper ‘Ceramic Raw Materials’ are:

**Objectives:**

1. To procure knowledge about the earth
2. To gain knowledge regarding the rocks which are host useful ores.
3. To know about the physical and optical properties of the minerals and ores
4. To gain acquaintance with formation of different raw materials.
5. To collect information about the different types of clays
6. To put on the knowledge regarding other raw materials used in the ceramics
7. To get information regarding the distribution of the deposits

**Outcome:**

1. Will be gained knowledge about the availability of raw materials for ceramics
2. Able to identify the suitable raw materials for the production of good ceramics
3. Be expertise in the selection of raw materials with quality.
4. Will be gained knowledge regarding the different beneficiation techniques through materials can be purified for further process.
5. Acquaintance with chemistry of the different raw materials suchas quartz, feldspar and rheological properties of the different clays

**Syllabus: General geology and minerology**: Formation of rocks, their characteristics, classification into igneous, sedimentary and metamorphic groups, formation of mineral deposits, physical and mineral characteristics of minerals – composition, color, streak, luster, fracture, cleavage, hardness, density and tenacity, elements of optical mineralogy.

**Clays:** Clay minerals, clay structure – kaolinite and montmorillonite groups, geology of clay deposits, their classification - china clay, ball clay, fire clay, building clay etc., beneficiation of clays, mica chlorite, illite group, talc, pyrophyllite, wollastonite group, chemical properties, physical properties.

**Fluxes:** Soda and potash feldspar, other feldspars, nephline syenite, geology of formation, physical and chemical properties, beneficiation.

**Silica and silicate materials:** Silica, polymorphic modification, silica structure, physical and chemical properties of silica, silicate chemistry, minerals, sillimanite, kyanite, and alusite, availability in India and their uses in ceramic industry.

**Other raw materials:** Geology of bauxite, magnesite, dolomite, chrome, limestone, rutile, zircon, beryllia minerals, alumina, carbides, nitrides, properties and uses.

**Textbooks:**

1. ‘Fine Ceramics Technology and Applications‘ by F.H.Norton, McGraw Hill

 Publishers, New York,

2. ‘Ceramic Raw Materials’ by W.E.Worrall, Pergamon press, New York.

**Reference books:**

1. ‘Forming Minerals’ by W.A.Deer, R.A. Howie & J.Rock, Longman Publishers,

 London

2. ‘Properties of Ceramic Raw Materials’ by W.Ryan, Pergamon press, 2nd Edition

3. ‘Clay Mineralogy’ by M.J.Wilson, Chapman & Hall.

**CHE 1503 (E) Fuel Cell Technology (Core Elective – I)**

**3L- 1T- 0P-3C**

1. Introduction – fuel cell; brief history of fuel cells, types of fuel cells and fuel cell applications.
2. Thermodynamics and Electrochemical kinetics – Engineering thermodynamics, conversion efficiencies of heat engines and fuel cells, chemical reactions, chemical thermodynamics and electrochemical kinetics.
3. Fuel cell components and their impact on performance – General design features, fuel cell performance: the MEA and the current/voltage curve, MEA components and the fuel cell stack.
4. Stack design – Sizing of a fuel cell stack, stack configuration, uniform distribution of reactants inside each cell, heat removal from a fuel stack and stack clamping.
5. Fuel cell modeling – Theory and governing equations, modeling domains and modeling examples.
6. Fuel cell system design – Hydrogen-air system, fuel cell systems with fuel processor, electrical subsystems and system efficiency.
7. Fuel cell applications – Transportation applications, stationary power, backup power and fuel cells for small portable power.

Text books:

1. For chapters 1 to 3: Fuel Cell Technology Hand Book, Edited by Gregor Hoogers, CRC Press.

2. For Chapters 4 to 7: PEM Fuel Cells: Theory and practice By Frano, Elsevier Academic Press.

Reference Books:

1. Fuel cells principles and applications by B.Viswanathan and M. Aulice Scibioh, Universal Press. (India) Private Limited, Hyderabad.
2. Fuel Cell Systems Explained, second edition, by James Larminie and Andrew Dicks, John Wiley & Sons Ltd.

**CHE 1503 (F) Polymer Technology (Core Elective – I)**

**3L- 1T- 0P-3C**

**Introductory concepts and fundamentals:** Definitions and concepts of plastics and polymers, comer, co-monomer, mesomer, co-polymer, functionality, visco-elasticity,

Classification of polymers, methods of determining molecular weights of polymers-

1. Methods based on colligative properties
2. Sedimentation velocity method
3. Sedimentation equilibrium method
4. Gel-chromatography method
5. Light scattering analysis method
6. End-group analysis method

Natural polymers- brief study of rubber, shellac, rosin, cellulose, proteins, Lignin’s,

**Chemistry of polymerization:** Elementary concepts of addition polymerization, condensation polymerization and co-polymerization, glass transition temperature of polymers, methods of determining Tg, degradation of polymers due to mechanical, hydrolytic, thermal and backbone effects,

Relation of the mechanical, thermal, electrical, physical and chemical properties with the structure of the polymer,

**Methods of polymerization:** Mass, solution, emulsion and suspension, role of the initiators, catalysts, inhibitors, solvents, fillers, reinforcing agents, stabilizers, plasticizers, lubricants, blowing agents, coupling agents, flame retardants, photo-degradants and bio-degradable on polymerization,

**Methods of manufacture, properties and uses of the following addition products;**

Polyethylene (LDPE and HDPE) , polypropylene, PVC and its copolymers, Polystyrene and its copolymers, acetals and PTFE (polytetraflouroethylene),

**Methods of manufacture, properties and uses of the following condensation products:** (i)Polyesters-PMMA, PET and ALKYO, (ii) PF-, UF- and MF-resins (iii) epoxy resins, polyurethanes and silicones,

**Description of the following processing methods:** (with the principles involved and equipments used) Mixing and compounding, extrusion, calendaring, laminating, moulding-compression, transfer, injection and blow moulding.

***Text books:***

1. `Plastic Materials’ by J.A.Brydson, Newnes-Butterworths (London) 1989
2. `Textbook of Polymer Science’, Billymeyer, F.W.Jr., 3rd edition, John Wiley & Sons,

***Reference books:***

1. ‘Introduction to Plastics’ by J.H.Briston and C.C. Gosselin, Newnes, London
2. ‘Polymeric Materials’ by C.C.Winding and G.D.Hiatt, McGraw-Hill Publishers

**CHE 1503 (G) Intellectual Property Rights (Core Elective – I)**

 **3L- 1T- 0P-3C**

**UNIT-I Introduction to Intellectual Property:**

Historical Perspective, Different Types of IP, agencies and treaties, Importance of protecting IP, international organizations Innovations in products, processes, services and procedures - product life cycles, favorable and unfavorable aspects in innovation; Inventions as intellectual property.

**UNIT-II Patents**

Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Healthcare – balancing promoting innovation with public health, Software patents and their importance for India, Foundation of patents and patent laws, procedures in India and developed countries; study of patents indifferent fields and their innovative content; patent searching process, ownership rights and transfer.

**UNIT-III Copyrights and GI**

**Copyrights:** Introduction, How to obtain a copy right and Law of copy rights: Fundamental of copy right law, originality of material, rights of reproduction, rights to perform the work publicly, copy right ownership issues, copy right registration, notice of copy right, international copy right law, Differences of copyrights from Patents.

**Geographical Indications:** Definition, rules for registration, prevention of illegal exploitation, importance to India.

**UNIT-IV Trademarks and Trade Secrets**

**Trade Marks:** Introduction to trademarks, Purpose and function of trademarks, acquisition of trade mark rights, protectable matter, selecting, and evaluating trade mark, trade mark registration processes.

**Trade Secrets:** Introduction and Historical Perspectives, Scope of Protection, Trade secrete law, Risks involved and legal aspects of Trade Secret Protection, Determination of trade secrete status, liability for misappropriations of trade secrets, protection for submission, trade secrete litigation, Unfair competition: Misappropriation right of publicity, false advertising.

**UNIT-V New developments and Infringement Issues of IP**

**New development of intellectual property:** new developments in trade mark law; copy right law, patent law, intellectual property audits. International overview on intellectual property, international – trade mark law, copy right law, international patent law, and international development in trade secrets law, motivating and encouraging innovative attitude in individuals and organizations; entrepreneurial qualities and skills, learning and training.

**IP Infringement issue and enforcement** – Role of Judiciary, Role of law enforcement agencies – Police, Customs etc. Economic Value of Intellectual Property – Intangible assets and their valuation, Human attitudes, risks, hardships, examples of failure, case studies of inventors; Intellectual Property in the Indian Context – Various laws in India Licensing and technology transfer.

**Reference Books:**

* Ganguli, P. Intellectual Property Rights: Unleashing the Knowledge Economy, Tata McGraw-Hill (2001).
* Intellectual property right, Deborah. E. Bouchoux, Cengage learning.
* Acharya, N.K. Textbook on intellectual property rights, Asia Law House (2001).
* Miller, A.R. & Davis, M.H. Intellectual Property: Patents, Trademarks and Copyright in a Nutshell, West Group Publishers (2000).
* Watal, J. Intellectual property rights in the WTO and developing countries, Oxford University Press, New Delhi.

**CHE 1504 Thermodynamics-II**

**3L- 1T- 0P-3C**

**Objectives:** The course will help to learn about :

1. Solution thermodynamics and Applications
2. Thermodynamic properties and VLE from equations of state
3. Concept of phase equilibrium
4. Concept of reaction equilibrium

**Outcome:**

1. This course helps the students to be proficient in applying thermodynamic principles to various chemical engineering processes involving energy flow.
2. Understand the phase equilibrium.
3. Understand the Chemical reaction equilibrium

**Syllabus :**

**Solution thermodynamics: Theory:** Fundamental property relation, chemical potential as a criterion for phase equilibria, partial properties, ideal gas mixtures, fugacity and fugacity coefficient for a pure species, fugacity and fugacity coefficient for species in solution, generalized correlations for the fugacity coefficients, the ideal solution, excess properties, behaviour of excess properties of liquid mixtures.

**Solution thermodynamics: Applications:** Liquid-phase properties from VLE data, models for the excess Gibbs Energy, property changes of mixing, heat effects of mixing processes.

