Syllabus
B. Tech. Chemical Engineering and Chemical Technology (Plastics, Paint, Oil and Food)

IInd Year (Semester- III and IV)

(With effect from 2015-16)

NAAC Re- Accredited
B (CGPA 2.88)

Faculty of Engineering and Technology
North Maharashtra University, Jalgaon

BSL-201 Mathematics-II

Theory: 04 Hrs. / week **Teaching Hours: 03**
Total Credits (Theory): 04 **Tutorial:01**

Course Prerequisites:
Mathematics-I & Mathematics-II courses of H.S.C. and BSL-101 (Mathematics-I) course of F. Y. B. Tech. (Chemical Engineering & Technology).

Course Objective:
a) To make aware students about the importance and symbiosis between Mathematics and Engineering.
b) To develop the ability of mathematical modelling of systems using differential equations and ability to solve the differential equations.
c) To introduce the concept of Vector differentiation and integration that finds applications in solid mechanics, fluid flow, heat problems and potential theory etc.
d) To introduce the concepts of Laplace Transforms and its applications to various problems related to engineering and technology.
e) To develop the knowledge of probability theory, various distributions and their properties.

Course Content:

Unit-I: Linear Differential Equations with Constant Coefficients
Introduction to n^{th} order Linear Differential Equation, Auxiliary Equation, Complementary Function, Solution of L.D.E using General Method, Particular Integral using Short Cut Methods, Solution of 2^{nd} order L.D.E using Method of Variation of Parameters, Solution of Cauchy's D.E., Solution of Legendre's D.E. (10)

Unit-II: Multiple Integrals and its Applications
Introduction to three Co-ordinate Systems, Double integration, Change of order of integration, Application to Area & Volumes (10)

Unit-III: Laplace Transform
Definition and Existence of Laplace transforms, Laplace Transform of Elementary/Standard functions, Properties & Theorems of Laplace Transform (without proof), Problems based on Properties & Theorems of Laplace Transform, Definition and Properties of Inverse Laplace Transform, Inverse Laplace Transform of Some Standard Functions, Problems based on Properties of Inverse Laplace Transform, Partial Fraction, Convolution Theorem, Applications to the Solution of L.D.E. (10)

Unit-IV: Vector Calculus
Definition and Physical meaning of Vector differentiation, Tangential and Normal Components of Acceleration, Vector Differential Operator Del, Gradient of Scalar Point Function, Directional Derivative of Scalar Point Function, Divergence and Curl of Vector Point Function, Solenoidal and Irrotational Vector Fields, Vector integration: Line Integral, Surface and Volume integrals, Gauss's, Stoke's and Green's Theorems (without proof). (10)

Unit-V: Statistics and Probability Distributions
Introduction to Mean, Median, Mode, Standard Deviation, Variance, Coefficient of Variation, Moments, Skewness and Kurtosis, Correlation and Regression, Binominal Distribution, Poisson Distribution, Normal Distribution. (10)

Reference Books:

1) B. S. Grewal, 'Higher Engineering Mathematics', Khanna Publishers, Delhi.
2) H. K. Dass, 'Advanced Engineering Mathematics', S. Chand Publication, New Delhi.
3) Erwin Kreyszig, 'Advanced Engineering Mathematics', Wiley Eastern Ltd.
4) Wylie C. R. & Barrett - Advanced Engineering Mathematics - Mc Graw Hill.

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

a) Apply knowledge of mathematics in engineering and technology.
b) Draw the rough sketch of Cartesian and polar curves.
c) To find the velocity and acceleration of a particle moving along a space curve.
d) To apply partial fraction expansion to simplify a transform function for inverse Laplace transformation.
e) To use shift theorems to compute the Laplace transform, inverse Laplace transform and the solutions of second order, linear equations with constant coefficients.
f) To use the knowledge of multiple integrals in finding the area and volume of any region bounded by the given curves.
g) To calculate the gradients and directional derivatives of functions of several variables.
h) Apply various probability distributions to solve practical problems.

BSC 202 Organic Chemistry-II

Theory: 04 Hrs/Week **Teaching Hours: 03**
Total Credits: 04 **Tutorial: 01**

Course Prerequisite:
BSC-102, Organic Chemistry-I course have to study in F.Y. B. Tech. (Chemical Engg. and Chemical Technology).

Course Objectives:
1. To develop the arts and culture of organic chemical reactions and its significance in chemical and technology process industry.
2. To study how chemical reactions takes place differently in different environments ie, reaction mechanism.
3. To study and apply the basic reactions mechanism to design synthesis of some classes of molecules.
4. To study industrially important chemical reactions, substrates and some reagents.
5. To study interconvertion of functional group and their applications.
6. To study methods of determination of structure of molecules.

Course Content:
Unit-I
Aromatic Molecules: Huckel's rule of aromatic molecules, different classes of aromatic molecules, resonance, resonance energy.
Aromatic Electrophilic Substitution bimolecular reactions (ArSE2 reactions): Mechanism of ArSE2 reaction, Orientation of ArSE2 reaction in monosubtituted benzene ring, Mechanism and application of Friedel-Craft's alkylation, acylation, Formylation reactions like Reimer-Tiemann reaction, Gattermann-Koch reaction and Vilsmeier-Haak reaction**.** (08)

Unit-II
Amino aromatics: Preparation-Benzyne mechanism, reduction of nitro aromatics, Properties- basic nature and applications.
Diazonium Salts: Preparation-diazotization reaction, Chemical properties and reactions such as Coupling-Synthesis of azo dyes and Replacement- Sandmeyer reaction and deamination. Ullman reaction and Benzidine rearrangement reaction. (08)

Unit-III
Reaction Mechanism: Mechanism of Mannich's reaction, Blank Chloromethylation Claisen rearrangement and Kolbe's electrolysis.
Sulphonic acids: Preparation-Mechanism of sulphonation, Sulphonation in Naphthalene-Effect of temperature on sulphonation and applications such as solubalizing and blocking agent. (08)

Unit-IV

Nitro aromatics: Preparation-Nitration, reduction reaction. ArSE2 reaction-halogenation, nitration and sulphonation. **Heterocyclic Compounds:** Preparation-important methods and ArSE2 reactions such as Nitration, sulphonation, halogenations, acylation, mercuration, metallation of Furan, Thiophene, Pyrrole and Pyridine. (08)

Unit-V

Spectroscopy: Basic principle and application of IR spectroscopy to functional group identification of organic molecules. Basic principle and application of UV and ^{1}H NMR spectroscopy to structure determination of small molecules. (10)

Reference Book:

1. Organic Chemistry by Morrison & Boyd
2. Reaction Mechanism by Singh and Mukherji
3. Organic Chemistry by S. H. Pine
4. Organic Chemistry-Vol I & II by I. L. Finar
5. Organic Chemistry by Bahl and Tuli
6. Organic Spectroscopy by P. S. Kalsi
7. Organic Spectroscopy by Y. R. Sharma

Course Outcomes:

1. Students completing this course will have clear basic concepts of different classes of organic molecules, their important reactions and functional group interconvertions.

2. They would know how organic reactions are takes place, how to design the desired product and factors to take care of it.

3. They will understand how to apply different concepts of reactions to workup/separation of product, to improve yields and to study structure of molecules.

4. This course provides the knowledge of organic concept to undergraduate engineering students, and is designed to strengthen the fundamentals so that they can build their own interface of applied organic chemistry concept with their industrial applications in the branch of chemical engineering and Technology.

BSC 202 Organic Chemistry Practical-II (PR)

Practical: 03 Hrs/Week **Credit: 1.5**

Course Prerequisite:

BSC-102, Organic Chemistry-I Practical course have to study in F.Y. B. Tech. (Chemical Engg. and Chemical Technology).

Course Objectives:

1. To develop the arts and culture of organic chemical reactions and its significance in chemical and Technology process industry.
2. To study how chemical reactions takes place differently in different environments ie, reaction mechanism.

Course Content:

Qualitative analysis of organic binary mixture: Identifications of an organic compound through

1. Type of Determination
2. Elemental analysis,
3. Physical constant (m.p./b.p.)
4. Functional group determination (minimum 06)

Quantitative analysis of organic compound : Organic Estimation and Determinations (Minimum 2)

Reference Book:

1. Organic Qualitative Analysis and Separation — Kulkarni and Pathak
2. Practical Chemistry — Prof. R. B .Gujrathi, Prof V. S. Zope
3. Practical Chemistry — Prof. R. B .Gujrathi ,Prof .A .P. Rajput

Course Outcomes:

1. Students completing this course will have clear basic concepts of different classes of organic molecules, their important reactions with developed laboratory skill and awareness.
2. Students completing this course will have basic concepts in preservation of environment by adaptation of Green Chemistry concepts.

3. This course provides the knowledge of organic concept to undergraduate engineering students, and is designed to strengthen the fundamentals so that they can build their own interface of applied organic chemistry concept with their industrial applications in the branch of chemical engineering and Technology.

