Syllabus of Second Year

B. Tech. (Paint Technology)

(Revised Syllabus w. e. f. 2019-20)

Faculty of Science and Technology

University Institute of Chemical Technology
Kavayitri Bahinabai Chaudhari
North Maharashtra University, Jalgaon

(Academic Year 2019 – 20)

Semester-III

Course Code	Course Title	Teaching Hours	Tutorial	Credits	Practical Hours	Credits	Total Credits
CHC-203	Heat Transfer	03	01	04	03	1.5	5.5
CHL-204	Fluid Mechanics	03	01	04	-	-	4.0
CHL-206	Material and Energy Balances Computations	03	01	04	-	-	4.0
HML-202	Industrial Management and Economics	03	-	03	-	-	3.0
PTC-201	Introduction to Coating Technology	03	-	03	03	1.5	4.5
NC-202	Indian Constitution	-	-	-	-	NC	NC
Total Credit							**21**

Course Title: Heat Transfer

Course Code: CHC – 203

Theory: 03 Hrs + 01 Tutorial / Week **Credits: 04**

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. Fourier's law, significance of thermal conductivity of solid, liquid and gases, heat transfer through plane and composite wall, sphere and cylinder, problem related to this case. Thermal diffusivity, differential equation of heat conduction, lagging of pipes and other equipment, optimum lagging thickness, critical radius of insulation. Heat Transfer from extended surfaces (fins). (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 (horizontal & vertical Surfaces). (10)

Unit – III

Design aspects of condensers reboilers and evaporators, Concept of Boiling and their types, Nussult Equation. Evaporation: Single and Multiple effect evaporator. 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)

Text/ Reference Books

1. Holman,J..P.,S. Bhattacharya, Heat Transfer,10th edition, Tata McGraw-Hill,2011.
2. D.Q.Kern, Process heat transfer, Tata-McGraw Hill,1997.
3. R.Welty, C.E. Wicks, R.E.Wilson, G.Rorrer, Fundamentals of Momentum, Heat and Mass Tranfer, 4th edition, Wiley,2007.
4. W.J.Mccabe, J.Smith, P.Harriot, Unit Operations of Chemical Engineering, 6th edition, McGraw Hill, 2005.

Course Outcomes:

On completion of the course, students will be able to

1) Understands the various modes of heat transfer.
2) Understands the basics of fins
3) Design double pipe heat exchanger, shell and tube heat exchanger.
4) Design single effect evaporator

Heat Transfer Lab

Course Code: CHC-203 (PR)

Practical: 03 Hours/ week **Total Credits: 1.5**

Course Contents:

1. To determine the heat transfer coefficient of air by using natural convection.
2. To determine the Stefan Boltzmann constant for radiation.
3. To determine the thermal conductivity of metal bar.
4. To determine the thermal conductivity of liquid (Lubricating oil).
5. To determine the heat transfer coefficient of double pipe finned tube heat exchanger.
6. To determine the log mean temperature difference in double pipe heat exchanger for parallel flow arrangement.
7. To determine the log mean temperature difference in double pipe heat exchanger for counter flow arrangement.
8. To Study the drop-wise and film-wise condensation.

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.

Text/ Reference Books

1. Holman,J..P.,S. Bhattacharya, Heat Transfer,10th edition, Tata McGraw-Hill,2011.
2. D.Q.Kern, Process heat transfer, Tata-McGraw Hill,1997.
3. R.Welty, C.E. Wicks, R.E.Wilson, G.Rorrer, Fundamentals of Momentum, Heat and Mass Transfer, 4th edition, Wiley,2007.
4. W.J.Mccabe, J.Smith, P.Harriot, Unit Operations of Chemical Engineering, 6th edition, McGraw Hill, 2005.