**VLE at low to moderate pressures:** The nature of equilibrium, the phase rule, Duhem’s theorem, VLE- qualitative behavior, the gamma/phi formulation of VLE, dew point and bubble point calculations, flash calculations, solute (1)/solvent (2) systems.

**Thermodynamic properties and VLE from equations of state:** Properties of fluids from the virial equations of state, properties of fluids from cubic equations of state, fluid properties from correlations of the Pitzer type, VLE from cubic equations of state.

**Topics in phase equilibria:** Equilibrium and stability, liquid/liquid equilibrium(LLE), vapor/liquid/liquid equilibrium(VLLE), solid/liquid equilibrium (SLE), solid/vapor equilibrium (SVE).

**Chemical reaction equillibria:** 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, multi reaction equilibria.

**Thermodynamic analysis of processes:** Calculation of ideal work, lost work, thermodynamic analysis of steady-state flow processes.

***Text book:***

1. `Introduction to Chemical Engineering Thermodynamics’ by J.M.Smith, H.C.Van Ness and M.M.Abbott., 6th Edition, Tata McGraw-Hill Edition 2003

***Reference books:***

* 1. `Chemical Engineering Thermodynamics’ by Y.V.C.Rao, University Press (India) Ltd., Hyderabad 1997

**CHE 1505 Corrosion Engineering (Open Elective-I)**

**3L- 0T- 0P-3C**

**Introduction and scope**: Corrosion definition, wet and dry corrosion, mechanism, electro-chemical principles and aspects of corrosion, Faradays laws, resistance, specific resistance, conductance, specific conductance, transport numbers, ionic mobility, corrosion rate expressions, calculation of corrosion rates, thermodynamic aspects of corrosion, equilibrium potential, Nernst equation for electrode potential, EMF series, over voltage, application of Nernst equation to corrosion reactions,

**Polarisation and corrosion potentials**: References electrodes for corrosion measurements, types of polarisation, concentration, activation and resistance polarizations, Tafel constant, Evans diagrams, anodic control, cathodic control, mixed control, Pourbaix-diagram for Fe-H2O system,

 **Various forms of corrosion: U**niform attack, galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion, selective leaching (dezincification), cavitation damage, fretting corrosion, erosion corrosion, and stress corrosion and remedial measures,

**Prevention techniques:** Modification of the material by alloying, appropriate heat treatment, chemical and mechanical methods of surface treatment, metallic, non-metallic linings, inhibitors, passivity, Cathodic protection and anodic protection.

**Text books:**

1.’Corrosion Engineering’ by Mars G. Fontana, Tata McGraw Hill Publishing Company,

 New Delhi

2.’Corosion and Corrosion Control’ by H.H.Uhllg, John Wiley & Sons Inc., America

**Reference books:**

1.’Electrochemistry’ by Samuel Glasstone, Litton Educational Publishing Company

2.’Electrochemistry, Principles & Applications’ by Edmond C.Potter, Cleaver Hume

 Press Limited.

**CHE 1506 Heat Transfer**

**3L- 1T- 0P-3C**

**Objectives:**

* This course is designed to introduce a basic study of the phenomena of heat to develop methodologies for solving a wide variety of practical engineering problems, and to provide useful information concerning the performance and design of particular systems and processes.
* Conduction: Fourier's law, Thermal Conductivity – its variation with temperature & Pressure and its relationship with electrical conductivity. Heat transfer through composite walls and cylinders.
* To enable the students to learn heat transfer by conduction, convection and radiation and heat transfer equipments like evaporator and heat exchanger
* Radiation: Radiation laws like Stefan Boltzmann’s law, Kirchhoff’s law, Wien’s law, Plank's law etc. Black body, Grey body.
* Transmissivity, Absorptivity, Reflectivity, Emissivity of black bodies and gray bodies. Application of thermal radiation: Radiation Transfer between surfaces. Radiation through semi transparent materials.
* Heat transfer with phase change: Boiling of liquids, Pool boiling curve, different types of pool boiling, condensation of vapor, film wise & drop wise condensation, weighted LMTD & Overall Heat transfer Coefficient for desuperheating & sub cooling.
* Evaporation: Performance of tubular evaporator. Individual & overall Coefficients, Capacity & economy of evaporators. Boiling point elevation, Durhing’s rule, Effect of liquid head & friction on pressure drop, Types of evaporators, Multiple effect evaporators. Vapor recompression, Thermal recompression & mechanical recompression.

 **Outcome:**

* Understand the basic laws of heat transfer.
* Account for the consequence of heat transfer in thermal analyses of engineering systems.
* Analyze problems involving steady state heat conduction in simple geometries
* Develop solutions for transient heat conduction in simple geometries.
* Apply the concepts of heat transfer and associated thermal boundary conditions to transform the physical system into a mathematical model, selecting an appropriate solution technique and evaluating the significance of results.
* Understand various types of heat Transfer equipments
* Understanding of various types of heat transfer process and devices
* Evaluate heat transfer coefficients for natural convection.
* Evaluate heat transfer coefficients for forced convection inside ducts.
* Evaluate heat transfer coefficients for forced convection over exterior surfaces.
* Analyze heat exchanger performance by using the method of log mean temperature difference.
* Analyze heat exchanger performance by using the method of heat exchanger effectiveness.
* Calculate radiation heat transfer between black body surfaces.
* Calculate radiation heat exchange between gray body surfaces.
* Understanding of the basic concepts of conduction, convection and radiation heat transfer,
* Apply the concepts of heat transfer and associated thermal boundary conditions to transform the physical system into a mathematical model, selecting an appropriate solution technique and evaluating the significance of results.

**Syllabus:**

**Nature of heat flow:** Conduction, convection, natural and forced convection, radiation.

**Heat transfer by conduction :** Basic laws of conduction, thermal conductivity; Steady-state conduction – compound resistances in series, heat flow through a cylinder; Unsteady-state conduction – one dimensional heat flow with constant surface temperature, het flow with variable surface temperature, semi-infinite solid;

**Heat transfer by convection:** Principles of heat flow in fluids – Typical heat exchange equipment, countercurrent and parallel flows, energy balances, heat flux and heat transfer coefficients, overall heat transfer coefficients, integration over total surface, LMTD, individual heat transfer coefficients.

**Heat transfer to fluids without phase change :** boundary layers, laminar flow heat transfer, correction for heating and cooling, heat transfer in turbulent flow, estimation of wall temperature, cross-sections other than circular, analogy between transfer of momentum and heat, heat transfer to liquid metals, heating and cooling of fluids outside tubes, natural convection.

**Heat transfer to fluids with phase change:** heat transfer from condensing vapors, heat transfer to boiling liquids.

**Radiation heat transfer:** Fundamental facts concerning radiation, emission of radiation, absorption of radiation by opaque solids, radiation between surfaces, radiation to semitransparent materials, combined heat transfer by conduction-convection-radiation.

**Heat-exchange equipment:** General design of heat exchange equipment, shell and tube heat exchangers, plate-type exchangers, extended surface equipment, heat pipes, scraped-surface exchangers, condensers and vaporizers, heat transfer in agitated vessels, heat transfer in packed beds.

**Evaporation:** Evaporation, types of evaporators, performance of tubular evaporators, multiple-effect evaporators, methods of feeding, vapor compression.

**Text Book:** Unit Operations of Chemical Engineering, ***7***th Ed. by W. L. McCabe, J. C. Smith and P. Harriot, McGraw Hill International Edition, Singapore (2005).

**Reference book:** Process Heat Transfer, by D. Q. Kern, Tata McGraw Hill, New Delhi.

**CHE 1508 Heat Transfer Laboratory**

**0L- 0T- 3P-2C**

**List of Experiments:**

1. Determination of total thermal resistance and thermal conductivity of composite wall.
2. Determination of total thermal resistance and thermal conductivity of Lagged pipe.
3. Determination of the natural convective heat transfer coefficient for a vertical tube.
4. Determination of forced convective heat transfer coefficient for air flowing through a pipe.
5. Determination of over-all heat transfer coefficient in double pipe heat exchanger.
6. Study of the temperature distribution along the length of a pin fin under natural and forced convection conditions.
7. Estimation of unsteady state film heat transfer coefficient between the medium in which the body is cooled.
8. Determination of Stefan-Boltzmann constant.
9. Determination of emissivity of a given plate at various temperatures.
10. Determination of radiation constant of a given surface.
11. Determination of the thermal conductivity of a metal rod.
12. Determination of critical heat flux point for pool boiling of water

**CHE 1510 (A) General Chemical Technology Laboratory**

 **0L- 0T- 3P-2C**

**List of experiments:**

**A. Analysis of water:**

1. Total solids, dissolved solids,pH
2. Chlorides and sulphates
3. Temporary, permanent and total hardness.

**B. Analysis of oils:**

4. Acid value

5. Iodine value

6. Saponification value

**C. Miscellaneous analysis:**

7. Analysis of coal: Proximate analysis

8. Analysis of lime: Estimation of acid insolubles, available lime and

 calcium carbonate

9. Analysis of bleaching powder: Estimation of chlorine content.

10. Analysis of starch/glucose: Estimation of total reducing sugars

11. Analysis of saw dust: Estimation of total cellulose and –cellulose

**E. Miscellaneous preparations:**

12. Preparation of soap

13. Preparation of copper pigment

14. Preparation of chrome yellow pigment

15. Preparation of phenol formaldehyde resin

**CHE 1510 (B) Petroleum Engineering Laboratory**

**0L- 0T- 3P-2C**

**List of experiments:**

1. Evaluation and test methods for crude petroleum

2. Evaluation and test methods for products

3. ASTM distillation

4. TBP distillation

5. Flash and fire points

6. Viscosity index

7. Smoke point

8. Cloud and pour points

9. Carbon residue

10. Aniline point and diesel index

11. Drop point

12. Penetration number

13. Softening point

14. Water content and melting point

15. Demonstration experiments:

16. Extraction in RDC column and catalytic reactors

**CHE 1510 (C) Ceramic Technology Laboratory**

**0L- 0T- 3P-2C**

**List of experiments**:

1. Preparation of ceramic slip in a pot mill
2. Determination of slip specific gravity
3. Determination of slip viscosity
4. Effect of water on viscosity of slip
5. Effect of deflocculant on viscosity of slip
6. Determination of residue in a slip
7. Plaster mould making
8. Making of solid slip cast article
9. Making of drain slip cast article
10. Biscuit firing

**CHE 1512 Slot for MC (Constitution of India)**

**3L- 0T- 0P-0C**

* 1. Meaning of the constitution law and constitutionalism
	2. Historical perspective of the Constitution of India
	3. Salient features and characteristics of the Constitution of India
1. Scheme of the fundamental rights
2. The scheme of the Fundamental Duties and its legal status
3. The Directive Principles of State Policy – Its importance and implementation
4. Federal structure and distribution of legislative and financial powers between

the Union and the States

1. Parliamentary Form of Government in India – The constitution powers and

status of the President of India

1. Amendment of the Constitutional Powers and Procedure
2. The historical perspectives of the constitutional amendments in India
3. Emergency Provisions : National Emergency, President Rule, Financial

Emergency

1. Local Self Government – Constitutional Scheme in India
2. Scheme of the Fundamental Right to Equality
3. Scheme of the Fundamental Right to certain Freedom under Article 19
4. Scope of the Right to Life and Personal Liberty under Article 21.