ESL–201 : Applied & Structural Mechanics

Theory – 4 Hour/Week **Credits – 4**

Course Pre-requisite:

Physics, Mathematics and Engineering Graphics

Course Objective:

The general objective of the course is to know the concept of statics and dynamics In Applied & Structural Mechanics Course, Students will get familiar with the basic Concepts in Structural Mechanics like Forces, Columns, Beams, Trusses, Laws of Friction, Various types of Stress & Strains, Shear Force & Bending Moment Diagrams, Torsion, Transmission of Power & Dynamics of the Various Entities. Students will also get familiar with different Tools, Machines & Equipments in the Structural Mechanics. Besides this Student will also have a Hands-on Experience in Solving the Real Life Problems.

Course Contents:

Unit - I

Coplanar forces, Equivalent system, Conditions of equilibrium. Support reactions for determination of beams & trusses. Forces in members of pin joined plane trusses. Forces in cables & simple mechanisms. Centroid & center of gravity.

Friction: Laws of friction, Problem on block friction, wedge friction, belt friction & screw friction. (Excluding rolling pivot & journal friction). (10)

Unit – II

Various types of stress & strains. Relation between elastic constants. Introduction to temperature stresses. Problems on simple & composite sections, Concept of shear stress distribution. Concept of slope & deflection of beam. Standard cases of slope & deflection by Moment-area Method & mathematical method. Simple problems. (10)

Unit – III

Shear force & Bending moment diagrams for cantilever & simply supported beams (with or without overhang). Theory of bending: Concept & problems. Thin & thick cylinders. Problems on thin cylinders & spheres. (10)

Unit – IV

Torsion of a circular shaft. Transmission of Power-Close coiled Helical spring. Concept & derivation only. Simple problems. Short & long columns & struts. Standard cases with axial load. Euler's & Rankin's formulae. (Without Derivations) (10)

Unit – V

Dynamics: Kinetics of particles & rigid bodies - Force, mass & acceleration. Kinetics of particles & rigid bodies - Work & Energy., Kinetics of particles & rigid bodies - Impulse & momentum. (10)

Reference Books

1. Applied Mechanics & Strength of Materials: I. B. Prasad
2. A text Book of Engineering Mechanics: R. S. Khurmi
3. Strength of Material: Ramamurtham
4. Strength of Materials: R S Khurmi

Course Outcomes:

1. Able to understand basic concept in structural mechanics like forces, column, beams, trusses, law of friction and various types of stresses and strains.
2. To know about shear forces and bending moment diagrams, torsion, transmission of power and dynamics of various entities.

ESP–201 Applied & Structural Mechanics

Laboratory – 3 Hour/Week **Credits – 1.5**

Course Pre-requisite:

Knowledge of Physics, Mathematics and Engineering Graphics

Course Objective:

1. To make the students acquaint with basic concepts in structural mechanics like forces, column, beams, trusses, law of friction and various types of stresses and strains.
2. To perform the experiments on the basis of course contents.

Course Contents:

1. Law of Parallegram
2. Law of Polygon
3. Reactions in Beam, both Simply Supported & Overrunning
4. Banding Moment Apparatus
5. Chain Link Apparatus
6. Simple Lifting Machines - Screw Jack, Wheel & axle
7. Modulus of Rigidity
8. Roof Truss Apparatus

Course Outcomes:

1. Able to understand basic concept in Applied and structural mechanics
2. Knowledge about technological use of forces, column, beams, trusses, law of friction and various types of stresses and strains.

ESL-202 Material Technology Theory

Theory:-4 Hr. /week **Total Credits (Theory:-4.0)**

Course Prerequisite:

The background expected includes a prior knowledge of physics and Chemistry from HSC (science) and familiarity with various laws, principles and theories.

Course Objectives:

The objective of this course is to provide learner basic concepts and knowledge of Material sciences (various principles, theories, laws etc.) The learner can apply the same in Chemical Engineering and Technology.

Course Contents:

Unit – I

Classification of solids (Amorphous, crystalline, polycrystalline), Space lattice, Bravais Lattices, Miller Indices, Inter planar distances, Co-ordination number, Packing fraction, Planer density, Laws of crystallography, X- Ray Diffraction by Crystal, Bragg's Law (with simple numericals on Bragg's Equation) Imperfections in Crystals. (10)

Unit – II

Classification of engineering materials, Equilibrium diagrams, Hume-Rothery's rules of solid solubility, Solidification of pure metal, critical size of nucleus, Polymorphism,

Gibb's phase rule, Phase diagrams of important alloy systems such as steels, brasses, cupronickel, Lever rule, applications of phase diagrams. (10)

Unit – III

Heat treatment of steels: Annealing, Normalising, Tempering, Hardening, Carburizing, Nitriding, Carbonitriding, Tufftriding, Induction hardening etc.

Mechanical properties of solids such as plastic deformation, Mechanism of plastic deformation-slip, twinning, modulus of elasticity, tensile strength, toughness, elongation, plastic deformation, Schmid's law creep, requirement for creep resistance material, fracture, fatigue. (10)

Unit – IV

Thermosetting and thermoplastics, structure-property relationships in polymers, elastomers, wood, graphite, ceramics, Electrical, Ferroelectrical, and Piezo electrical properties of ceramics, cermets.

Composite materials-dispersion reinforced composites, laminated composites, fiber reinforced composites, loading under isostrain and isostress condition. (10)

Unit – V

Corrosion: Electrochemical principles, mechanisms, Formation and Growth of film, Growth Laws, polarization, Types of corrosion, prevention and control. Protective coatings, Application of inhibitors. Corrosion behavior of important alloys. Criteria for selection of materials for chemical industries. (10)

Reference Books:

1. Material Science and Engineering Metallurgy: V D Kodgire.
2. Material Science: G.B.S. Narang.
3. Material Science: O P Khanna.
4. Engineering Metallurgy and Material Science: S.P. Nayak.
5. Material Science: Raghavan.
6. Material Science: Hazra Chaudhari.
7. Principles of Material Science and Engineering: William F. Smith
8. Material Science-Tata MC-GrawHill Publication, V. Rajendran, R. A. Maricani.
9. Material Science and Engineering an Introduction, William D. Callister, David G. Rethwisch. WILEY Publications.

Course Outcomes:

After successful completion of this course the student will be able to:

a) To acquaint students with the basic concepts and properties of Material Science.
b) To impart a fundamental knowledge of Materials Processing, Selection and application of different Metals & Alloys.
c) To understand the structure of Engineering Materials.
d) To develop futuristic insight into Materials.

CHL-201 Introduction to Chemical Engineering

Theory: 4 Hrs/ Week **Credit: 4**

Prerequisite courses: Organic Chemistry, Physical Chemistry

Course Objectives:

To introduce the history, importance, current scenario in chemical, allied process industries and to impart the knowledge about unit operations & unit processes in chemical engineering, basic concepts in heat, mass & momentum transfer, safety engineering, various acts & rules from industrial point of view.

Course Contents:

Unit I

Definition of chemical engineering (AIChE), History of chemical engineering, Introduction: Unit operations, units and dimensions, role of chemical engineer in chemical industry, Symbol of various unit operations. (10)

Unit II

Introduction: Equipments used in chemical industry, Plant utility line diagram for various chemical processes. Basic laws: Newtons law, Ideal gas law, Raults law, Boyls law, Daltons law, Henrys law, Pascals law. (10)

Unit III

Basics fundamentals and application of heat, mass & momentum transfer, Introduction to different modes of heat transfer (conduction, convection, radiation) and heat exchangers, Introduction to mass transfer (diffusion, absorption, adsorption, distillation, extraction, crystallization and drying), Introduction to momentum transfer: various fluids and fluid properties, fittings, valves, pumps and compressors. (10)

Unit IV

Safety Management: -General Principles of Management, Need for safety – Humanitarian, economics, Legal & Social considerations, Role of management in Industrial Safety. Safety Management – Principle & practices.

Definitions: -Incident, Accident, Injury, dangerous occurrences, Unsafe acts, Unsafe conditions / hazards. Principles of accident prevention – theories / models of accident causation.

Safety Education & Training: -Elements of training cycle, employees participation, safety promotions & publicity. Safety suggestion scheme, safety competitions, Safety incentives scheme. Audiovisuals methods.

Safety Engineering: Principles, incidental safety devices.

Safety at work station & Plant layout: Plant layout & work station design, Improving safety & Productivity through plant layout & work station designs. Technical & engineering control measures. Preventive maintenance in safety. Importance of standards & codes of practices for plant & equipment. (10)

Unit V

Acts & Rules:

The Factories Act 1948 & Factories rule 1963: Safety related provision. ESI & Workmen compensation Act & rules. Indian Boiler Act & Regulations, Explosive Act, Petroleum Act, Gas Cylinder Rules, SMPV Rules. Environment Protection Act – Water & Air Act, MSIHC rules.

Regulation laws for quality control & environment protection Laws and definition of ISO 14000, ISO 18000, cGMP guidelines (10)

Referance Books:

1. Introduction to Chemical engg.by Bredger and branzo
2. Unit process and unit operation by Drydon
3. Industrial safety / Safety Management. K.G. Mistry
4. Safety Management, Grimaldi and Siemans.
5. IS 14489 on safety Audit.
6. Factories Act 1948.