Course Title: Fluid Mechanics

Course Code: CHL-204

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

Course Objectives

The objective of this course is to make student well acquainted with different concepts in fluid mechanics like fluid statics, kinetics, dynamics, hydrostatic forces on submerged bodies, flow through pipes, instruments for flow & pressure measurement, types of flows, boundary layer theory, dimensional analysis & transportation of fluids by pumps, blowers and compressors etc & their applications particularly in chemical engineering.

Course Contents:

UNIT I

Concept of Fluid, Properties of Fluids, Viscosity, Newton's Law of Viscosity, Types of Fluids, Measurement of Pressure, Fluid Pressure at a Point, Pascal's Law, Hydrostatic Law, Absolute, Gauge, Atmospheric & Vacuum Pressures, Measurement of Pressure, Simple Manometers, Differential Manometers, Total Pressure & Centre of Pressure for a Vertical, Horizontal Surface Submerged in Liquid, Buoyancy, Centre of Buoyancy, Stability of Floating & Submerged Body.
Problems Based on All the Topics in a Unit. (10)

UNIT II

Kinematics of Flow: Types of Fluid Flows, Continuity Equation, Continuity Equation in Three Dimensions, Continuity Equation in Cylindrical Polar Coordinates, Velocity & Acceleration Concept, Stream Functions, Potential Flow & Its Important Cases.
Dynamics of Flow: Euler's Equation, Bernoulli's Equation, Applications of Bernoulli's Equation (Venturi Meter, Orifice Meter, Pitot Tube), Rotameter, Notches & Weirs.
Problems Based on All the Topics in a Unit. (10)

UNIT III

Flow Through Pipeline System: Loss of Energy in Pipes, Laws of Friction, Major Losses & Minor Losses, Loss of Head Due to Friction in Pipes (Darcy-Weisbach Formula), Chezy's Formula, Water Hammer in Pipes, Hydraulic & Total Energy Line.
Viscous Flow: Flow of Viscous Fluid through Circular Pipe (Hagen Poiseuille Formula), Between Two Parallel Plates, Methods of Determination of Coefficient of Viscosity, Kinetic Energy & Momentum Correction Factor.
Turbulent flow: Reynolds Experiment, Velocity Distribution in Turbulent Flow in Pipes, Hydrodynamically Smooth & Rough Boundaries, Velocity Distribution for Turbulent Flow in Smooth & Rough Pipes, Velocity Distribution for Turbulent Flow in Terms of Average Velocity, Variation of Friction Factor.
Problems Based on All the Topics in a Unit. (10)

UNIT IV

Dimensional Analysis: Fundamental Dimensions, Methods of Dimensional Analysis, Rayleigh's Method, Buckingham's π Theorem, Types of Similarities, Types of Forces Acting on Moving Fluid, Dimensionless Numbers, Classification of Models.

Boundary Layer Theory: Laminar & Turbulent Boundary Layer, Boundary Layer Thickness, Displacement Thickness, Momentum Thickness, Energy Thickness, Drag Force on a Flat Plate Due to Boundary Layer, Separation of Boundary Layer, Methods of Preventing Separation of Boundary Layer.
Problems Based on All the Topics in a Unit. (10)

UNIT V

Pumping of Liquids: Classification of Pumps, Principle, Construction, Working, Design, Discharge, Work Done & Power Requirement by Centrifugal Pump, Reciprocating Pump (Single & Double Acting), Pumps in Series, Pumps in Parallel, All Curves for Centrifugal Pump, Pump Efficiencies, Selection of Pumps, Priming, NPSH, Cavitation.
Pumping of Gases: Classification of Compressors, Principle, Construction, Working, Design, Discharge, Work Done & Power Requirement by Centrifugal & Reciprocating Compressor, Blowers, Vacuum Pump.
Problems Based on All the Topics in a Unit. (10)

Course Outcome

- The students will have thorough knowledge of fluid properties, behaviour of fluid under different conditions, hydrostatics & pressure measurement.
- The students will get well acquainted with basic principles in kinematics & dynamics of fluid flow with its application.
- It will clear the basic concepts about various types of flows, complexities in flow through pipeline systems with detail study of laminar, turbulent flow.
- Students will get well acquainted with phenomena of boundary layer formation and separation. Students will be able to understand dimensional analysis and its application to solve the complex problems in heat & momentum transfer.
- Student will have thorough knowledge of handling of fluids by various pumps, compressors, blowers and will be able to design the fluid handling system with calculation of power requirement in it. It will enhance the ability of students to identify and solve various engineering problems.