**3/4 B.Tech(Chemical Engineering) – Second Semester**

**&**

**3/6 B.Tech + M.Tech (Chemical Engineering) Second Semester**

**CHE 1601** **Chemical Reaction Engineering**

**3L- 1T- 0P-4C**

**Introduction** and overview of the subject, kinetics of homogeneous reactions, non elementary reactions, Arrhenius relation, Collision theory and Transition-state theory, various methods of analyses of batch reactor data obtained for various types of reactions including variable volume and variable pressure data .

**Isothermal batch reactor design**, **Homogeneous flow reactors**: Design equation for plug flow reactor (PFR) and continuous stirred tank reactor (CSTR), data analysis in flow reactors, space time, space velocity, recycle reactor, cascade of CSTRs and combination for PFR and CSTR.

**Multiple reactions:** Design for multiple reactions, parallel reactions, series reactions.

**Non-isothermal design**: Energy balance equations for batch, PFR and CSTR under non-isothermal conditions, Equilibrium conversion under adiabatic conditions, Design of the homogeneous reactors under adiabatic conditions.

**Non-ideal flow:** Residence time distribution curves, C ,E and F curves; Interpretation of the response data for the “Dispersion” and “Tanks-in-series” models, calculation of conversion using E data and tanks- in -series model.

**Heterogeneous Catalysis:** Catalyst-properties, calculation of surface area, porosity and pore volume, catalyst preparation methods, promoters, inhibitors and catalyst poisons, physical adsorption & chemisorption, adsorption isotherms, Derivation of rate equations for various mechanisms (Adsorption, surface reaction and desorption controlling etc.,) Data analysis for heterogeneous laboratory catalytic reactors. Isothermal packed bed (PFR) rector design, effectiveness factor and internal pore diffusion, Criteria for internal pore diffusion limitation.

**Text book:**

1‘Chemical Reaction Engineering’ by Octave Levenspiel, 3rd Edition, John Wiley & Sons, 1999

**Reference books**:

1. ‘Elements of Chemical Reaction Engineering’ by H.S.Fogler, 3rd Edition, Printice

 Hall International, 2000

2. ‘Chemical Engineering Kinetics’ by J.M.Smith, 3rd Edition, McGraw Hill, 1981

**CHE 1602 Process Engineering & Economics**

**3L- 1T- 0P-3C**

**Objectives:**

1. To introduce types of interests, annuity, perpetuity, bond, debenture
2. To introduce depreciation and cost accounting methods
3. To introduce cash flow tree diagram, methods of cost estimation.
4. To introduce profitability, profitability evaluation
5. To introduce optimization in industries
6. To introduce economic balance of various operations.

**Outcome:**

1. Able to determine the different types of interests
2. Able to determine time value of annuity, perpetuity, bond and debenture
3. Able to determine depreciation costs and various ratios to tell about financial status of the company
4. Able to determine total cost of the project
5. Able to select an alternate investment using different profitability methods
6. Able to determine different optimum parameters in different operations.

**Syllabus:**

**Value of money - equivalence:** Value of money, equations for economic studies, equivalence, types of interest- discrete and continuous, annuities - relation between ordinary annuity and the periodic payments, continuous cash flow and interest compounding, present worth of an annuity, perpetuities and capitalized costs, bonds and debentures, value of a bond and yield rate,

**Depreciation:** Types and various methods of calculating depreciations, depreciation accounting,

**Cost accounting**: Basic relationship in accounting, balance sheet and income statement, various ratios to study the balance sheet and income statements,

**Cost estimation**: Cash flow for industrial operations, factors affecting investments and production costs, estimation of capital investment, cost indices, cost factors in capital investment, methods of estimating capital investment, estimation of total product cost- manufacturing costs and general expenses,

**Profitability:** Alternate investments and replacements. mathematical methods for profitability evaluation, economic production charts for plants operating below 100%, above 100% and under dumping conditions, general procedure for determining optimum conditions, break even chart for production schedule and its significance for optimum analysis,

**Economic balance** in fluid flow, heat transfer and mass transfer operations; optimum economic pipe diameter in fluid dynamics, optimum flow rate of cooling water in condenser in heat transfer and optimum reflux ratio in distillation operation,

**Economic balance** in cyclic operations and semi continuous cyclic operations, economic balance in yield and recovery, economic balance in chemical reactors, batch and flow reactors.

**Text books**:

1. `Plant Design and Economics for Engineers’ by Max S. Peters and K.D.Timmerhans, McGraw Hill Book Company,
2. `Process Engineering Economics’ by Herbest E. Schweyer, McGraw Hill Book Company.

**CHE 1603 (A) Process Modeling & Simulation (Core Elective-II)**

 **3L- 1T- 0P-3C**

**Objectives:**

* To introduce different types of models along with examples related to chemical engineering
* To instruct how to develop empirical models using different tools and the use of numerical methods for solution of Non- Linear Algebraic equations
* To disseminate the use of different numerical techniques for carrying out numerical integration and differentiation.
* To impart knowledge on modelling of various equipment and their simulation using different numerical techniques.
* To guide selection of the solution method based on the computational requirements of various solution options.
* To elucidate process simulation using modular and equation based solving approaches.

**UNIT I**

**Mathematical models for chemical engineering systems**: classification of mathematical models- steady state vs dynamic models, lumped vs distributed parameter models, deterministic vs stochastic models. **Examples of mathematical models**- Two heated tanks, batch reactor, constant volume CSTRs, non-isothermal CSTR, reactor with mass transfer, ideal binary distillation column, batch distillation with holdup.

**UNIT II**

**Empirical model building**- method of least squares, linear, polynomial and multiple regression, non-Linear regression. **Solution of Non- Linear Algebraic equations**- bisection, false position, Quasi Newton and Newton- Raphson methods.

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**UNIT III**

**Numerical integration**- Trapezoidal rule, Simpson’s rule and Newton– Cotes formula. **Numerical solution of differential equations**- Euler’s method, Runge- Kutta methods, predictor corrector methods.

**UNIT IV**

**Numerical solution of partial differential equations**- elliptic, parabolic and hyperbolic equations, finite difference methods, Leibman’s method, Crank Nicholson method. Applications to steady state and Unsteady state heat conduction and temperature distribution problems.

**UNIT V**

**Process Simulation examples**: VLE dew point and bubble point calculations, binary distillation column, gravity flow tank, batch reactor, Non- isothermal CSTR, countercurrent heat exchanger.

**Process simulation using modular and equation based solving approaches**: Developing a simulation model, a simple flow sheet, Sequential modular approach, Simultaneous modular approach, Equation solving approach.

**TEXTBOOKS:**

1. Process modelling, Simulation and Control for Chemical Engineers, 2nd ed., W. L. Luyben, McGraw-Hill, New York, 1990.
2. Numerical Methods for Engineers, S.K. Gupta, Wiley Eastern, New Delhi, 1995.

**REFERENCE:**

1. Numerical Methods for Engineers and Scientists, S.S. Rao
2. Introduction to Numerical Methods in Chemical Engineering, P. Ahuja, PHI learning Pvt. Ltd., New Delhi, 2010
3. Process Modelling and Simulation, Amiya K. Jana, 2012.

**Course outcomes:**

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

* Classify different types of mathematical models
* Develop mathematical model for the given chemical engineering problem from basic engineering principles.
* Identify the appropriate numerical method for solving a given model.
* Solve ODEs and PDEs using different numerical methods.
* Simulate binary distillation column, gravity flow tank, batch reactor, Non- isothermal CSTR, and counter-current heat exchanger.
* Compare and contrast modular approaches with equation oriented approach

 **CHE 1603 (B) Petrochemicals (Core Elective-II)**

**3L- 1T- 0P-3C**

**Objectives:**

  To make a thorough understanding of the availability of petroleum resources, technical and financial constrains of all the elementary problems. To know the development of petrochemical industries and methodolically furnishes the conversion of petroleum feedstock’s to chemical and intermediates.

**Outcome:**

* Able to know Petrochemical industry-Feedstock, various important Chemicals produced from ethylene and C3, C4 and higher carbon atoms.
* Able to know the structure of Polymer, methods of polymerization, high pressure polyethylene (LDPE), low pressure polyethylene (HDPE),
* Able to know Petroleum aromatics, synthetic fibers, Synthetic rubber, Plastics and Synthetic detergents.
* Able to understand all the production processes and will get an awareness on accidents that are occurring in industries during handling, storage, and manufacturing of chemicals, remedial measures to arrest the accidents immediately.

**Syllabus:**

**Petrochemical industry-Feedstocks:** Petrochemical industry in India, feed stocks for petrochemicals.

**Chemicals from ethylene:** Vinyl chloride monomer, vinylacetate monomer, ethylene oxide, ethylene glycol, acetaldehyde.

**Chemicals from C3,C4 and higher carbon atoms:** Isopropylalcohol, acrylonitrile, acrylic acid, phenol, bisphenol-A, iso and n-butanol, methyltertbutylether, methacrylic acid, malic anhydride.

**Polymers of olefins:** Polymer structure, methods of polymerization, high pressure polyethylene (LDPE), low pressure polyethylene (HDPE), polypropylene, polyvinylchloride, polystyrene.