Course Outcome:

a) To understand the history, importance & current scenario of chemical engineering.
b) The students should get well acquainted with unit operations & unit processes in chemical engineering before facing these subjects in depth in the following years.
c) To clear the basic concepts of students about units, dimensions & various parameters in heat, mass & momentum transfer.
d) To make students aware about importance of safety when they actually entered in their professional life.
e) The get the students well acquainted with various rules & regulations, industrial standards in chemical engineering.

CHC-202 Mechanical Operation

Theory- 4 Hour/ Week, **Credits – 4**

Prerequisite courses: Mathematics,

Course Objective:

To understand basic principles of various mechanical operations, construction and working of the equipment's.

Course Contents:

Unit- I

Properties & Handling of Particulate Solids: Particle size, shape; mixed particle size & size analysis, specific surface of mixture, average particle size; properties of particulate masses; storage of solids. types of conveyers, elevators & their design. Size Reduction: Size reduction equipments for coarse, intermediate & fine size reduction; energy & power requirement; open & closed loop circuit. (10)

Unit - II

Screening: Equipment, ideal screen. Screen analysis methods & std. screen series; capacity & effectiveness of screen. Mixing of Solids & Pastes: Mixers for coasive solids,
free flowing solids, paste & plastic masses, power requirement, mixing effectiveness by mixing index calculation, rate of mixing. Mixing & Agitation of Liquids: Agitation equipment & flow pattern; circulation velocities & power consumption in agitated vessel; blending & mixing. (10)

Unit -III

Flow Past Immersed Bodies: Drag coefficient, Stokes law, Cozeny- Carman equation. Flow of Solids Through Fluids: Maximum settling velocity, free & hindered settling conditions. Fluidization: Minimum fluidization velocity, types of fluidization, application of fluidization in catalytic cracking, drying, etc.; fixed bed, spouted bed system. (10)

Unit - IV

Classification & Sedimentation: Clarification & thickening, separation ratio; equipment for centrifugal & gravity classification; cyclone separator & design; hydrocyclones; principle of jigging, tabling, magnetic & electrostatic separation. Gravity sedimentation; laboratory batch & continuous sedimentation, centrifugal sedimentation.

(10)

Unit -V

Filtration: Filter aids, classification of filters, selection of filter media. Principle of batch filtration: constant pressure & constant rate filtration, factors affecting filtration. Continuous, centrifugal, vacuum, gravity filtration & related equipments. Washing of filter cake. (10)

Reference Books:

1. Mc Cabe W. L. & Smith J. C. " Unit Operation for Chemical Engg." 5th Edt.
2. Coulson J. M. & Rechardson J. F. " Chemical Engg.- Vol. II"
3. Badger W. L. & Banchero J. T. " Introduction to Chemical Engg."
4 Narayan & Bhatacharya " Mechanical Operation In Chemical Engg."
5 P. Chattopadhaya " Unit Operation In Chemical Engg. Vol. I "
6. G. G. Brown " Unit Operations"

Course Outcome:

a) Ability to define the properties of solid and to select suitable size reduction equipment
b) Ability to analyse mixing processes and solid-solid separation method
c) Ability to understand fluid particle system, solid liquid separation process.
d) Understanding of fluidized beds

CHC-202 Mechanical Operation Lab

Laboratory 3 Hour/ Week, Credits – 1.5

Course Objective:

To understand basic principles of various mechanical operations, construction and working of the equipment's.

Course Contents:

Minimum 8 Experiments based on 1. Grinding efficiency, 2. Law of crushing, 3. sieve analysis, 4. Efficiency of screening, 5. Sedimentation, 6. filtration, 7. Cyclone separators, 8. Fluidisation, 9. Mixing etc., 10. Stock law and 11. Properties of solids.

Course Outcome:

a) Ability to calculate the properties of solid
b) Analysis of the performance of size reduction equipment
c) Ability to analyse separation process for solid liquid system.
d) Ability to analyse separation process for Gas solid system.

CHC-203 Momentum Transfer

Theory- 4 Hour/ Week Credits – 4

Prerequisite courses:

Knowledge of Mathematics and Physics taught in first year

Course Objectives:

To provide the in depth knowledge of the fluid mechanics along with basic principles in the subject like properties of fluids, pressure measurement, hydrostatics, kinematics of flow, dynamics of flow, types of flows, dimensional analysis, boundary layer & handling of fluids in order to enhance the knowledge from industrial point of view.

Course Contents:

Unit I

Fluid Properties : Definition of fluid. Viscosity concept, properties of fluid like mass, density, specific weight, specific volume, vapour pressure, compressibility, elasticity, surface tension and capillarity. Types of fluids, Compressible and incompressible, Newtonian and Non-Newtonian

Pressure measurement: Fluid Pressure at a point, Pascal's Law, Hydrostatic Equilibrium, Atmospheric, Gauge, Absolute and Vacuum Pressure. Measurement of pressure.
Hydrostatics: Total Pressure and Centre of pressure, Total pressure on a plane surface, Buoyancy, Buoyant Force, Centre of Buoyancy , Metacentre and Metacentric height, Stability of floating and submerged bodies. (10)

Unit II
Kinematics of Flow**:** Velocity concept, Types of flows **(**Laminar-turbulent, steady-unsteady, two and three-dimensional flows, Uniform –Non uniform, Rotational – Irrotational Flows.) Continuity Equation. Acceleration concept.
Dynamics of Flow: Nature and mechanism of fluid flow, Euler's equation of motion Bernoulli's equation for different conditions. Applications of Bernoulli's Equations to Flow measurement (Flow meters)
Momentum changes in fluid in a bend, Notches and Weirs. (10)

Unit III
Flow Through Pipeline System: Reynold's Experiment, Laws of Friction, Major Losses, and Friction factor chart, Effect of heat transfer on friction factor, Minor losses. Distribution of flowing fluids through branched pipes. Hydraulic Gradient Line and Total Energy Line.
Laminar Flow: steady laminar flow in circular pipes (Hagen Poiseuille equation), through annulus, parallel plates, around a sphere (Stoke's law), relations between shear and pressure gradient, average velocity and maximum velocity, momentum correction factor.

Turbulent flow: velocity distribution in turbulent flow in pipes, hydro dynamically smooth and rough boundaries, velocity distribution equation in turbulent flow in terms of mean velocity for smooth and rough pipes, resistance to flow of fluid in smooth and rough pipes, variation of frictional factor for commercial pipes, types of problems in pipes designs. (10)

Unit IV
Boundary Layer Theory: The thickness of boundary layer Boundary Layer growth along a thin flat plate (definition and formulae only). boundary layer equations laminar and turbulent boundary lever , Boundary layer in straight tubes, Boundary layer on rough surfaces, Separation of Boundary Layer, Methods of controlling the Boundary layer.
Dimensional Analysis: Dimensional Analysis, fundamental dimensions, units of various quantities used in fluid mechanics. Buckingham's Pi theorem. Dimensionless numbers, application to fluid flow problems. (10)

Unit V
Pumping of fluids : Pumping equipments for liquid. The reciprocating pump, positive displacement, Rotarypumps, Centrifugal pumps, design and operating characteristics, NPSH calculations, Air lift pump.
Pumping Equipment for gases: Reciprocating piston compressors, Rotary blowers and compressor, Centrifugal blowers and compressor including turbo compressor, vacuum producing equipments.
Power required for Compression of gases: Clearance volume, multi-stage Compressor efficiency. The power requirement for pumping through pipeline for liquids and gases. (10)

REFERENCE BOOKS:

1. Momentum Transfer : Vyas.
2. Momentum Transport Operations: Gupta.
3. Hydraulics and fluid mechanics : Dr. P.N. Modi & S.M.Seth
4. Unit Operation : P. Chattopadyaya
5. Fluid Mechanics: R.K. Bansal

Course Outcome:
a) To enhance the knowledge about fluid properties, behaviour of fluid under different conditions, hydrostatics & pressure measurement by various means.
b) The students should get well acquainted with basic principles in kinematics & dynamics of fluid flow with its application.
c) To clear the basic concepts of students about various types of flows, complexities in flow through pipeline systems with detail study of laminar, turbulent flow.

d) The students should get well acquainted with phenomena of boundary layer formation and separation. Also to understand the dimensional analysis and its application to solve the complex problems in heat & momentum transfer.
e) The get the students well acquainted with handling of fluids, to get them introduce with various pumps, compressors, blowers and power requirement in it and to enhance the ability of students to identify and solve various engineering problems.

CHC-203 Momentum Transfer Lab

Laboratory 3 Hour/ Week, Credits – 1.5

1. Determination viscosity
2. Study of different types of manometers.
3. Verification of Bernoulli's Theorem
4. Venturimeter.
5. Orificemeter
6. Notch or Weirs
7. Study of flow through pipe fittings
8. Verification of Darcy's law.
9. Characteristics of Centrifugal pump.
10. Flow of gases through pipes (Study of Friction factor versus Reynolds' number)
11. Reynolds' Experiment
12. Study of different types of compressors (Minimum Eight experiments

Course Outcome:
To enhance the knowledge and clear the theoretical concepts in the subject by performing the hands on experiments in the laboratory for detail understanding of the topic.