Text/Reference Books

1. M. White, Fluid Mechanics, 8th Edition, Tata-McGraw Hill, 2016.
2. V. Gupta and S. K. Gupta, Fundamentals of Fluid Mechanics, 2nd Edition, New Age International 2011.
3. W. L. McCabe, J. C. Smith and P. Harriot, Unit Operations of Chemical Engineering, 7th Edition, McGraw-Hill International Edition 2005.
4. O. Wilkes, Fluid Mechanics for Chemical Engineers, Prentice Hall of India, 2005.
5. R. W. Fox, P. J. Pritchard and A. T. McDonald, Introduction to Fluid Mechanics, 7th Edition, Wiley-India 2010.
6. R. Welty, C. E. Wicks, R. E. Wilson, G. Rorrer, Fundamentals of Momentum, Heat and Mass Transfer, 4th Ed., Wiley (2007).
7. B. R. Munson, D. F. Young, T. H. Okiishi and W. W. Huebsch, 6th Edition, Wiley-India 2010.
8. R. B. Bird, W. E. Stewart and E. N. Lightfoot, Transport Phenomena, 2nd Edition, Wiley India 2002.

Course Title: Material and Energy Balance Computations

Course Code: CHL-206

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

Course Prerequisites: Physics, Chemistry-I, Mathematics-I, Thermodynamics-I

Course Objectives:

1. To teach students fundamental knowledge of chemical engineering and application of this knowledge in the solving of material and energy balances of chemical processes.
2. The course will cover concepts ranging from basics such as units and dimensions, stoichiometry to the simultaneous application of material and energy balances with and without occurrence of chemical reaction.

Course Contents:

UNIT- I

Units and Dimensions: Basic and derived units, different ways of expressing units of quantities and physical constants.

Calculations for mole, molecular weight, equivalent weight, etc., Composition of gaseous mixtures, liquid mixtures, solid mixtures, etc., Ideal gas law & other equations of state and their applications, Dalton law, Raoult's law, Hess's Law, Henry's law, Solutions and their properties. (10)

UNIT-II

Stoichiometry and unit operations:

Introduction to unit operation, development of block diagram and material balance for unit operations like blending, evaporation, crystallization, extraction and leaching, distillation, absorption & stripping, drying etc. (10)

UNIT-III

Material balance involving chemical reaction:

Introduction, definition and concept of terminologies like Excess Reactant, Conversion, Yield, Selectivity. Problems on material balance for chemical reactions for calculation of feed composition and product composition, Conversion, Yield, Selectivity etc. (10)

UNIT-IV

Humidity: Terminologies of Humidification like Humid Heat, Humid volume, % saturation, Molal Humidity, Molal saturation, absolute humidity etc.

Energy balance: Enthalpy calculation for systems (single component and multi components) without Chemical Reaction with Mean and Temperature dependent Heat Capacity, Enthalpy calculation for systems with Chemical Reactions. Heat of Reaction from Heat of Formation and Heat of Combustion Data, Effect of Temperature and Pressure on Heat of Reaction. (10)

UNIT-V

Introduction to Recycle, Bypass and purge operations: Applications of Recycle, Bypass and purge operations in unit operations and processes for calculation of recycle ratio, purge ratio, combined feed ratio.