**Petroleum aromatics:** Benzoic acid, caprolactum, terephthalic acid, phthalic anhydride,

**Synthetic fibres**: Production techniques of synthetic fibres, production of polyester, nylon-6,6, nylon-6, acrylic fibers.

**Synthetic rubber:** Styrene butadiene rubber (SBR), butyl rubber, synthesis of polyurethane.

**Plastics:** Phenol formaldehyde resins, urea formaldehyde resins, polycarbonates.

**Synthetic detergents:** Classification of detergents, general manufacture of sulphonates, keryl benzene sulphonate (Surf).

***Textbook:***

1. `A Text on Petrochemicals’ by B.K.Bhaskara Rao, 3rd Edition, Khanna Publishers, NewDelhi.

***Reference text books:***

1. `Petrochemical processes’, Vol.2, 2nd edition, by A.Chanvel and G. Lefebvre, Gulf publishing company.
2. `Shreve’s chemical process industries’, 5th edition, by George T. Austin, Mc Graw Hill Publishers

 **CHE 1603 (C) White ware And Heavy Clayware (Core Elective - II)**

**3L- 1T- 0P-3C**

**OBJECTIVE:**

The main objective of this subject is: Applications for advanced ceramics have received major media attention in recent years, particularly for use as parts in a future ceramic heat engine. However, corrosion resistance, chemical inertness, thermal shock resistance and other properties that materials scientists and engineers can design into ceramic materials make both traditional and advanced ceramics highly attractive in a large number of applications.

**OUTCOME:**

At the end of the course student will be able to understand

1. Lowering the social cost and risks of waste.
2. Reducing the damage to the environment from waste generation and disposal.
3. Use resources more efficiently.
4. Enhance product design.
5. Include the costs of waste management into the price of products.

**Syllabus:**

**Claassification of whiteware products:** Body formulation and properties, tableware, earthenware talc bodies, vitreous bodies, high alumina bodies, porcelain, bone china, sanitary ware, stoneware, majolica, terracotta, art ware, physical properties of mixtures, role of water.

**Whiteware:** Classification, body composition, white wares at home, construction, electrical appliances, industrial uses, manufacturing and properties.

**Heavy clayware:** Raw materials, methods of winning and handling, classification of building materials, manufacture of building bricks, hollow bricks and other bricks, roof tiles, paving tiles, sewer pipes.

**Fine ceramics:** Packing of two component system, porosity, effect of grain size, unfired porosity, experimental verifications, wet to dry contraction, unfired strength, permeability and casting rate, dry to fired contraction.

**Tests and quality control:** IS inspection, LOI, plasticity, strength, MOR, thermal shock resistance, abrasion resistance, porosity, acid and alkali resistance, chipping resistance, chemical analysis, electrical and thermal conductivity.

**Text books:**

1. ‘Pottery Science: Materials, Processes and Products’ by Allen Dinsdale, Ellis Horwood Ltd., New York,
2. ‘Ceramic White Ware’ by Sudhir Sen, Oxford & IBH Publishing Co., New Delhi

**Reference book:**

1. ‘Industrial Ceramics’ by F. Singer and S. Singer, Oxford & IBH Publishing Company,

 **CHE 1603 (D)** **Computational Fluid Dynamics (Core Elective - II)**

**Numerical solution of ordinary differential equations:** Initial value problems of first order, Runge-Kuta methods, linear multi-step and predictor-corrector methods, R-K method for two simultaneous first order equations,

**Finite difference discretization of first and second derivatives: I**mplementation of finite difference equations, explicit and implicit methods, errors and stability analysis,

**Selected examples for finite difference applications in heat conduction:** Heat dissipation through a constant area fin, two-dimensional steady heat conduction in rectangular geometry, one dimensional transient heat conduction in a slab, Crank-Nicolson method, Thomas algorithm,

**Fundamentals of fluid flow modeling**: Upwind scheme, transportive property, second upwind differencing, hybrid scheme,

**Solution of unsteady Navier-Stokes equations for incompressible flows:** Staggered grid, introduction to MAC method, MAC formulation of momentum balance equation, pressure correction equation,

**Introduction to SIMPLE method**: One-dimensional convection, diffusion equation, formulation of flow problem, discretized continuity and momentum equations, pressure correction equation,

**Concept of finite volume method:** Regular finite volumes, discretization procedure for continuity equation.

**Text Book**:

1. ‘Computational Fluid Flow and Heat Transfer’ 2nd edition by K. Muralidharan and T.

 Sundararajan, Narosa Publishing House, New Delhi, 2003

**Reference book:**

1.‘Computational Fluid Dynamics - The Basics and Applications’ by John D. Anderson,

 Jr., McGraw-Hill Inc., New Delhi, 1995.

 **CHE 1603 (E)** **Multi Component Separation Processes (Core Elective - II)**

**3L- 1T- 0P-3C**

**Multi component vapor –liquid equilibria**: Ideal mixtures at low pressures, non-ideal mixtures, activity coefficient models - Wilson, NRTL, UNIQUAC and UNIFAC equations, evaluation of model constants from binary experimental data, prediction of multicomponenet VLE from the model constants of the constituent binaries,

**High pressure equilibria:** Vaporization constants, K, Thermodynamic method for K, graphical charts, chao-Seader correlation,

**Equilibrium and Simple Distillation**: Multicomponent equilibrium, flash vaporization(EFV), multicomponent differential distillation,

**Design considerations in fractionating process:** Quantitative relationships, temary and multicomponent system fractionation, key fractionation concepts, selecton of key components, column pressure, material balance, rigorous and approximate minimum reflux calculations, recommended short-cut methods for minimum reflux minimum plates at total reflux, FUG methods, Smith Brinkley method,

**Multicomponent fractionation rigorous design procedures**: Sorel method, Lewi Metheson method, Thiele-Geddes method and its versions in distillation column design, techniques of separating azeotropic and close boiling mixtures by fractional distillation, azeotropic and extractive distillation, selection of solvents, design considerations, pseudo binary methods, solvent recovery,

**Tray design and operation**: The common tray types, tray capacity limits, tray hydraulics parameters, flow regies on trays, column sizing, tray efficiency, fundamentals, tray efficiency prediction,

**Packing design and operation**: Packing types, packing hydraulics, comparing packings and trays, packing efficiency and scale-up.

**Text books:**

1. ‘Distillation’ by M.Van Winkle, McGraw Hill Book Company

2. ‘Phase Equilibria in Chemical Engineering’ by S.M.Wales, Butterworth

 publishers, 1985

3. ‘Distillation Design’ by Henery Z Kister, McGraw Hill Book Company

**CHE 1603 (F)** **Chemical Engineering Mathematics** (**Core Elective - II)**

 **3L- 1T- 0P-3C**

*Objectives:*

* To learn various computational techniques for analyzing and solving chemical engineering problems.
* To develop engineering models by integrating the fundamentals of mathematics and computer programming.

*Outcome:*

* Understanding of fundamental Mathematics and to solve problems of algebraic and differential equations, simultaneous equations and partial differential equations.
* Ability to convert problem solving strategies to procedural algorithms and to write program structures.
* Ability to solve engineering problems using computational techniques.

**Syllabus:**

**Mathematical formulation of the physical problems**: i). Application of the law of conservation of mass, salt accumulation in stirred tank, starting an equilibrium still, solvent extraction in N stages, diffusion with chemical reaction and ii). application of the law of conservation of energy, radial heat transfer through a cylindrical conductor, heating a closed kettle, flow of heat from fin,

**Analytical (explicit) solution of ordinary differential equations encountered in Chemical engineering problems:** i). First order differential equations, method of separation of variables, equations solved by integration factors, certain examples involving mass and energy balances and reaction kinetics and ii). second order differential equations, non-linear equations, linear equations, simultaneous diffusion and chemical reaction in a tubular reactor, continuous hydrolysis of tallow in a spray column,

**Partial differential equations:** i). Formulation of partial differential equations, unsteady-state heat conduction in one dimension, mass transfer with axial symmetry, continuity equation, ii). boundary conditions- function specified, derivative specified and mixed conditions and iii). particular solutions of partial differential equation- compounding the independent variable into one variable, superposition of solutions, the method of images and particular solution suggested by the boundary conditions,

**Finite differences:** i). The difference operator, properties of the difference operator, difference tables, other difference operators, ii). linear finite difference equation, complementary solution, particular solution, simultaneous linear difference equations and iii). non-linear finite difference equations, analytical solutions,

**Solutions for the following type of problems by finite difference method:** a). Calculation of the number of plates required for an absorption column, b). calculation of the number of theoretical plates required for distillation column and c). calculation of number of stages required for a counter current extraction and leaching operation,

**Application of statistical methods:** i). Propagation of errors of experimental data, ii). parameter estimation of algebraic equations encountered in heat and mass transfer, kinetics and thermodynamics by method of averages, linear least squares and weighted linear least squares methods and iii). design of experiments - factorial and fractional factorial methods.

**Text book:**

1. ‘Mathematical Methods in Chemical Engineering’ by V.G.Jenson and G.V.Jeffreys, Academic Press, London

**Reference books:**

1. ‘Applied Mathematics in Chemical Engineering’ by Harold S. Mickley, Thomas S.