CHL-204 Process Calculation

Theory- 4 Hour/ Week, Credits – 4

Prerequisite courses: Mathematics, Organic Chemistry, Physical Chemistry

Course Objective:
To understand and apply the fundamentals of calculations related to material and energy balance in the unit operations and unit processes mostly used in Chemical Industry.

Course Contents:
Unit I
Units and dimension: Basic and derived units, dimensional analysis, dimensional and empirical equations, different ways of expressing units of quantities and physical constants. Properties of gases, liquids and solids: Ideal and real gas laws, critical properties, properties of mixtures and solutions and equilibrium. (10)

Unit II
Stoichiometry and unit operations:
Introduction to unit operation and material balance, blending, evaporation, crystallization, extraction and leaching, distillation, absorption & stripping, drying. (10)

Unit III
Material balance involving chemical reaction
Introduction, definition of terms, material balance for chemical reactions concept of limiting & excess component. (10)

Unit IV

Humidity & energy Balance

Humidity: terms, Humidity charts, and problems,

Energy balance: heat of reaction, combustion of formation, heat capacity & effect of pressure and temperature, heat capacity of gaseous mixture .energy balance for system. (10)

Unit V

Recycle: Bypass operation & Material balance for them.

Combustion: Introduction, fuels, C.V. of fuels combustion calculation. (10)

Reference Books:

1. Chemical Process Principles : O.A. Hougen, K.M. Watson, R.A. Regalz.
2. Industrial Stoichiometry : W.K. Levis, A.H. Radash, H.C. Lewis.
3. Process Calculations for Chemical Engineering : Durgaprasad Rao, D.V.S. Murthy.
4. Stoichiometry: Bhatt and Vora
5. Process Calculations : Himmablue
6. Process Calculation: S. L. Pandharipande

Course Outcome:

a) Ability to perform basic calculation for gases base on PVT relationship.
b) Ability to make mass and component balance on unit operations and processes.
c) Ability to perform simultaneous material and energy balances.
d) Understanding of the concept of humidity and related terminologies of Humidification operation.
e) Hands on Recycle, Bypass and Purge operation problems.
f) Understanding Combustion operation and related problems.

CHL-205 Chemical Engineering Thermodynamics

Theory- 4 Hour/ Week, **Credits 4**

Prerequisite courses:

Knowledge of Mathematics, Organic Chemistry, Physical Chemistry subjects

Course Objective:

The objective of this course is to introduce the basic laws of thermodynamics and to clear the concept of phase equilibrium and chemical equilibrium.

Course Contents:

Unit I

Basic concepts of thermodynamics like temperature, energy & Zeroth law.

First Law of Thermodynamics: Thermodynamic analysis of control volume & Steady- state flow processes, concept of work & enthalpy.

Second law of Thermodynamics: Kelvin Planck & Clausius statements, Introduction & efficiency calculation to heat engine, heat pumps, Refrigeration cycle & Carnot cycle. Concept of entropy, calculation for entropy changes. Third law. (10)

Unit II

Properties of Pure Substances: T-V, P-V, P-T diagram. Ideal gas law, compressibility factor, principle of corresponding state, Van der waals equation, Viral equation, Redlich Kwong equation, Redlich Kwong Soave equation of state, generalized correlations.

P-V-T relation for isothermal, isobaric, isochoric, adiabatic & polytropic processes. (10)

Unit III

General Thermodynamic Property Relations: Residual properties Mathematical preliminaries on partial derivatives & associated relations, reciprocity & cyclic relations: The Maxwell relations, Gibbs & Helmotz relations, the Clapeyron equation. The general relations for du, dh, Cv, & Cp; Mayer relation.

Isothermal compressibility, volume expansivity, coefficient of linear expansion, adiabatic compressibility & adiabatic bulk modulus.The Joule Thomson coefficient. (10)

Unit IV

Solution Thermodynamics& Phase Equilibria: Chemical potential, partial molar properties, Gibbs/Duhem equation, ideal gas mixtures, Kay's rule, real gas mixtures, fugacity coefficient for pure substances & for species in solution, generalized correlation for fugacity, ideal gas solution, excess properties, activity & Data reduction for VLE system (low pressure), Consistency test, models for the excess energy like Margulus equation Van Laar equation & Wilson equation, etc.

Dew point & Bubble point calculations for VLE system (low to moderate pressure), modified Roult's law. (10)

Unit V

Chemical Equillibrium: Chemical equilibrium criteria, Equillibrium constant for ideal & real gas mixtures, chemical equillibria for simultaneous reactions, Effect of temperature on equilibrium constant, various factors affecting equilibrium constant. (10)

Reference Books:

1. Introduction to Chemical Engg. Thermodynamics Fifth Edition by J.M.Smith
2. Fundamentals of Engg. Thermodynamics, by E.Rathakrishnan
3. Thermodynamics – An Engg. Approach, Third Edition by Yunus A. Cengel & Michale A. Boles.
4. Chemical Engg. Thermodynamics by Y.V.C.Rao.
5. Chemical Engg Thermodynamics by Daubert.

Course Outcomes:

Upon successful completion of this course the student will be able to:

a) Understand the basic concepts of various laws of thermodynamics.
b) Explain the concept of Heat engines, Entropy and enthalpy.
c) Understand the concept of Phase equilibria.
d) Understand the concept of Chemical equilibria.

CHC – 206 Heat Transfer

Theory- 4 Hour/ Week **Credits – 4**

Prerequisite courses: Mathematics

Course Objective:

The objective of this course is to provide basic knowledge of various modes of heat transfer and detail design knowledge of various heat exchangers and evaporators.

Course Contents:

Unit I

Concept of heat transfer and transport of heat,Fouriers law significance of thermal conductivity of solid liquid and gases, heat transfer trough plane &composite wall, sphere and cylinder, problem related to this cases

Differential equation of heat conduction, lagging of pipes and other equipment, optimum lagging thickens, critical radius of insulation. Heat transfer from extended surfaces (fins), fin effectiveness. (10)

Unit Ii

Convection: Individual and overall heat transfer coefficients. natural and forced convection, laminar and turbulent flow, significance of dimensional numbers, dimensional analysis and heat transfer analogy , Flimwise and dropwise

condensation, Problem based on film wise condensation and dropwise condensation. (10)

UNIT III

Concept of condensation and boiling, their types, condensation from horizontal and inclined surface, Nussult equation. Evaporation : Heat transfer to vaporization processes. Single and multiple effect evaporations. B.P.R. and hydrostatic head, Economy and capacity of evaporator. Problem based on single effect evaporator. (10)

UNIT IV

Radiation : laws of radiation, radiation from solid surfaces types of surfaces. Heat exchange by radiation between two finite black surfaces, between two infinite parallel surfaces, shape factor. Laws of shape factor, Solid angle and radiation intensity, Green house effect. Electrical analogy of radiation shield. (10)

Unit V

Heat Exchangers: classification overall heat transfer coefficient, fouling factor LMTD in single pass parallel, counter and cross-flow arrangements. N.T.U – effectiveness method for parallel and counter flow heat exchangers general Design aspect of heat exchangers. Problem based on LMTD AND NTU effectiveness method. (10)

Reference Books:

1. Engineering Heat Transfer : Gupta & Prakash
2. Problem on Heat Transfer : P. Chattopadhya
3. Heat Transfer : D. S. Pavaskar
4. A text book of Heat Transfer : Sukhatme S.P.
5. Chemical Engineering Vol. 1 and 2 : Richradson & Coulson
6. Principles of Heat and Mass Transfer : S. D. Davande

Course Outcomes:

Upon successful completion of this course the student will be able to:

a) Understand the basic knowledge of various modes of heat transfer like conduction, convection and radiation.

b) Design shell and tube heat exchanger and single effect evaporator.

c) Solve heat losses technical problems.

d) Understand the problems created by fouling in heat exchanger.

e) Understand the theoretical knowledge of drop wise and film wise condensation.

CHC – 206 Heat Transfer Lab

Laboratory 3 Hour/ Week, **Credits – 1.5**

1. To determine thermal conductivity of metal bar.
2. To determine thermal conductivity of an insulating material
3. To determine heat transfer coefficient by natural and forced convection.
4. To determine heat transfer coefficient in shell and tube type heat exchanger.
5. To determine heat transfer coefficient in double pipe heat exchanger.
6. To determine efficiency of pin fin.
7. To determine the critical heat flux.
8. To determine Stefan Boltzaman's constant.
9. To determine the emissivity of aluminum plate.
10. To study dropwise and filmwise condensation
11. Study of evaporators.
12. Study of different types of heat exchangers.

(Minimum eight experiments)

Course Outcome:
To enhance the knowledge and clear the theoretical concepts of heat transfer by performing the hands on experiments in the laboratory for detail understanding of the topic.