Fuels: Types of fuels, Calorific value of fuels, Problems on combustion of coal, liquid fuels, gaseous fuels, etc., Proximate and ultimate analysis, Combustion calculations, Air requirement and flue gases. (10)

Text/ Reference Books:

Author, name of Book, latest edition year, publication

1. Bhatt., B.I. and Vora S.M. "Stoichiometry" 2nd edition, Tata McGraw Hill.
2. O.A. Hougen, K.M. Watson and R.A. Ragatz "Chemical Process Principles" Part-I, CBS Publishers & distributors ,New Delhi.
3. K.A.Gavhane "Introduction to process calculations" Nirali Publications.
4. Shekhar Pandharipande and Samir Musharaf "Process Calculations" Pune Vidyarthi Griha Prakashan, Pune.
5. Himmelblau, D.M. "Basic Principles and Calculations in Chemical Engineering", 6th edition. Prentice Hall.

Course Outcomes:

1. The capability to convert units and dimensions and modify equations from system to another.
2. The capability to apply the laws of physics and chemistry in solving process industry related applications.
3. The proficiency to integrate the data and formulate the mass and energy balance problems.
4. The capability to use mathematical knowledge for solving mass and energy balance problems with and without chemical reactions.

Course Title: Industrial Management and Economics

Course Code: HML-202

Theory: 03 Hours/week **Total Credits: 03**

Course Prerequisite: Basic Manufacturing Process, Principle of Economics

Course Objective

1. Identification and selection of management & administration with aspect towards the Production planning and management.
2. Understanding Micro and Macroeconomics Demand and Supply factors of market economy &institutional feature inside the organisation as well as outside the organisation.
3. Understanding GDP statement, Entrepreneurship Development

Course Content

Unit-I

Management: Introduction & meaning management & administration
Industrial management: Connotation of Industrial management
Organisation: Explication and Types of organisation
Manufacturing system: definition, class of manufacturing system
Plant layout: Classification of Plant layout (8)

Unit-II

Business organization: Forms of business organization
Productivity: Various techniques to increase Productivity
Sound wage program: Mechanics of sound wage program
Wages & Wage Administration: Introduction &meaning of Wages & Administration of remuneration
(8)

Unit-III

Marketing management: Introduction meaning and Concept of marketing management
Concept Sales management: Introduction meaning and Concept of Sales management significance of Sales management
Functions of Marketing management: prominence of marketing management
Functions of Sales management, role of Sales management (8)

Unit-IV

Economics: Introduction, meaning of Economics
Concept of GDP: Introduction meaning and Concept of GDP
Concept of ADP: influence of ADP
Introduction of Micro economics and Macro economics
Difference between Micro economics and Macroeconomics (8)

Unit-V

Entrepreneurship: Introduction, meaning and Concept of Entrepreneurship,
Types of Entrepreneurship: Order of Entrepreneurship
Entrepreneurship Development (8)

Text/ References Books:

1) John R. Hicks, "Value and Capital", 10th edition, Oxford, Clarendon Press, 2017
2) R. R. Barthwal, "Industrial Economics: An Introductory Text Book", 11th edition, New Age International, 2015
3) Martin Ricketts, "The Economics of Business Enterprise", 5th edition, ELGAR International, 2019
4) H. L. Ahuja, "Modern Economics" 9th edition, S. Chand Publishing, 2016
5) Alfred Marshal, "principle of Economics", 15th edition, Prometheus Books, 2016.

Course Outcomes:

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

1. Understanding of management and Productivity aspect towards the material management Production planning. Processes/operations according
2. Identification, selection and understanding the meaning and utility of Marketing management, consumer satisfaction, sales and advertising
3. Understand the importance of Entrepreneurship Development

Course Title: Introduction to Coating Technology
Course Code: PTC-201

Theory: 03 Hours/week **Total Credits: 03**

Course Prerequisite: Chemistry-I and Material Science & Technology

Course Objective:

1. The Technocrat will have basic understandings of the commonly used terminologies, various ingredients and their role in coating formulations.
2. The Paint Technocrat will have general exposure to polymers technology
3. The Technocrat will have in-depth exposure to manufacturing, characterizations, and applications of modified oils and Alkyd resins