 Sherwood and Charles E. Reed, Tata McGraw Hill Publications

2. ‘Applied Statistics’ 2nd edition by Volk, W., McGraw Hill Chemical Engg. series

3. ‘Applied Numerical Methods with Personal Computers, by Alkis Constantinides,S.,

 McGraw Hills, Chemical Engineering series, 1987

**CHE 1604 Transport Phenomena**

**3L- 1T- 0P-4C**

***PART-A***

**Momentum transport:** Viscosity and the mechanism of momentum transport- i). Newton’s law of viscosity, ii). Non-Newtonian fluids and iii). pressure and temperature dependence of viscosity,

**Velocity distributions in laminar flow**: i). Shell momentum balances boundary conditions, ii). flow of a falling film, iii). flow through a circular tube and iv). flow through an annulus,

**The equations of change for isothermal systems**: i). The equations of continuity, motion and mechanical energy in rectangular and curvilinear coordinates, ii). use of the equations of change to set up steady flow problems and iii). dimensional analysis of the equations of change,

**Velocity distributions** with more than one independent variable and unsteady viscous flow,

***PART-B***

**Energy transport:** Thermal conductivity and the mechanism of energy transport- i). Fourier’s law of heat conduction and ii). temperature and pressure dependence of thermal conductivity in gases and liquids,

**Temperature distributions in solids and in laminar flow**: i) Shell energy balances-boundary conditions, ii). heat conduction with an electrical heat source, iii). heat conduction with a viscous heat source, iv). heat conduction through composite walls, v). forced convection and vi). free convection,

**The equations** **of change for non-isothermal systems:** i). The equation of energy in rectangular and curvilinear coordinates, ii). the equations of motion for forced and free convection in non-isothermal flow, iii). use of the equations of change to set up steady state heat transfer problems and iv). dimensional analysis of the equations of change,

**Temperature distribution with more than one independent variable**: Unsteady state heat conduction in solids,

***PART-C***

**Mass transport:** Diffusivity and mechanism of mass transport- i). Definitions of concentrations, velocities and mass fluxes, ii). Fick’s law of diffusion and iii). temperature and pressure dependence of mass diffusivity,

**Concentration distribution** in solids and in laminar flow: i). Shell mass balances – boundary conditions, ii). diffusion through a stagnant gas film, iii). diffusion with heterogeneous chemical reaction, iv). diffusion with homogeneous chemical reaction and v). diffusion into a falling liquid film,

**The equations of change** **for multicomponent systems:** i). The equations of continuity for a binary mixture, ii). the equations of continuity of A in curvilinear coordinates and iii). dimensional analysis of the equations of change for a binary isothermal fluid mixture,

**Text book**:

1. ‘Transport Phenomena’ by R. Byron Bird, W.E. Steward and Edwin N. Lightfoot, John

 Wiley & Sons Inc., New York

**Reference books:**

1. ‘Transport phenomena’ by Robert S. Brodkey & Haryr C. Hershey, McGraw Hills

 Company, New Yark

1. Transport Phenomena-for engineers’ byLouis Theodore, International Book

 Compnay, London

1. ‘Transport Phenomena’ by W.J.Book and K.M.K.Multzall, JW&Sons Ltd.
2. ‘Fundamentals of Momentum, Heat and Mass Transfer’ by Mames R Welty, Charlese Wicks and Robert E Wilson, J W & Sons Inc., New York
3. ‘Fluid Dynamics and Heat Transfer’ by James G. Knudsen and Donald L.Katz., McGraw Hills Company Inc., New York.

**CHE 1605 Mass Transfer –II**

**3L- 1T- 0P-3C**

**Objective :** To explore about different mass transfer operations and its applications in industrial scale.

**Outcome:** At the end of the course student would have learnt about the liquid-liquid extraction processes ,leaching, adsorption phenomena, drying, crystallization and different membrane separation process/techniques and their applications.

**SYLLABUS:**

**Liquid-liquid operations: Extraction:** Introduction, liquid-liquid equilibria, analytical and graphical solutions for single and multistage operations, continuous counter current operation without and with reflux, fractional extraction, equipment for liquid-liquid contacting operations, single stage, multistage and continuous contacting equipment,

**Leaching:** Preparation of solid, steady and unsteady state operation, equipment, analytical methods both theoretical and problematic approaches for single and multistage operations,

**Adsorption:** Theory of adsorption, Industrial adsorbents, adsorption equilibria, Freundlich equation, single and multistage operations, unsteady state adsorption, equipment for single stage and continuous contact, ion-exchange,

**Drying:** Equilibria, drying rate curve, batch and continuous drying, time of drying and calculations, mechanism of batch drying, equipment’s for batch and continuous drying operations,

**Crystallization:** Equipment and analytical methods, factors governing nucleation and crystal growth rates, controlled rate of crystals, incorporation of principles into the design of the equipment,

**Less conventional operations:** Dialysis, thermal diffusion, mass diffusion,

**Membrane separation processes**: Separation of gases, separation of liquids, dialysis, membranes for liquid extraction, pervaporation, reverse osmosis.

***Text book:***

1. ‘Mass Transfer Operations’, by Robert E.Treybal, III Edition, McGraw-Hill Book Co.

***Reference books:***

1. ‘Unit Operations in Chemical Engineering’ by McCabe,W.L., Smith, J.C. and Harriot, P., 5th Edition, McGraw-Hill Book Co.
2. ‘Chemical Engineering Hand Book’ by J.H.Perry

**CHE 1606 Nano Science & Technology**

**3L- 0T- 0P-3C**

 **General Introduction:** Basics of quantum mechanics, harmonic oscillator, magnetic phenomena, band structure in solids, Mossbauer and Spectroscopy, optical phenomena bonding in solids, anisotropy,

**Silicon Carbide:** Application of silicon carbide, nano materials preparation, sintering of SiC, X-ray diffraction data, electron microscopy sintering of nano particles, nano particles of alumina and zirconia, nano materials preparation,

characterization, wear materials and nano composites,

 **Mechanical properties**: Strength of nano crystalline SiC, preparation for strength measurements, mechanical properties, magnetic properties,

**Electrical properties**: Switching glasses with nanoparticles, electronic conduction with nano particles,

**Optical properties:** Optical properties, special properties and the coloured glasses

**Process of synthesis of nano powders**, electro deposition, important nano materials,

**Investigaing and manipulating** materials in the nanoscale: Electron microscope, scanning probe microscope, optical microscope for nano science and technology, X-ray diffraction,

**Nanobiology:** Interaction between bimolecules and naoparticle surface, different types of inorganic materials used for the synthesis of hybrid nano-bio assemblies, application of nano in biology, naoprobes for analytical applications - a new methodology in medical diagnostics and biotechnology, current status of nano biotechnology, future perspectives of nanobiology, nanosensors,

**NanoMedicines**: Developing of nano-medicines, nanosytems in use, protocols for nanodrug administration, nanotechnology in diagnostics applications, materials for used in diagnostics and therapeutic applications, molecular nanomechanics, molecular devices, nanotribology, studying tribology at nanoscale, nanotribology applications.

**Text books:**

1. ‘Nano Materials’ by A.K.Bandyopadhyay, New Age Publishers
2. ‘Nano Essentials’by T.Pradeep, TMH.

**CHE 1608 Chemical Reaction Engineering Laboratory**

**0L- 0T- 3P-2C**

1. Determination of the order of a reaction using a batch reactor and analyzing the data by

 (a) differential method and (b) integral method

2. Determination of the activation energy of a reaction using a batch reactor

3. To determine the effect of residence time on conversion and to determine the rate

 constant using a CSTR

4. To determine the specific reaction rate constant of a reaction of a known order using a

 batch reaction.

5. To determine the order of the reaction and the rate constant using a tubular reactor

6. Determination of RTD and dispersion number in a tubular reactor using a tracer

7. Mass transfer with chemical reaction (solid-liquid system) – Determination of mass

 transfer coefficient

8. Axial mixing in a packed bed - Determination of RTD and the dispersion number for a

 packed bed using tracer

9. Langmuir adsorption isotherm - Determination of surface area of activated charcoal.

10. Performance of reactors in series: (i) A plug flow reactor followed by a CSTR and

 (ii) A CSTR followed by a plug flow reactor.

**CHE 1610 Mass Transfer Laboratory**

**0L- 0T- 3P-2C**

**List of Experiments:**

1. Steam distillation
2. Differential distillation
3. Height equivalent to a theoretical plate
4. Vapor-liquid equilibria
5. Determination of liquid diffusion coefficient
6. Determination of vapor diffusion coefficient
7. Surface evaporation
8. Height of a transfer unit
9. Ternary liquid equillibria (Binodal curve)
10. Liquid-liquid equilibria.
11. Limiting flow rates in spray tower
12. Hydrodynamics of perforated plate tower
13. Volumetric mass transfer coefficients in perforated plate tower
14. Dynamics of liquid drops (Single drop extraction tower)
15. Studies of axial mixing characteristics in a packed bed
16. Gas-liquid mass transfer in packed tower
17. Drying characteristics of a given material

**4/4 B.Tech(Chemical Engineering) - First Semester**

**&**

**4/6 B.Tech + M.Tech (Chemical Engineering) First Semester**

**CHE 1701 Process Instrumentation and Control**

**3L- 1T- 0P-4C**

**Objectives:**

To understand how physical quantities are measured and how they are converted to electrical or other forms.

To have an adequate knowledge on various types of instruments.

To study the characteristics of Instruments.

To deal with control equipment and various controllers and their functions and applications. So, in studying this course Chemical Engineering students will come to know the measurement of various process variables and learn the operation of control systems effectively.

**Outcome:**

Understand the measurement techniques for Pressure, Temperature, Flow and Level.

Understand recording, indicating and signaling instruments.

Analyze repeatability, precision and accuracy of instruments.

Able to understand the simple control system and its elements

Study various Controllers like P, P-I ,P-I-D Controllers and its mechanism

Develop transfer functions for Controllers Control systems

Understand the tuning of Controllers

**UNIT-I**

**Qualities of measurement:** The elements of instruments, static and dynamic characteristics, dynamic response of first order and second order instruments.

**Expansion thermometers:** Temperature scales, constant-volume gas thermometer, bimetallic thermometer, pressure spring thermometer, theory of volumetric and pressure thermometers, static accuracy of thermometer, comparison of pressure-spring thermometers.

**Thermoelectric temperature measurement:** Thermoelectricity, industrial thermocouples, thermocouple lead wires, thermal wells, response of thermocouples, the mill voltmeter.

**Resistance thermometers:** Thermal coefficient of resistance, industrial resistance thermometer bulbs, resistance thermometer circuits, null-bridge resistance thermometers, deflectional resistance thermometers.

**Radiation temperature measurement**: Introduction, blackbody devices and radiation receiving elements, radiation pyrometers, photoelectric pyrometers and optical pyrometers.

**UNIT-II**

**Methods of Composition analysis**: Spectroscopic analysis, absorption, Emission and Mass spectroscopy- IR, UV absorption and mass spectrometers, Gas analysis by thermal conductivity, analysis of moisture in gases (humidity), psychrometer method, hygrometer method, dew-point method for moisture analysis in gases, measurement of moisture in paper, textile and lumber.

**UNIT-III**

**Measurement of pressure and vacuum**: Pressure, vacuum and head, liquid column manometers, measuring elements for gauge pressure and vacuum, indicating elements for pressure gauges, measurement of absolute pressure, measurement of pressure in corrosive fluids, static accuracy of pressure gauges.