CHL-207 Chemical Process Technology

Theory- 4 Hour/ Week, **Credits – 4**

Prerequisite courses: Knowledge of Chemistry Courses of first year

Course Objectives:
To impart the thorough knowledge of industrial process technologies for the manufacturing of various organic and inorganic chemicals and to get the students well acquainted with various process industries.

Course Contents:

Unit I
Salient features of manufacture commodity chemicals, status of chemical industry in India, Current trend in chemical industry. Water for industrial use, sources of impurities, methods of softening, treatment for boiler feed water. (10)

Unit II
Engineering aspect of manufacture of basic inorganic chemicals such as sulphuric acid, caustic soda, soda ash, chlorine, ammonia, nitric acid and urea. (10)

Unit III
Introduction to petrochemicals, physical and chemical properties of petrochemicals, classification of petrochemicals, crude types and properties, concept of onshore and offshore drilling, desalting of crude and feed preparation. (10)

Unit IV
Fluidized bed and catalytic cracking, thermal and hydrocracking, reforming, alkylation, isomerization, polymerization of petrochemicals, study of linear alkyl benzene, aromatic compounds, and separation techniques. (10)

Unit V
Engineering aspect of the manufacture with alternative routes for basic organic chemicals such as aldehydes, ethylene, other olefins, acetylene, butadiene, phenols, amines, alcohols, carboxylic acids, esters, ketones, and ethylene oxides. Classification, sampling, analysis and selection of coal, carbonization and complete gasification of coal. (10)

References Books:

1. Unit Processes in Organic Synthesis: Groggins
2. Industrial Chemicals : Faith
3. Chemical Process Industries: Shrieves
4. Outlines of Chemical Tech0nology : Dryden
5. Petroleum Refining: Ram Prasad

Course Outcome:
a) To enhance the ability of students to understand the manufacturing of various inorganic and organic chemicals.
b) To get the students well acquainted with concept of onshore and offshore drilling, manufacturing and treatment processes of various petrochemicals.
c) To enhance the ability of students to understand the process flow diagram and various process parameters.
d) To enhance the ability of students to identify and solve engineering problems during production.
e) The get the students well acquainted with water and waste water treatment processes.

Plastics Technology (PL) Core

PLL-201: Introduction to Polymer Technology

Teaching: 4 hrs/week **Credits: 4**

Course Pre-requisite:

Organic Chemistry, Physical Chemistry, Inorganic Chemistry

Course Objective:

1. To gain knowledge of polymer basics.
2. To make the student acquire knowledge of structure and properties of polymers.
3. To acquaint the student with the techniques of polymerization.
4.

Course Content:

Unit I

Classification of polymers : plastics, elastomers ,resins,& fibers, Addition and Condensation polymers, Natural and Synthetic polymers, Thermoplastics and thermosetting, Linear, branched, Cross-linked polymers, Homopolymer and copolymers, Commodity, Engineering and Specialty polymers, Organic and Inorganic polymers. [10]

Unit II

Different techniques of polymerization, Distinctive features of bulk, solution, suspension and emulsion polymerization method merits, demerits and applications, Thermodynamics of polymer solutions Melting, Softening and freezing glass transition point, Phase equilibrium, crystalline, amorphous and oriented states in polymers. [10]

Unit III

Structural features of polymers, the chemical nature of polymers, Relation of structure to chemical properties, polymer solubility, solubility parameter & chemical reactivity, effect of thermal, photochemical & high energy radiation on polymers, aging & weathering, diffusion & permeability, toxicity, fire & plastics. [10]

Unit IV

Molecular weight of polymer, Introduction to average molecular weights, Degree of polymerization, Different types of average molecular weight , Number average weight average , viscosity average & z- average molecular weights & their mathematical expressions, concept of average molecular weight & molecular weight distribution, solubility & swelling, polymer fractionation, nature of distribution curve in polymers, integral and differential distribution curve. [10]

Unit V

States of aggregation in polymers, linear amorphous, crystalline polymers, relation of structure to thermal & mechanical properties, density glass transition temperature & melting temperature, stress- strain curve of polymers, tensile strength, elongation, yield strength, impact strength and melt viscosity, polymer degradation, Definition and types of degradation. [10]

Reference Books:

1. Plastic materials(6th edition) : J. A. Brydson
2. Polymer Science : By Gowarikar- Viswanathan-Sreedhar
3. Polymer Science and Technology of palstic and rubber : P. Ghosh

Course Outcomes:

Upon completion of the course the students will be

1. Able to understand the fundamentals of polymers.
2. Able to understand the structure and properties of polymers.
3. Able to understand the physical properties of polymers.
4. Acquainted with the techniques of polymerization.

PLP – 202: Polymer Identification and Analysis

Practical: 4hrs/week **Credits: 2**

Course Pre-requisite:
Organic Chemistry, Physical Chemistry, Inorganic Chemistry

Course Objective:
To make the students acquire a practical skills in

1. Identification of polymers.
2. Physical and chemical analysis of polymers.

Course Content
Identification of following polymers
Polyethylene, Polypropylene, Polystyrene, Polyamide, Polyvinyl chloride, PMMA, PE, UF, MF
Analysis of following polymers
PVA, Alkyd resin, PVAc, Epoxy resin

Course Outcomes:
At the end of the course the students will have

1. Ability to identify the polymers.
2. Ability to carry out physical and chemical analysis of different polymers.
3. Knowledge about technological use of polymers

PLL-203: Polymerization Kinetics

Teaching: 4 hrs/week **Creadits: 4**

Course Pre-requisite:
Organic Chemistry, Physical Chemistry, Inorganic Chemistry, Introduction to Polymer Technology

Course Objective:

1. To gain knowledge of mechanism and kinetics of homo polymerization and copolymerization.
2. To make the student understand the various factors influencing polymerization.

Course Content

Unit I
Step-Growth (Condensation) Polymerization: Functionaltiy principle, carothers equation, Polycondensation Mechanisms**,** Polymerization Rates**,** Molecular Weight Distribution**,** Non-linear Polycondensation. [10 hrs]

Unit II
Free-Radical Chain-Growth (Addition) Polymerization: Free-Radical Mechanisms and kinetics, Polymerization Rates, Molecular Weight Distribution, Gel Formation, living Radical Polymerization. [10 hrs]

Unit III
Ionic Addition Polymerization : Anionic Polymerization and its kinetics, Cationic Polymerization, Heterogeneous Ziegler- Natta Polymerization, Metallocene Polymerization. [10 hrs]

Unit IV
Copolymerization : Copolymer Composition, monomer reactivity ratio, copolymer equation and behaviour, Pseudo-Kinetic Rate Constant Method, Vinyl / Divinyl Copolymerization. [10 hrs]

Unit V

Polymer solutions: The process of polymer dissolution, thermodynamics of polymer dissolution, the Flory-Huggins theory of polymer solutions, nature of polymer molecules in solutions, size and shape of macromolecules in solutions. [10 hrs]

Reference Books:

1. Principles of polymerization : George Odian Willy interscience 4th edition
2. Text book of polymer science : F. W. Bilmayer Willy interscience
3. Polymer Science : Gowarikar- Viswanathan- Sreedhar

Course Outcomes:

Upon completion of the course the students has the knowledge of:

1. The different types of polymerization mechanisms.
2. Kinetics of different types of polymerization
3. The effect of reaction features on the polymer formed.
4. The copolymerization kinetics and the factors affecting copolymer formed.

PLP – 204 Synthesis and Characterization of Polymers

Practical: 3hrs/week, **Credits: 1.5**

Course Pre-requisite:

Organic Chemistry, Physical Chemistry, Inorganic Chemistry, Introduction to Polymer Technology

Course Objective:

To make the students acquire a practical skills in

1. Different techniques of Polymerization
2. Polymerization of different monomers.
3. Characterization methodologies for synthesised polymers.

Course Content

Synthesis of following polymers (at least five)

1. Polyvinyl acetate by bulk polymerization,
2. Polyvinyl chloride by emulsion polymerization,
3. Polystyrene by solution polymerization,
4. PMMA by Suspension polymerization,
5. Epoxy resin by condensation polymerization,
6. UF by condensation polymerization,
7. PF by condensation polymerization,
8. MF by condensation polymerization

Characterization (at least five)

1. Acid value,
2. Hydroxyl value,
3. Iodine value,
4. Epoxy value and epoxy content,
5. Amine value,
6. K-value,
7. Chlorine content

Course Outcomes:

Upon completion of this practical course, the student would be able

1. To carry out polymerization of different monomers.
2. To characterize different polymer synthesis in laboratory.
3. Handle chemical and laboratory equipments with required safety.

Paints Technology (PT) Core

PTC-201 Chemistry & Technology of Polymers-I (Th)

4 Hrs/week **Credits- 4**

Course Prerequisite: BSC-102, BSC-103, BSC-104

Course Objective:
a. The Paint Technocrat will have general exposure to polymers, paints and surface coatings.
b. The student will learn what elements make up paint and the basic role of paint ingredients.
c. The Technocrat will have in-depth exposure to manufacture, characterisations and applications of Alkyd , phenolic and amino resins.