Course Content:

Unit-I

Overview of Indian and Global Paint Industry. Various terminologies and general classifications and Types of Coatings, Paints, Varnishes and Lacquers; Their components and functions; Binders, media/vehicles, pigmentations, PVC and CPVC, Paint making; Mechanism of film formation; Modern Surface Coatings; Properties of Surface Coatings and their films; Sealers, fillers, undercoats, topcoats. Convertible and non-convertible coatings, 1K and 2K systems (8 hrs)

Unit-II

Fundamentals of film-formers; resins and polymers; Thermosetting and thermoplastic, linear, branched; homo-polymers and co-polymers. Chain growth and step-growth polymerization, Chemical structure of monomers; Functionality; Degree of polymerization. Molecular weight and molecular weight distribution. Different types of molecular weights, number average, weight average, viscosity average, z average, Melting, Softening and freezing of polymers, Glass transition temperature, Mechanical properties of polymers.

(8 hrs)

Unit-III

Pigment- Introduction to Pigments, extenders, dyes, lakes, and toners. Introduction to colour science, Inorganic and organic pigments with examples, Colour and chemical constituents, Chromophores, Adsorption and scattering of light; Influence of physical structure on colour, Colour index, General properties of pigments, Crystal structure, Particle size shape and distribution, Refractive index and hiding power, Oil absorption, Specific gravity, bulking value, tinting strength, Reducing strength. Fastness properties such as resistance to light, heat, water, chemicals, bleeding, etc. Corrosion resistance, Toxicity of pigments, Green pigments (8 hrs)

Unit-IV

Solvents; properties of solvents – solvent power, the rate of evaporation, boiling point & vapor pressure, distillation range, flash point, toxicity, thermodynamics of solubility; solubility parameters; solvent mixture (thinners) – true solvents, latent solvents, and diluents; safety, health & environmental aspects. Alcohols, ethers, esters, ether alcohols, ketones and hydrocarbons, Overview of paint and ink additives; Driers: active & auxiliary, primary and secondary, surface & through

driers. Natural resins: Sources availability and properties of Congo, Copal, Kauri, etc. Rosin: sources, recovery, grades, composition, modification; limed rosin, rosin esters, maleic resins, Shellac: composition, properties, chemical modification, Natural Bitumens and Asphalts, petroleum bitumens; pitches, gums, glues, casein

(8 hrs)

Unit-V

Oils for surface coatings: Drying, semi drying and non-drying oils; Properties and uses of oils; Chemical modifications of oils- heat bodied, polymerized oils, blown oils, isomerized oils; maleinized oils. Oleoresinous varnishes, Varnish making, spar varnish 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 (8 hrs)

Text/ Reference Books:

1. Organic Coating Technology, Volume I, by Henry Fleming Payne, John Wiley & Sons.1954
2. Surface Coatings, Volume I, by OCCA Australia (Prepd.), Chapman and Hall
3. Outlines of Paint Technology, III Ed. By W.M.Morgans,
4. Surface coatings: Science and Technology, by Swaraj Paul, John Wiley and Sons 1995
5. Organic Coatings: Science and Technology, by Z.W.Wicks, F.N.Jones and S.P.Pappas, Wiley-Interscience 2007
6. Basics of Paint Technology, Part I & II, by V.C. Malshe & Meenal Sikchi 2004
7. '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, SITA Technology Ltd, London, UK

Course Outcomes:

On completion of this course, the Technocrat will have

1. Awareness of the present scenario of the national and global paint industry.
2. Understanding of polymers, essential components of paints and their functions
3. Understanding of manufacturing methods of modified oils, varnishes and alkyd resin,
4. Understanding of chemistry and technological aspects of natural resins, oleo resinous media

Introduction to Coating Technology Lab
Course Code: PTC-201 (PR)

Theory: 03 Hours/week **Total Credits: 1.5**

Course Prerequisite: Chemistry-I and Material Science & Technology

Course Objective:

1. The Technocrat will be exposed to laboratory practices related to the determination of physical and chemical characteristics of natural resins, oils, solvents, and plasticizers.
2. The Technocrat will be exposed to laboratory practices related to the synthesis and analysis of modified oils and alkyd resins.