**Measurement of Head and Level:** Density and specific gravity, direct measurement of liquid level, pressure(level) measurement in open vessels, level measurement in pressure vessels, density measurement, level measurement by weighing.

**UNIT-IV**

Introduction to process dynamics and control, Response of First Order Systems - Physical examples of first order systems.

**UNIT-V**

Response of first order systems in series, higher order systems: Second order and transportation lag.

**UNIT-VI**

Control systems Controllers and final control elements, Block diagram of a chemical rector control system.

Closed loop transfer functions, Transient response of simple control systems.

**UNIT-VII**

Stability Criterion, Routh Test, Root locus. Transient response from root locus, Application of root locus to control systems Introduction to frequency response, Control systems design by frequency response.

**UNIT-VIII**

Advanced control strategies, Cascade control, Feed forward control, ratio control, Smith predictor, dead time compensation, internal model control. Controller tuning and process identification. Control valves.

**Text Books:**

1. Donald P Eckman. Industrial Instrumentation, CBS Publishers, New Delhi, 2004. (For Units I, II, III)

2. D.R. Coughanowr. Process Systems Analysis and Control, Mc Graw Hill, 1991.(For Units IV to VIII)

**Reference books:**

1. Hand Book of Instrumentation and control, Considine.

2. Chemical Process Control, G. Stephanopolous, Prentice Hall, 1984.

**CHE 1702 Chemical Process Equipment Design**

**3L- 1T- 0P-4C**

**Introduction of plant design and costs,**

**Process design development:** Design project procedure, design information from the literature and other sources of information, flow diagrams, preliminary design, comparison of different processes, firm process design, equipment design and specialization, scale up in design, safety factors specifications, materials of construction,

**General design considerations:** Health and safety hazards, fire and explosion hazards, personnel safety, loss prevention, thermal pollution control, noise pollution and control, plant location, plant layout, plant operation and control, utilities, structural design, storage, materials handling, materials and fabrication selection.

**Material transfer, handling and treatment equipment design and costs:** Incompressible fluid flow systems design, flow through parallel, series and piping network systems, compressible fluid flow systems design, design and cost estimation of filters.

**Mechanical design of process equipment:** Design and selection of storage vessels and low pressure vessels, design of roofs, bottom plates, formed heads, flat plate and conical closures, tall vertical columns, supports to process vessels, distillation columns, heat exchanges, evaporators.

**Heat transfer equipment design and costs:** Heat exchangers for sensible heat exchange - double pipe, shell and tube, plate heat exchangers, heat exchangers with extended surface, optimum heat exchanger design, heat exchangers with phase change – single effect evaporators, multiple effect evaporators, vapor recompression evaporators, condensers – condensation of single vapors, condensation with boiling range, reboilers.

**Mass transfer equipment design:** Continuous distillation- design for binary systems and pseudo binary systems for multi component distillation, plate efficiencies, entrainment, approximate column sizing, selection of plate type, plate construction, plate hydraulic design, plate design procedure, plate areas, diameters, liquid flow arrangements, entrainment, weep point weir dimensions, perforated area, hole size, hole pitch, hydraulic gradient, liquid flow, plate pressure drop, down comer design, packed columns - choice of plate or packing, types of packing, packed bed height, prediction of height of transfer unit (HTU) liquid distribution, stimulation of pressure drop in packed towers, allowable velocities, column diameter, column internals, wetting rates, reactor design, equations for reactor design application - batch reactor, tubular flow reactor, back mix reactors expression of reaction rates mechanical features of reactor design.

**Text books:**

 1. ‘Plant design & Economics for Chemical Engineers’, 4th edition, M.S.Peters &

 K.D.Timmerhaus, Mc Graw Hills Publishing Company

2. ‘Process Equipment Design’, 3rd Edition, M.V.Joshi, MacMillan India Ltd 1981

**Reference books:**

1. ‘Process-Plant-Design’ by J.R.Backhurst & J.H.Harker, Heieman Education London

2. ‘Chemical Engineering’ Volume-VI (An introduction to Chemical Engineering

 Design’ by J.M.Coulson & J.F.Richardon

**CHE 1703 (A) Computer Aided Design (Core Elective -III)**

**3L- 1T- 0P-3C**

**Objective:**

To revise the basic concepts in Fluid Mechanics, Heat Transfer, Mass Transfer and Chemical Reaction Engineering and apply the numerical methods with the aid of computer in designing such systems.

**Outcome:**

Able to understand the concept behind the designing of various systems which includes Fluid Mechanics, Heat Transfer, Mass Transfer and Chemical Reaction Engineering. From this course, student gains the knowledge of how to apply the theoretical knowledge gained into practical design of any process; equipment. From this course, student also gains knowledge in terms of application of various numerical methods, correlations and computer applications in designing the equipment. In addition, student is able to know the importance of optimization of the process conditions with the given conditions.

Using the knowledge gained during this course, one can easily start the job as process engineer or design engineer. Student knows the importance of practical aspect of any process. This outcome is very helpful for the student in delivering the job as basic design engineer.

**Syllabus:**

**CAD of fluid flow system:**

Flow of Newtonian fluids in pipes

Pressure drop in compressible flow

Flow of Non-Newtonian fluids in pipes

Pipe network calculations

Two phase flow system,**CAD of Heat transfer equipment:** Shell and tube exchangers without phase change,Condensers, Reboilers,Furnaces,**CAD of Mass transfer equipment:** Distillation,Gas absorption ,Liquid extraction,**CAD of chemical Reactors:** Chemical reaction equilibrium ,Analysis of rate data, Ideal reactor models,Non-ideality in chemical reaction,Performance analysis using residence time distribution,Temperature effects in homogeneous reactors,Heterogeneous systems, Fluidized bed reactors.

**Text Book:** Chemical Process Computations by Raghu Raman.

Elsevier Scientific Publishers, London, 1987

**Ref. Books:**

1. Fundamentals and Modelling of Separation process by C D Holland, rentice Hall Inc. New Jercey, 1975
2. Catalytic Reactor Design by Orhan, Tarhan, Mc Graw Hill, 1983
3. Chemical Engineering, Vol 6 by Sinnot, Pergamon Press, 1993

**CHE 1703 (B) Industrial Pollution And Control Engineering (Core Elective -III)**

 **3L- 1T- 0P-3C**

**Objectives:**

  To understand the types of emissions from chemical industries and their effects on environment, methods of analysis of air pollutants, general methods of control like primary, secondary, tertiary treatment methods, solid waste management and Industrial safety.

**Outcome:**

* Able to know the types of pollution and pollutants, sources of these pollutants from domestic and industrial wastes, permissive and excessive limits of the pollutants and standards of these pollutants especially in drinking water.
* Able to know the sophisticated instruments used for the analysis of water and air pollutants. The student will be having knowledge to design the equipment used for the abatement of these pollutants.
* Able to modernize the solid waste management and acquiring awareness on accidents that are occurring in industries during handling, storage, and manufacturing of chemicals, remedial measures to arrest the accidents immediately.

**Syllabus:**

**Types of emission** from chemical industries and their effects on environment, Environmental legislation, noise pollution, occupational health hazards, meteriological factors in pollution dispersion (ALP and ELP), plume behaviour and characteristics, chimney design considerations: Plume raise, effective stack height,

**Methods of analysis of air pollutants**, particulate matter, SOx, NOx, COx analysis, removal of particulate matters: principles and design of setting chambers, solid traps, cyclone separators, fabric and design of fibre filters, scrubbers and electrostatic precipitators,

**General methods of control** and removal of sulphur dioxide, oxides of nitrogen, organic vapors from gaseous effluents with design aspects, sources of waste waters, effluent guidelines and standards, characterization of effluent streams, oxygen demanding wastes, oxygen sag curve, BOD curve, analysis of water pollutants,

**Methods of primary treatment**: Screening, sedimentation, floatation and neutralization, biological treatment, bacteria and bacterial growth curve, aerobic processes suspended growth processes, activated sludge process, extended aeration, contact stabilization, aerated lagoons and stabilization ponds, attached growth process with design aspects, trickling filters, rotary drum filters, fluidized bed contactors, anaerobic processes,

**Methods of tertiary treatment:** Carbon adsorption, ion exchange, reverse osmosis, ultra filtration, chlorination, ozonation & sonozone process, sludge treatment and disposal,

**Solid waste management**: solid waste collection, transportation, solid waste processing and recovery, hazards in waste management, risk assessment and safety measures, types of hazardous wastes, health effects, safety measures, risk assessment response measures, case studies or pollutants removal and safety measures in fertilizer, petrochemical, paper, pharmaceutical industries and petroleum refinery,

**Industrial safety:** Why safety, accidents, causes and remedial measures, safety aspects of site selection, plant layout and unit plot planning, hazards of commercial chemical operations and reactions, safety aspects of process design, instrumentation for safe operations, safety aspects in design and inspection of pressure vessels, effect of toxic agents, toxicity vs hazards, respiratory hazards, safe experimentation and testing of reactions, materials for safety,

**Flamable materials:** Fire extinguishing agents and their applications, eye safety in chemical processing, personnel protective equipment, permit systems, hazard evaluation techniques, modern safety management systems, safety effectiveness.