Course Content:

Unit I

General classification of surface coatings, Constituents of paints and their role/functions, Elaboration of following terms: polymers, plastics, elastomers, resins, & fibers, Natural and Synthetic polymers, Thermoplastics and thermosetting, Linear, branched, Cross-linked polymers, Homopolymer and copolymers, Commodity, Engineering and Specialty polymers, Organic and Inorganic polymers, Step growth and chain growth polymerization **(10 hrs)**

Unit II

number average, weight average, viscosity average and z-average molecular weights and their mathematical expressions Degree of polymerization and molecular weight distribution; Distinctive features of Bulk, solution, suspension and emulsion polymerization, method, merits, demerits and applications, Melting, Softening and freezing, glass transition temperature, first and second order transition, Stress-strain curve of polymers, Tensile strength, elongation, yield strength, impact strength. **(10 hrs)**

Unit III

Pigments, Extenders and Dyestuff, Solvents, Thinners and Diluents, Paints, Varnishes, Lacquers, Electrodeposition, Powder Coatings, Printing Inks, PVC and CPVC, Convertible and non-convertible coatings, 1K and 2K systems, thermal/ air/ radiation curing etc.; Salient features/ desirable requirements of sealers, primers, stoppers, fillers, undercoats, topcoats for different surfaces; Overview and present status of Architectural, OEM, Refinish, Industrial, Maintenance and Special Purpose Surface Coating Industry. **(10 hrs)**

Unit IV

Alkyd Resin: Selection of raw materials like oils/ fatty acids, polyols, polyacids etc. Oil length, chemical reactions involved in the Synthesis of alkyd resins, monoglyceride & fatty acid route, solvent & fusion process, Problems on Formulation Calculations of alkyd resins. Reactors and Plant for the manufacture of alkyd resins, Chemical & physical modifications of alkyd resins, High solids and water reducible alkyds, Alkyd Emulsions **(10 hrs)**

Unit V

Phenolic resins: Chemistry of novolac and resoles. Plant and process for manufacture. Properties and characterization of phenolic resins.

Amino resins: Urea, Benzoguanamine and Melamine Formaldehyde resins. Chemistry of methyloaltion and etherification. Plant and process for manufacture, Self condensation polymerisation, MF–Polyol Reactions in Coatings, Properties and characterization of amino resins. **(10 hrs)**

Reference Books:

1 . 'Organic coatings : Science and Technology'**,** Edited by Zeno W. Wicks, Jr., Frank N. Jones, S. Peter Pappas; Douglas A. Wicks,Third Edition, John Wiley & Sons, Inc., Hoboken, New Jersey. 2007.

2. Morgans, W.M., 'Outline of Paint Technology', 3rd Edition, CBS Publishers and Distributors, New Delhi, 1996
3 . " Surface Coatings" Volume 1 " Raw material and their usages" Oil and Colour Chemists' Association, TAFE Educational Books, NSW, Australia,1987.
4 . Paul Swaraj, "Surface Coatings – Science and Technology", Wiley Interscience Publishers, John Wiley and Sons, Inc.1986.
5. 'Paints, Coatings and Solvents', Dieter Stoye; Werner Freitag (ed.), 2nd. Edition, Wiley-VCH. Weinheim ; (1998).
6 . 'Resins for Surface Coatings', VOL. II 'Alkyds & Polyesters' by P. Deligny and N. Tuck, Edited by PKT Oldring, Second Edition, ,John Wiley and Sons, New York Published In Association With SITA Technology Ltd, London, UK.

Course Outcomes:
On completion of this course, the Technocrat will display the
a. awareness of historical and current status of paint industry in national as well as global context.
b. understanding of polymers, essential components of paints and their functions
c. understanding of selection of monomers and different routes for manufacture of Alkyd, phenolic and amino resins
d. understanding of chemistry and technological aspects of manufacture, and characterisations of Alkyd , phenolic and amino resins in reference to end use.

PTC-201 Chemistry & Technology of Polymers-I (Pr)

4 Hrs/week **Credits- 2**

Course Prerequisite:
BSC-102, BSC-103, BSC-104

Course Objective:
The Technocrat will be exposed to laboratory practices related to the determination of physical and chemical characteristics of oils, solvents and plasticizers.
The Technocrat will be exposed to laboratory practices related to the synthesis and analysis of alkyd, phenolic and amino resins.

Course Content:
Minimum of ten experiments with due coverage of following:
1.Determination of various physical and chemical characteristics of drying, semi-drying and non-drying oils used in surface coatings such as colour, refractive index, specific gravity, acid value, saponification value, iodine value and hydroxyl value. Analysis of metal content and preparation of various driers
2.Spot Tests for Natural resins, Acid value of Rosin, preparation of limed rosin and ester gum
3.Technical Refining of Drying Oils, Preparation of modified oils used in surface coatings such as stand, boiled and double boiled oils, blown oils, D.C.O., isomerised oils, malenised oils etc.
4.Synthesis of coconut/ soya/ sunflower/ DCO alkyds (monoglyceride & fatty acid route, solvent & fusion process); determination of oil length of alkyd resins; preparation of alkyd emulsions
5. Synthesis of Novolac and Resoles; Synthesis of Urea formaldehyde resin; etherification of amino resins

Course Outcomes:
On completion of this course, the Technocrat will develop laboratory skills and good practices related to
a. determination of analytical parameters of oils
b. evaluation of solvency and plasticization.
c. the techniques of refining of drying oils,
d. empirical skills for synthesis of Alkyd, phenolic and amino resins.
e. analytical skills for characterisation and testing of natural resins, vegetable oils, Alkyd, phenolic and amino resins.

PTC-202 Technology of Pigments (Th)

4 Hrs/week **Credits- 4**

Course Prerequisite: PTC-202

Course Objective:
The Technocrat will learn the chemistry and technology of manufacture, characterisations and applications of inorganic pigments, organic dyestuffs and extenders.

Course Content:

Unit I

General methods of processing and synthesis of inorganic pigments: Crushing and grinding, vaporization, coprecipitation, filtration, drying, flushing, calcinations/roasting, vapour phase oxidation etc..
Raw materials for organic pigments: A brief study of coal tar distillation and the role of distillation products in the manufacture of synthetic dyes: bases and precipitants used in the colour striking, toners and lake formation.
Intermediates: brief study of the types of chemical reactions involved in the manufacture of various benzene, naphthalene and anthracene intermediates.
Synthetic organic pigments: General methods for preparation and classification; Diazotization and coupling reactions and processes, General layouts for Colour House. (10 hrs)

Unit II

Extenders or filler pigments: Sources, manufacture, properties and uses of carbonates, sulphates and other extender pigments like Calcium carbonate, hydrated aluminium oxide, aluminum silicates/ china clays, Magnesium silicate/ talc, silica, Barytes /blanc fixe (barium sulfate), silica, mica etc.
Anticorrosive pigments: Red lead, basic lead silicochromate, zinc and strontium chromates, white molybdate, calcium plumbate, etc. Passivation mechanism of corrosion resistance. (10 hrs)

Unit III

White prime pigments: methods of manufacturing, comparison of properties and composition of TiO_2, ZnO, Zinc sulphide and lithopone, basic lead carbonate, basic lead sulphate, antimony oxide, zinc phosphate zirconium oxide. surface treatment of TiO_2, crystal structure and hiding power of TiO_2
Manufacture, properties and applications of Black Pigments: Channel blacks, Furnace blacks, Lampblacks, Acetylene black, Graphite, black iron oxide, Jetness of black. (10 hrs)

Unit IV

Properties, composition and manufacturing of Yellow and Orange Pigments: Iron oxide yellows, FeO(OH), lead chromate ($PbCrO_4$), combinations of lead chromate with PbO, co-crystals of lead chromate with lead molybdate ($PbMoO_4$) and lead sulphate, titanium nickel yellow, bismuth yellow($BiVO_4$- Bi_2MoO_6), cadmium sulphoselenide; lithol fast yellow, Monoarylide (monoazo) yellow pigments, Diarylide yellows, Nickel azo yellow, benzidine yellow, isoindoline/ isoindoline yellow, flavanthrone yellow, benzimidazolone orange pigments, perinone and perylene orange/ yellow, 1,4diketopyrrolo-pyrrlo orange/ yellow etc.
Properties, composition and manufacturing of Red Pigments: Natural and synthetic iron oxides, cadmium sulphide; Quinacridones, para red, Toluidine red, rubine red, monoazo metallised pigments, lithol reds, perinone and perylene reds, BON acids coupled with diazo compounds, Naphthol reds, alizarine red, thioindigo red, etc. (10 hrs)

Unit V

Properties, composition and manufacturing of violet, Blue and Green Pigments:
manganese violet, cobalt violet phosphate, chrome green, ultramarine blue, Prussian blue, Cobalt blue etc.
Phthalocyanines: Copper phthalocyanines, phthalocyanine green, metal free phthalocyanines, comparison with other pigments.
indathrone blue, pigment green B, carbazole/ dioxazine violet, Azo tonners and lakes, Diazo and tetra azo compounds, Basic and acid dye pigments: PTA, PMA and PTMA pigments, Non permanent type basic, acid dyes and pigments. Xanthane. (10 hrs)

Reference books:

1.Braun, J. H., White Pigments, Federation of Societies for Coatings Technology, Blue Bell, PA, 1995.
2. Challener, C., Update on Inorganic Pigments, JCT Coat. Tech, 2005, 2(18), 44.
3. Herbst, W.; Hunger, K., Industrial Organic Pigments, 3rd ed., Wiley-Interscience, New York, 2004.
4. Lewis, P. A., Ed., Pigment Handbook, 2nd ed., Vol. I, Wiley-Interscience, New York, 1988.
5.Herbst, W.; Hunger, K., Industrial Organic Pigments, VCH, New York, 1997.
6.Vanderhoff, J. W.; et al., Polym. Mater. Sci. Eng., 1991, 64, 345.
7.Lewis, P. A., Organic Pigments, Federation of Societies for Coatings Technology, Blue Bell, PA, 1995.