Course Content:

Minimum of ten experiments with due coverage of the following:

1. Determination of various physical and chemical characteristics of drying, semi-drying and non-drying oils used in surface coatings such as color, 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. Preparation of varnishes by cold blending and cooking.
4. 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., Isomerized oils, Malenizedoils, etc.
5. 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

Text/ Reference Books:

1. Organic Coating Technology, Volume I, by Henry Fleming Payne, John Wiley & Sons.1954
2. Surface Coatings, Volume I, by OCCA Australia (Prepd.), Chapman and Hall
3. Outlines of Paint Technology, III Ed. By W.M.Morgans,
4. Surface coatings: Science and Technology, by Swaraj Paul, John Wiley and Sons 1995
5. Organic Coatings: Science and Technology, by Z.W.Wicks, F.N.Jones and S.P.Pappas, Wiley-Interscience 2007
6. Basics of Paint Technology, Part I & II, by V.C.Malshe & MeenalSikchi 2004
7. '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, SITA Technology Ltd, London, UK

Course Outcomes:

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

1. Determination of analytical parameters of oils
2. Evaluation of solvency and plasticization.
3. Empirical skills for the synthesis of varnishes, modified oils, and Alkydresins.
4. Analytical skills for characterization and testing of natural resins, vegetable oils, and Alkyd resins

Course Title: Indian Constitution
Course Code: NC-202

Credit: Non-credit course

Course Objectives:

To percolate & disseminate knowledge about constitution of India for imbibing & understanding importance of fundamental rights & duties so as to aware the students towards justice, equality & liberty.

Course Content:

- **Introduction to the Indian Constitution:** History and Making of the Constitution, Constituent Assembly, Salient features, The preamble
- **Fundamental Rights & Duties:** Meaning and types of fundamental rights; Fundamental duties, the Right to Equality, the Right to Freedom, the Right against Exploitation, the Right to Freedom of Religion, Cultural and Educational Rights and Right to Constitutional Remedies

- **Directive Principles and Human Right:** Meaning of Directive Principles; difference between of Fundamental Rights and Directive Principles of State Policy – Implementation of Directive Principles of State Policy
- **Union Government & Administration:** Structure of Indian union, Loksabha, Rajyasabha, Powers and Functions of the President, the Prime Minister, Council of Ministers; composition, powers and functions of the Parliament, organisation of judiciary; jurisdiction of the Supreme Court; independence of judiciary, Election Commission

- **State Government & Local Administration:** Powers and Functions of Governor, Chief Minister and Council of Minister; composition, powers and functions of State Legislature, Local administration and constitution: Panchayati, Municipalities.

Suggested Books/ Readings:

1. M. V. Pylee – An Introduction to Constitution of India, Vikas Publications, New Delhi-2005.
2. Subhash C. Kashyap – Our Constitution: An Introduction to India's Constitution & Constitutional Law, National Book Trust, New Delhi-2000.
3. Durga Das Basu – Introduction to the Constitution of India, PHI, New Delhi-2001.
4. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
5. J. C. Johari – Indian Government & Politics, Sterling Publishers, Delhi-2004.
6. V. D. Mahajan – Constitutional Development & National Movement in India, S. Chand & Company, New Delhi.
7. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
8. Granville Austin – Working of a Democratic Constitution: The Indian Experience, Oxford University Press, New Delhi-1999.
9. A. P. Avasthi – Indian Government & Politics, Naveen Agarwal, Agra-2004.
10. S. A. Palekar – Indian Constitution, Serials Publication, New Delhi-2003.