**Text books:**

1. ‘Environmental Pollution Control’, by C.S. Rao, Wiley Eastern Limited
2. ‘Safety and Accident Prevention in Chemical Operations’ by Fawcett and Wood

**Reference books:**

1. ‘Environmental Engineering’ by Arcdio P.Sincero and Geogoria Sincero

2. ‘Loss Prevention in Chemical Industries’ by Frank P.Lees

**CHE 1703 (C) Process Optimization (Core Elective -III)**

**3L- 1T- 0P-3C**

**Objective:**

Optimization of Chemical Process is an important of subject for Chemical Engineers. It deals with various optimization techniques in reducing cost of production ,energy consumption, maximum throughput and minimum labour cost etc. Onstudying the course one can understand how to write a model of the process optimize the process using the model

**Outcome:**

 1.Understand the definition of Optimization and how to write an Objective function

 2. Understand various types of Objective functions like Concave and Convex functions and its properties

 3. Study the Optimization of uni and multi dimensional search problems

 4. Solve the Optimization problems by Linear and Non-Linear Programming methods

**Syllabus:**

UNIT I: Definition of optimization Applications of optimization optimal insulation thickness Requirements for an optimization technique, Writing an objective function Production schedule ,material balance requirements , six steps of solving an optimization problem

UNITI I: Basic concepts of optimization continuous and discontinuous , unimodal and multi modal functions concave and convex functions, Finding the optimal point, definition of maximum, minimum and saddle points with examples

UNITIII: Unconstrained unidimensional search , Newton method Quasi Newton method and Secant method, Speed of iterations linear ,order p and super linear, Quadratic interpolation, cubic interpolation, Region elimination method, Fabonacci and Golden section method

UNITIV: Multivariable unconstrained optimization ,direct methods Powell method,Conjugate searchdirection, Gradient and conjugate Gradient, Fletcher Reeves method , Positive definite of Hessian matrix Marquadt method

UNITV: Linear programming ,definition , solving the refinery schedule problem by linear programming method using graph, Simplex method and definition

UNITVI: Non linear programming , Lagrange multiplier method, Iterative linearization and Quadratic programming method, Necessary and sufficient condition for a minimum value ,Kuhn-tucker conditions

Text books:

1. Optimization of Chemical Process by Edgar and Himmelblau, 2nd edition, Mc GrawHill Publications.
2. Optimization Theory and Applications by S.S. Rao, 2nd Edition, Wiley Eastern Limited.
3. Formulation and optimization of Mathematical Models by C.L.Smith, R.W. Pike and P.W.Mur.

**CHE 1703 (D) Reservoir Engineering (Core Elective -III)**

**3L- 1T- 0P-3C**

**Objective**: To know the fundamental concepts of reservoir engineering, basic properties of reservoir rocks, various types of reservoirs and driving mechanisms for the production of Oil and gas from an oil reservoir.

**Outcome**:

1. Able to identify the type of oil reservoirs by knowing the characteristics and mechanisms.
2. Able to predict the reservoir performance by knowing the past performance history of the oil reservoir.

**Syllabus**:

**Fundamental concepts of Reservoir Engineering**: Porosity, fluid saturation, permeability, flow through layered beds, flow through series beds, Klinkenberg effect, effective permeability data, phase behavior.

**Oil reservoirs:** Reservoir driving mechanisms, basic equation and tools, volatile oil reservoirs, identification of volatile oil reservoirs, ultimate recovery, predicting reservoirs behavior, performance, mechanics of reservoir performance, prediction procedure, limitations of predictions, relating reservoir performance to time, factors affecting ultimate recovery, analysis of gas oil ratio history.

**Depletion drive reservoirs**: Producing characteristics and methods of identification, detailed procedure for predicting reservoir performance, limitations of predictions, factors affecting ultimate recovery.

**Water drive reservoirs:** Effect of free gas saturation on recovery, predicting reservoirs performance, calculating water influx, use of the unsteady state equation in predicting reservoir performance, validity of performance prediction, limitations in predicting reservoir performance, the material balance equation as a straight line.

**Gravity drainage reservoirs:** Permeability in the direction dip, dip of the reservoir, reservoir producing rates, oil viscosity, relative permeability characteristics, fundamental recovery process, predicting reservoir performance, apparent relative permeability, oil saturation method.

**Combination of drive reservoirs:** Index of drives, equations used, material balance equations, instantaneous gas- oil ratio equation.

**Pressure maintenance:** Pressure maintenance by gas injection, condensing gas drive, predicting performance by gas injected gas drive index, pressure maintenance by water injection, predicting performance by water injection, index of injected water drive, control of the gas cap, typical water injection pressure maintenance operations.

**Improving oil recovery**: Improving oil recovery by fluid immiscible gas–water, miscible fluid injection thermal oil recovery, predicting recovery from fluid injection products, Stiles’s method of water flood prediction, derivation of water cut and recovery equations, frontal advance techniques for prediction result of either water or gas injection, well arrangements, peripheral water flooding, predicting behavior of peripheral water floods, special consideration involved in water flooding, water flood case history, predicting the results of water flooding.

**Text book:**

1. ‘Reservoir Engineering Manual’ – 2nd Edition by Frank W. Cole, Gulf Publishing

Company, Houstan, Texas, 1969.

**CHE 1703 (E) Fuels, Refractories And Furnaces (Core Elective - III)**

**3L- 1T- 0P-3C**

**Objective:** The main objective of this course is to study the different minerals used for the manufacturing of different types of refractories and its large scale applications in industries**.**

**Outcome:** At the end of the course the students would have learnt about the importance, types of refractories, properties, design and installation and different types of coatings on refractories.

**SYLLABUS:**

INTRODUCTION OF REFRACTORIES

Production, demand and growth of refractories in India – layout of modern refractory plant – fundamental properties of refractories – Indian and international standards – factors for selection and use of refractories – test and quality control procedures.

 SILICA REFRACTORIES

Raw materials and composition – manufacturing process steps – quality of raw materials and process parameter on quartz inversion – glassy phase and other micro structural features – porosity, strength, RUL dependence on micro structure – specifications of silica refractories.

ALUMINA – SILICA REFRACTORIES

Al2O3 – SiO2 phase diagram – clay, pyrophyllite, sillimanite, grog, bauxite and diaspore as raw materials – manufacturing processes – micro structure and properties

BASIC PROPERTIES

Magnesite, forsterite, dolomite and chrome based refractories – raw materials and composition – manufacturing processes – micro structure and properties.

SPECIAL REFRACTORIES

Oxide based, carbide based and nitride based refractories – cordierite – zirconia – carbon – fusion cast refractories, slide gate, purging refractories, and continuous casting refractories – ceramic fibres.

 REFRACTORIES FOR IRON AND STEEL INDUSTRY

Coke oven, blast furnace, twin hearth, LD converter – continuous casting – electric arc furnace, induction furnaces – reheating furnaces – slide plate system – nozzle, shroud/ SDN – ladle and tundish lining practices – monolithic - gunning techniques – refractor, slag and metal interactions.

REFRACTORIES FOR CEMENT AND NON FERROUS INDUSTRY

Wet/ dry process for cement making – preheater and pre calcinatory and zone lining – alkali and wear resistance – refractory requirement and use in copper, aluminum and hydro carbon industry – use of monolithic.

REFRACTORIES FOR GLASS INDUSTRY

Design of glass tank for container, sheet, lamp, float glasses, refractory practices in side wall, throat, forehearth, and roof of glass tanks – regenerator systems – alumina and AZS fused cast refractories – glass corrosion resistance, oxidation, seed potential tests – glass defects and analysis – feeder expendables

REFRACTORIES FOR CERAMIC INDUSTRY

Kiln furniture – types – properties of requirement - silicon carbide, mullite, corderite, alumina, zirconia – mullite, zirconia types – kiln design – LTM concept – fast firing technology

REFRACTORIES FOR ENERGY CONSERVATION

Insulation refractories – types- ceramic fiber product – design and installation – ceramic coatings – case studies in ceramic fiber usage.

**Textbook:**

1. B. M. Coop and E. M Piekson, Raw Materials for the refractory industries and industry materials and consumer survey, 1981.

**References**

1. J. H. Eheslers Refracrtories: production and Properties. Iron and Steel Institute, London, 1972.

2. Akira Nistrikawa, Technology of monolithic refractories, Plibrico japan co. Tokyo 1984

3. D.N. Nandi, Hand Book Refractory’s, Tata Mc Graw hill publishing Co. New Delhi 1991

4. K.Shaw, Refractories and thick uses ADP sciences publisher U K 1972

5. Keishi GOTON, Powder Technology Hand Book, Marcel Dekker Inc. 1997

**6.**Chester J.H., Steel Plant Refractories, 2nd Edition, 1973, United Steel Companies Limited, Sheffield UK8.Advances in Refractory Technology, Ed. Robert E Fisher, Ceramic Transaction Vol 4., American Ceramic society, 1990, Westerville, Ohio, USA.

**CHE 1703 (F) Biochemical Engineering (Core Elective - III)**

 **3L- 1T- 0P-3C**

**Syllabus:**

**Introduction to Biochemical engineering and Biotechnology**: Overall view of biotechnology since its practice–to date, enzyme kinetics, derivation of M.M. equation of single as well as multiple substrates, enzyme inhibition, determination of M.M. parameters, industrial applications of enzymes,

**Cell cultivation & kinetics**: Microbial, animal and plant cell cultivation, cell immobilization, batch growth of cells, yield coefficient, monod growth kinetics,

**Analysis and design of fermenters**: Batch fermenter, mixed flow fermenter (chemostat), plug flow fermenter, mixed flow fermenters in series, and cell recycling,

**Genetic engineering**: DNA and RNA, cloning of genes, stability of recombinant microorganisms, gene manipulation,

**Sterilization**: Sterilization of media and air, thermal death kinetics, design criterion, continuous sterilization methods,

**Aeration and agitation in fermenters**: Correlations of mass transfer coefficient, measurement of interfacial area and gas holdup, power consumption, scale up concepts,

**Bioanalytical techniques**: Gas chromatography, thin layer and paper chromatography, HPLC, affinity, gel, adsorption and ion exchange chromatography.

**Text book:**

1. ‘Biochemical Engineering Fundamentals’ 2nd edition by J.E.Bailey and D.F.Ollis,

 McGraw-Hill Publishers, Newyork, 1986

**Reference books:**

1. ‘Chemical Engineering’ volume-3, 3rd Edition by J.F Richardson and D.G. peacock, (Chapter-5: Biochemical Reaction Engineering), Pergomon Press, U.K, 1994
2. ‘Bioprocess Engineering: Basic Concepts’ 2nd edition by M.L.Shuler and F.Kargi, Prentice Hall India, New Delhi, 2003

3. ‘Biochemical engineering’ by D.G. Rao, Tata McGraw-Hill Publishers, New Delhi,

4. ‘Biochemical Engineering’ by J.M. Lee, Prentice Hall, Englewood Clifts, 1992.