Course Outcomes:

On completion of this course, the Technocrat will exhibit

a. acquaintance of raw materials, general methods of processing and testing of inorganic pigments, organic dyestuffs and extenders.
b. understanding of chemical constitution and polymorphism in relation to colour development and visualisation
c. in-depth knowledge of methods of manufacture of important prime pigments.
d. awareness of recent developments, eco-friendly trends, good manufacturing practices and future challenges in relation to prime pigments.

PTC--202 Technology of Pigments (Pr)

3 Hrs/week **Credits- 1.5**

Course Prerequisite: PTC-202

Course Objective:

The Technocrat will be exposed to laboratory practices related to the synthesis and testing of major inorganic pigments, organic dyestuffs and extenders.

Course Content:

Minimum of ten experiments with due coverage of following:
Identification of pigments, spot tests for organic pigments,
Evaluation of following pigmentary properties: Hiding power, Oil absorption, Refractive Index, Tinting Strength, Reducing power, Mass tone, colour permanence, resistance to bleeding in solvents, oils and resins, particle size, specific gravity and bulking value, resistance against acids, alkalies and different chemicals, Shade matching etc. Preparation of typical inorganic pigments, extenders and synthetic organic pigments and their analysis -Lead chromes, Zinc chromes , red and yellow iron oxide, Iron Blues, Para Red, lithol Red, Phthalocanine blue , Toludine Red, carbon black, $CaCO_3$, $BaSO_4$ etc. Synthesis of nanopigments.

Course Outcomes:

On completion of this course, the Technocrat will develop laboratory skills and good practices related to

a. The techniques of purification of pigments,
b. Empirical skills for synthesis of . inorganic pigments, organic dyestuffs and extenders..
c. Analytical skills for characterisation and testing of inorganic pigments, organic dyestuffs and extenders.

Oil Technology (OT) Core

OTC-201 Chemistry and Technology of Oils and Fats (TH)

Total Hrs : 04 **Course credit : 04**

Course description:
This course deals with the lipid biosynthesis mechanism and the general introduction of terminologies, classification and theories of triglyceride and non-triglyceride constituents. The course also includes physicochemical properties, chemical modification methodologies, oxidation mechanisms and adulteration techniques of oils/fats.

Course Objectives:
This course aims at providing the general understanding of fundamental and applied chemistry of oils and fats. The non-triglyceride constituent of oils/fats, physicochemical characteristics, chemical modifications and the knowledge of the adulteration and oxidative changes in oil/fats will be explored.

Course Outcomes:

1. Describe the general features such as composition, nomenclature, physical properties and statistical production data of oil/fats.
2. Understand the basic concepts of non-glyceride constituents of oils/fats.
3. Discuss the important physical and chemical characteristics of oil/fats.
4. Outline the key chemical reactions of oil/fast for industrial applications.
5. Explain the relationship between the chemical structure and the physical properties of fats and oils.
6. Describe the fundamental knowledge of the adulteration and oxidative changes in oil/fats.

Pre-requisite for the course
Organic chemistry (BSC-102), Physical Chemistry (BSC-103), Inorganic Chemistry (BSC-104)

Course Content:

Unit I
General introduction to oils, fats, waxes and essential oils; Lipid biosynthesis in developing seed of oleaginous plant; Classification of oils and fats- By source type and fatty acid composition; Nomenclature of fatty acids- IUPAC, *cis-trans*, Conjugated-Non-conjugated, omega terminology; Comparative statistics of Indian as well as world production, import and export of oils/fats

Unit II
Theories of glyceride structure; Effect of fatty acid distribution on physical properties; Non-glyceride constituents of natural oils and fats, phosphatides, sterols, hydrocarbons, constituents imparting color, odor and stability, toxic constituents

Unit III
Physical characteristics of oils/fats: oiliness and viscosity, density and expansibility, melting point, smoke, fire and flash point, stability and miscibility, refractive index and molecular refraction, color value.
Chemical characteristics of oils/fats: Acid Value, Saponification Value, Acetyl and Hydroxyl Value, Richert Missel and Polanske values and Kirschner value, Peroxide value, Diene value, Thyocyanogen value

Unit IV
Chemical modification of oils/fats and their industrial applications: Neutralization, hydrolysis, saponification, esterification and hydrogenation
Reaction of fats and Fatty acids: interesterification, acylation, formation of metallic soap, pyrolysis, halogenations, diels-alder reaction

Unit V
Auto-oxidation, chemical oxidation, atmospheric oxidation and rancidity; Factors determining the rate of oxidations; Accelerated oxidation test; flavor reversion; antioxidants, pro-oxidants and synergists; Common adulterants in oils/fats and methods of their detection.

OTC-201 Chemistry and Technology of Oils and Fats (PR)

Total Hrs : 03 **Course credit : 1.5**

Course description:
This course provides a basic scientific and technological approach for the determination of the physicochemical characteristics and some important analytical tests of oils and fats.

Course Objectives:
This course is designed to intensively develop an ability to perform the experimental oil chemistry techniques for determining the physicochemical characteristics of oils and fats.

Course Outcomes:

1. Analyze the oilseeds for their essential properties such as moisture and oil content.
2. Determine the physical characteristics of oils such as specific gravity, melting point etc.
3. Demonstrate practical proficiency in chemical analysis of oil/fat samples.
4. Calculate the concentration of solutions and be able to prepare standard solutions
5. Carry out appropriate experiments safely in the laboratory, make accurate observations and summarize the scientific results.

Pre-requisite for the course:
Organic chemistry (BSC-102) (PR), Physical Chemistry (BSC-103) (PR), Inorganic Chemistry (BSC-104) (PR)

Laboratory Content:

a) Analysis of physical characteristics of oils such as moisture content, specific gravity, refractive index, polarity, flash point, fire point, color value,
b) Analysis of chemical characteristics of oils such as acid value, saponification, iodine value, hydroxyl value
c) Determination congeal point and titre point of oil/fat samples
d) Determination of cloud point of Palmolein
e) Polybromide test for mustard oil

OTC-202- Post Harvest Technology of Oil Bearing Materials

Total Hrs : 04 **Course credit : 04**

Pre-requisite for the course:
OTC-201 Chemistry and Technology of Oils and Fats

Course description:
This course deals with the sources, composition and properties of plant and animal origin oils and fats. The course also comprehensively covers the topics such as harvesting conditions, pretreatment methods and extraction technologies for obtaining oils and fats.

Course Objectives:
The objective of the course is to provide the students a thorough understanding of knowledge about different oil and fat materials, the skills required to control post harvesting losses and the different technologies of oil/fat processing.

Course Content:

Unit I
Plant based oil bearing materials, their production, composition, characteristics, fatty acids and glyceride composition: Coconut, soybean, Cottonseed, Groundnut, Sunflower, Safflower, Rice bran, Palm kernel, Palm, Castor

Unit II
Sources utilization, characteristics and composition of -

Milk fat and Butter, Animal fats: Lard, Tallow and Greases, Fish and marine oils: Herring, Halibut, Shark, Menhaden, Whale, Sardine and Fish liver oils
Standard methods of grading and evaluation of oilseeds

Unit III
Handling, drying and storage of oilseeds/oil bearing materials: Importance of proper handling practices, various methods and conditions of drying and storage, their effect on oil yield and characteristics
Pre-treatment methods: Cleaning, dehulling, size reduction and flaking, heat treatment/cooking

Unit IV
Extraction of oils: Introduction to traditional and newer methods- Mechanical extraction, Pre-press solvent extraction, Direct solvent extraction, Supercritical extraction
Expeller or screw press extraction: Construction and working of screw press, Advantages and limitations of expeller process
Solvent extraction: Classification and details of extractors, criteria of solvent selection, food grade Hexane, Alternative solvents

Unit V
Post Extraction operations: Recovery of solvent from miscella, meal desolventization
Oil-bearing fruit extraction: Olive oil, Palm oil
Animal fat extraction: Different methods of rendering, production of tallow, lard, fish oil/ fish liver oil.