**CHE 1704 Industrial Management and Entrepreneurship**

 **(Common for all 1/4 B.Tech and 1/6 B.Tech + M.Tech Branches)**

**3L- 1T- 0P-3C**

**Unit-I**

**Basic Concepts of Management :**

**Management :-** Definition, Nature and Importance ; Functions of the Management; Levels of Management; F.W Taylor's Scientific Management; Henry Fayol's Principles of Management;  **( Eight Periods)**

**Unit-II**

**Forms of Business Organizations:** Introduction, **Types of Business organizations:**  **Private Sector**- Individual Ownership , Partnership, Joint stock companies and Co-Operative organizations**; Public sector**- Departmental Organizations, Public Corporations and Government Companies; The Joint sector Management.                    **( Eight periods)**

**Unit-III**

**Production and operations Management:** Plant location- Factors to be considered in the selection of Plant location; Break - even analysis- Significance and managerial applications; Importance of Production Planning and Control and its Functions; Human Resource Management and Functions of Human Resource Manager (in brief); Functions of Marketing; Methods of Raising Finance.         **(Ten periods)**

**Unit-IV**

**Entrepreneurship :** Definition, Characteristics and Skills , Types of Entrepreneurs, Entrepreneur vs. Professional Managers, , Growth of Entrepreneurs, Nature and Importance of Entrepreneurs, Women Entrepreneurs, Problems of Entrepreneurship.         **(Six periods )**

**Unit-V**

**Entrepreneurial Development and Project Management:** Institutions in aid of Entrepreneurship Development, Idea generation: Sources and Techniques;, Stages in Project formulation ; Steps for starting a small enterprise - Incentives for Small Scale Industries by Government.   **(Eight periods )**

**Text Books:**

(1 ) Sharma,S.C, and Banga, T.R., **Industrial Organization & Engineering Economics**, Khanna

 Publishers, Delhi, 2000.

(2) Vasant Desai , **The Dynamics of Entrepreneurial Development and Management (Planning**

 **for future Sustainable growth),** HImalayan Publishing House, 2018.

**Reference Books:**

 (1) Aryasri , A.R., **Management Science,** McGraw HIll Education (India Private Limited , New

 Delhi 2014.

(2) Sheela, P. , and Jagadeswara Rao, K., **Entrepreneurship**, Shree Publishing House, Guntur,

 Andhra Pradesh, 2017.

**CHE 1705 (A) Industrial Safety & Management (Open Elective-III)**

**3L- 0T- 0P-3C**

**Introduction :** Industrial Safety, Incident, accident, near miss, hazard, risk, emergency, disasters, risk criteria, Safety at work.

**Pediction and evaluation of unsafe conditions :**

Identification of unsafe areas, unsafe acts, manifestation of unsafe conditions to emergency situation, lessons from accidents and disasters, safety audit and its elements, safety in plant layout, equipment design. Construction, erection, commissioning, material handling.

**Hazards** – chemical hazards, thermodynamic hazards, electrical & electromagnetic hazards, mechanical hazards.

**Risk** – Definition, causes, potential and adverse effects.

**Hazard Analysis** – incident scenarios, residual risk, Concept Hazard Analysis (CHA), Preliminary Process Hazard Analysis PPHA, HAZOP, Fault Tree Analysis (FTA), Event Tree Analysis (ETA).

**Risk Assessment** – Risk criteria, causes of death/damage, individual risk, societal risk, criteria for acceptable risk tolerable risk, application of risk assessment, computation of fatality rates, severity rates, vulnerability analysis, introduction to computerized risk assessment techniques.

**Safety Management (General)** – safety policy perceptions, safety organization, safety audit techniques, project and **Construction Safety** – welding & cutting operations, fabrication, material handling, equipment spacing, safe plant layout procedures, storage tanks, erection & commissioning works, housekeeping methods, maintenance of storage yards, erection & maintenance of electrical panels and MCC rooms, electrical & mechanical safe guarding.

**Emergency Preparedness** – onsite & offsite emergency preparedness, emergency preparedness plans, site specific action plans and contingency plans, emergency facilities, rehabilitation & rescue operations, post emergency actions.

**Safety Management (Industry Specific)**

Chemical Manufacturing Plants, Fertilisers, Steel Plants, Petrochemical Plants, Metallurgical Plants, Mineral Process Industries, Sugar plants, semiconductor industry, Polymer manufacturing plans, Paper industry, Pharmaceutical and bulk drug industries, Vessel manufacturing industry, LPG bottling plants, Power Plants, tanneries and textiles.

**Statutory framework** – key provisions of Factories Act, Environmental Protection Act, Manufacture, Storage and Import of Hazardous Chemical rules, Static and Mobile Pressure Vessels rules, NFPA specifications, OSHA regulations.

**Occupational health management** – occupational health perspectives, pre-employment & periodical medical examinations, diseases, causes, consequences, **Occupational health hazards in various industries** – aluminium industry, asbestos, battery manufacturing, sugar, cement, coke ovens, cotton ginning, dairy, electro plating, fish canning, poultries, irrigation, lead smelting, mining, pesticides, power plants, refineries, pulp & paper industry, PVC processing, steel plants, fertilizers, sulphuric acid plants, tanneries and textiles.

**International standards** – British council’s five star rating systems, International Safety Rating Systems (ISRS), ISO 14001 EMS, ISO 18001 OHSAS, BIS 14489 Code of Conduct for conducting safety audits.

**Prescribed books:**

* 1. “Hazards in Chemical industries, 3rd edition” – Authored by Frank P.Lees
	2. “Hazard identification and risk assessment” – Authored by Geoff Wells ; Published by Institution of Chemical Engineers, Davis Building, 165-189 Railway Terrace, Rugby, Warwickshire CV21 3HQ, UK.

References

* + 1. “Safety Management 5th edition” – Authored by John V. Grimaldi and Rollin H. Simonds; Published by A.I.T.B.S. Publishers & Distributors, J-5/6, Krishna Nagar, Delhi – 110051.

“Environmental Health and Safety Management” – Authored by Nicholas P. Cheremisinoff and Madelyn L. Graffia; Published by Jaico Publishing House, Hyderabad.

**CHE 1705 (B) Environmental Pollution Control (Open Elective-III)**

**3L- 0T- 0P-3C**

**Objectives:**

  To understand the types of emissions from chemical industries and their effects on environment, methods of analysis of air pollutants, general methods of control like primary, secondary, tertiary treatment methods, solid waste management and Industrial safety.

**Outcome:**

* Able to know the types of pollution and pollutants, sources of these pollutants from domestic and industrial wastes, permissive and excessive limits of the pollutants and standards of these pollutants especially in drinking water.
* Able to know the sophisticated instruments used for the analysis of water and air pollutants. The student will be having knowledge to design the equipment used for the abatement of these pollutants.
* Able to modernize the solid waste management and acquiring awareness on accidents that are occurring in industries during handling, storage, and manufacturing of chemicals, remedial measures to arrest the accidents immediately.

**Syllabus:**

**Types of emission** from chemical industries and their effects on environment, Environmental legislation, noise pollution, occupational health hazards, meteriological factors in pollution dispersion (ALP and ELP), plume behaviour and characteristics, chimney design considerations: Plume raise, effective stack height,

**Methods of analysis of air pollutants**, particulate matter, SOx, NOx, COx analysis, removal of particulate matters: principles and design of setting chambers, solid traps, cyclone separators, fabric and design of fibre filters, scrubbers and electrostatic precipitators,

**General methods of control** and removal of sulphur dioxide, oxides of nitrogen, organic vapors from gaseous effluents with design aspects, sources of waste waters, effluent guidelines and standards, characterization of effluent streams, oxygen demanding wastes, oxygen sag curve, BOD curve, analysis of water pollutants,

**Methods of primary treatment**: Screening, sedimentation, floatation and neutralization, biological treatment, bacteria and bacterial growth curve, aerobic processes suspended growth processes, activated sludge process, extended aeration, contact stabilization, aerated lagoons and stabilization ponds, attached growth process with design aspects, trickling filters, rotary drum filters, fluidized bed contactors, anaerobic processes,

**Methods of tertiary treatment:** Carbon adsorption, ion exchange, reverse osmosis, ultra filtration, chlorination, ozonation & sonozone process, sludge treatment and disposal,

**Solid waste management**: solid waste collection, transportation, solid waste processing and recovery, hazards in waste management, risk assessment and safety measures, types of hazardous wastes, health effects, safety measures, risk assessment response measures, case studies or pollutants removal and safety measures in fertilizer, petrochemical, paper, pharmaceutical industries and petroleum refinery,

**Text books:**

1. ‘Environmental Pollution Control’, by C.S. Rao, Wiley Eastern Limited

**Reference books:**

1. ‘Environmental Engineering’ by Arcdio P.Sincero and Geogoria Sincero

**CHE 1708 Process Instrumentation & Control** **Laboratory**

**0L- 0T- 3P-2C**

1. Response of mercury-in glass thermometer
2. Response of mercury-in glass thermometer with thermal well.
3. Calibration & response of resistance thermometer
4. Response of manometer
5. Calibration of thermocouples
6. Response of single-tank liquid level system
7. Response of two-tank non-interacting liquid level system
8. Response of two tank interacting liquid level system
9. Study of on-off control – Control let off position.
10. Valve characteristics of equal % control valve
11. Valve characteristics of linear control valve
12. On-off control – controller on position
13. Studies on hysteresis characteristics of Bourdon pressure gauze
14. Hysteresis characteristics of equal % control valve
15. Studies on hysteresis characteristics of linear control valve
16. Response studies for different types of controller (P, PI, PID) using PID control trainer.
17. Level control trainer
18. Pressure control trainer
19. Temperature control trainer

**CHE 1710 Chemical Process Equipment Design Laboratory**

(**Open book practical examination**)

**0L- 0T- 3P-2C**

The following equipment are to be designed in detail:

1. Sensible heat exchangers (1-2 or 2-4),

2. Condenser and reboiler,

3. Multiple effect evaporator,

4. Fractionating column-Plate and packed columns,

5. Packed bed absorber,

6. Continuous tubular reactor (homogeneous and heterogeneous)

**4/4 B.Tech(Chemical Engineering) Second Semester**

**&**

**4/6 B.Tech + M.Tech (Chemical Engineering) Second Semester**

**CHE 1801 Project Work**

**0L- 0T- 0P-12C**

The project work should consist of a comprehensive design of a chemical plant in the form of a report with the following chapters.

1. Introduction
2. Physical and chemical properties and uses
3. Literature survey for different processes
4. Selection of the process
5. Material and energy balances
6. Specific equipment design (Process as well as mechanical design with drawings)
7. General equipment specifications
8. Plant location and layout
9. Materials of construction
10. Health and safety factors
11. Preliminary cost estimation
12. References