Course Outcomes:
1. Describe the primary knowledge about the production, composition, characteristics, fatty acid and glyceride distribution among the traditional edible plant based oil bearing materials.
2. Outline the major sources, chemical composition, characteristics and utilization of oils/fats of plant and animal origin.
3. Understand the role and significance of harvesting, drying and storage conditions on oil yield.
4. Know the deterioration mechanisms in oilseeds and the methods to control the spoilage.
5. Understand the principles and current practices of processing techniques including pretreatment and solvent extraction methods.

OTC-202 Post Harvest Technology of Oil Bearing Materials (PR)

Total Hrs : 06 **Course credit : 03**

Course description:
The principles and practices of oilseed pretreatment, extraction techniques, oilseed and oilcake quality check, oil/fat adulteration detection methods are considered in this course.

Course Objectives: The course is focus on the development of skills required to efficiently perform the oil processing systems and ensure the quality of the products thereby.

Course Outcomes:
1. Be able to select the appropriate extraction method for different oilseeds when presented with a practical problem.
2. Carry out laboratory procedures of solvent extraction of oil bearing materials as relevant to the academic content of the module.
3. Identify and perform the different test methods for detection of adulteration of oils.
4. Be able to use the laboratory techniques to analyze the non-glyceride constituent of oils and fats.

Pre-requisite for the course:
Chemistry and Technology of Oils and Fats (OTC-201) (PR)

Laboratory Content:
a) Decortication and mechanical extraction of oilseeds

b) Analysis of oilseed quality in terms of acid value and peroxide value.
c) Soxhlet extraction of oilseeds, Solvent (Hexane and Petroleum ether) analysis as per BIS standard
d) Analysis of oilcake quality for cattle feeding eg. protein content, urease activity ,trypsin inhibition activity
e) Adulteration test methods such as Holds test, Belliers test, Baudouins test, Halphens test
f) Test for presence of beef fat in Lard
g) Test for presence of Argemone oil
h) Test for the presence of animal body fat in vegetable fat

Food Technology (FT) Core
FTC 201 : Food Chemistry

Theory:4 hrs/week **Credits- 4**

Pre-requisite for course:
To learn the basic knowledge of food chemistry that require pre-knowledge of organic chemistry (BSC-102), Physical Chemistry (BSC-103), Inorganic Chemistry (BSC-104), Physics (BSC-105)

Course Objectives:
The purpose is to provide basic knowledge of food chemistry competent enough to work in food industry.

Course content:
Unit I
Origin of life, history of food chemistry, development of food chemistry, Importance of water in food, water activity, structure and physico-chemical properties of water and ice, concept of free and bound water and their implication, Physical properties of food system, colloidal properties, sensory perception of taste. (10)

Unit II
Chemistry of Carbohydrates: Definition, Nomenclature, classification, structure, physical and chemical properties of carbohydrates, sensory properties of carbohydrates, interaction with other food components, pectic substances, gums and other polysaccharides, modified carbohydrates (10)

Unit III
Chemistry of Proteins: Definition, Nomenclature, Classification, Structure and chemistry of amino acids & proteins, Sources and distribution of proteins, physico-chemical and functional properties of proteins, Isolation identification and purification of proteins, applications of proteins in food industry. (10)

Unit IV
Chemistry of Lipids: Definition, nomenclature, classification of lipids, Chemistry of fatty acids and glycerides, Physico-chemical and functional properties, Processing of fats and oils, hydrogenated fats, shortening agents, confectionery fats etc., Rancidity of fats and oils, its prevention , Antioxidants, fat replacer, emulsions and emulsifiers. (10)

Unit V
Enzymes: Definition**,** Nomenclature, Classification, Specificity, Industrial application.
Papain, Glucose Oxidase, Phenol Oxidase, Amylase, Pectic and lypolytic enzymes.
Browning reaction in foods: Enzymatic and non-enzymatic and their control, advantages and disadvantages.

Food Additives: Definition, Classification and their applications. (10)

Books Recommended:

1. Principles of Food Science, Vol. II by G. Borgstrom, McMillan Co. Ltd., London
2. Encyclopedia of Food Science, Food Technology and Nutrition by Macrae, Robinson and Sadler
3. Encyclopedia of Food Science, by G. D. Raj
4. Mechanism and Theory in Food Chemistry, Wong, DWS., AVI Publishers, N. York.
5. Biophysical Chemistry by Upadhyay and Nath, Himalaya Publ. Bombay.
6. Essential of Food Science, Vaclavik V., Chapman and Hall, N. York

7. Food Chemistry by L.H.Meyer
8. Principles of food Science, Part I Food Chemistry by Owen R. Fenemma.

Course Outcomes:
1. The students will understand and gain the basic industrial knowledge of food chemistry.
2. The students will gain basic technical knowledge of food component like water, carbohydrates, protein, lipids, enzymes and their analytical techniques.

FTC-201 Food Chemistry Lab

Practical: 4 hrs/week **Credits- 2**

Pre-requisite for course:
To learn the basic knowledge of food chemistry there require pre-knowledge of organic chemistry (BSC-102) lab, Physical Chemistry (BSC-103) lab and Inorganic Chemistry (BSC-104) .
Course Objectives: The purpose is to provide practical knowledge of food chemistry competent to industrial requirement for analysis of food stuffs.
Course content:-
Quality evaluation of water. (pH, Hardness, TDS, Turbidity of water).
Proximate analysis of food samples.
Qualitative test for carbohydrates, Proteins & Fats.
Books Recommended:
1. Analysis of fruits and vegetables products by S. Ranganna TATA Mc Graw Hill publication.
2. Official Methods of Analysis Association of Official Analytical Chemist , Benjamin Franklin Station, Washington D.C.20044,1976
3. Manual of Analysis of Fruits & Vegetables Products S. Tata,Mc Granholl publication

Course Outcomes:
1.The students are able to quantitatively estimate proteins, fats, carbohydrate, moisture, ash, crude fiber and acidity in food samples in food industries.
2. They are able to evaluate water quality parameters used in food industries.

FTC - 202 : Food Biochemistry and Nutrition

Theory: 4 hrs/week **Credits- 4**

Pre-requisite for course:
To learn the basic knowledge of food biochemistry and nutrition that require pre-knowledge of organic chemistry (BSC-102), Physical Chemistry (BSC-103), Inorganic Chemistry (BSC-104), Food chemistry(FTC201).

Course Objectives: The purpose is to provide industry based basic knowledge of food biochemistry and nutrition.

Course content:
Unit I
Enzymes:
Specificity of enzymes, Enzyme kinetics, Activation and inhibition, Technique of enzyme immobilization, Assay techniques, Isolation, identification and purification of enzymes, Different activators and inhibitors. (10)

Unit II
Cell Structure: Cell membrane, Structure and transport mechanism,
Bioenergetics: Generation of energy phosphates. Different biochemical pathways and their significance. (10)

Unit III
Digestion, Absorption and metabolism of carbohydrates, lipids and proteins, Anti-nutritional factors in food, Toxic compounds. (10)

Unit IV
Nutrition: Function of food, energy value of food, Food groups, BMR and its measurements, Energy requirement for individual, Recommended dietary allowances of proteins, fats and carbohydrates.
Nutritive value of foods, Balanced diet, enrichment and fortification, formulation of diets for infants, pre-school and school going children, effect of processing on nutrients. (10)

Unit V
Vitamins: Definition, Classification, Sources, function, chemistry, deficiency symptoms of Vitamins **Minerals**: Definition, Classification, Sources, function and deficiency symptoms of macro and micro minerals, Recommended dietary allowances of Vitamins and minerals. (10)

Recommended Books:
1. Outline of Biochemistry by Conn and P. Stumpf
2. Food Biochemistry by Estin and Henderson
3. Biochemistry by Lehninger
4. Food Science and Nutrition by M. Swaminathan
5. Food Science by Srilaxmi.
6. Nutrition by R. Rajlaxmi.

Course Outcomes:
1. The students are able to understand enzymes kinetics, Techniques **for enzyme** immobilization**.**
2. The students are able to understand enzyme assay techniques, Isolation of enzymes from natural sources and their applications.
3. The students are able to understand identify Anti-nutritional factors in food and control them.

FTC - 202 Food Biochemistry and Nutrition Lab

Practical: 3 hrs/week **Credits- 1.5**

Pre-requisite for course:
To learn the basic knowledge of food biochemistry and nutrition that require pre-knowledge of), Physical Chemistry (BSC-103) lab, Inorganic Chemistry (BSC-104) lab , Food chemistry(FTC201) lab.

Course Objectives:
The purpose is to provide industry based knowledge of food biochemistry and nutrition.

Course content:
Effect of pH, temperature and substrate concentration on activity of enzymes
Quantitative evaluation of enzyme action
Quantitative estimation of sugars, proteins
Estimation of vitamin and minerals
Planning and preparation of diet for different age group individuals

Recommended Books:
1. Fundamental Biochemistry by J. Raman.
2. Biophysical techniques by Manikam and Sadashivam.

Course Outcomes:
1. Students are able to understand enzymatic reaction kinetics
2. Students are able to understand carry out assay of vitamins, minerals proteins and sugars in food samples by different techniques.