Semester-IV

Course Code	Course Title	Teaching Hours	Tutorial	Credits	Practical Hours	Credits	Total Credits
ESL-205	Engineering and Solid Mechanics	03	01	04	-	-	4.0
BSC-206	Chemistry-II	03	01	04	03	1.5	5.5
CHL-201	Thermodynamics-II	03	01	04	-	-	4.0
CHC-207	Mechanical Operations	03	-	03	04	02	5.0
ESC-206	Engineering Workshop	01	-	01	04	02	3.0
PTC-202	Technology of Pigments	03	-	03	03	1.5	4.5
Total Credit							**26**

Course Title: Engineering and Solid Mechanics

Course Code: ESL – 205

Theory: 03 Hrs + 01 Tutorial / Week **Credits: 04**

Course Pre-requisite: Physics, Mathematics and Engineering Graphics

Course Objective:

- Students would be introduced to fundamentals of Engineering Mechanics with emphasis on force systems, axioms, dynamics of rigid bodies.
- Second part of the course would be an introduction to Solid Mechanics, and students would be introduced to basic concepts of mechanics of deformable media: concept of stress tensor, strain tensor, strain rates, constitutive relations, and applications to one/two dimensional problems.

Course Contents:

Unit - I

Coplanar forces: Introduction, basic concepts, composition & resolution of forces. Resultant forces. Moment of forces, couples, equivalent force systems, free body diagrams, distributed forces. Equilibrium of coplanar force system, conditions of equilibrium. Types of supports. Support reactions for determination of beams. Problems on above topics.

Analysis of structure: Plane trusses, method of joints, cables subjected to part loads. (10)

Unit – II

Centroid &Centre of gravity of composite plane figures. Principal Moment of Inertia, Moment of Inertia of various geometry.

Friction: Laws of friction, Application of friction on horizontal & inclined planes, belt friction.

Introduction to point Kinematics: Curvilinear Motion: Moving point in various coordinate systems (Cartesian, cylindrical, path), Equation of motion.

Kinetics & Kinematics of Rigid body: Translation & Rotation motion, Linear and Angular velocity, momentum. (10)

Unit – III

Concept of stress & strain, classification, Hooke's law, Poisson's ratio, Modulus of elasticity, Modulus of rigidity, Bulk modulus, relation between elastic constants, Problems on stresses & strains for prismatic, linear varying & composites sections.

Introduction to thermal stresses& strains. Problems on simple & composite sections. (10)

Unit – IV

Concept & definition of shear force & bending moment in determinate beams due to concentrated loads, UDL, UVL, Shear force & Bending moment diagrams for cantilever & simply supported beams (with or without overhang). Theory of bending. Concept of shear stress distribution. (10)

Unit – V

Thin Cylinder: Hoop stress, longitudinal stress, riveted cylindrical vessels, wire bound thin pipes. Thin spherical shells, cylinder with hemispherical ends.

Torsion of a circular shaft: Theory of pure torsion, Assumptions. Simple problems on torsion & power transmission. Short & long columns & struts. Standard cases with axial load. (10)

Text/Reference Books

1. I. B. Prasad, "Applied Mechanics & Strength of Materials", Khanna Publishers.
2. Timoshenko, "Mechanics of Materials", CBS Publisher
3. Ramamruthan S., "Strength of Material", Dhanpat rai Publications
4. Bear & Johnson, "Mechanics of Materials", 7th edition, McGraw-Hill Education, 2015
5. R. K. Rajput, "Strength of Materials", S Chand Publications
6. R S Khurmi, "Strength of Materials", S Chand Publications

Course Outcomes:

1. Able to solve basic concept in structural members like column, beams, trusses, and concept in laws of frictions and various types of stresses and strains.
2. Able to solve shear forces and bending moment and plot diagrams.
3. Able to analyse various parameters on torsion in transmission system.

Course Title: Chemistry-II

Course Code: BSC-206

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

Course Prerequisite: Chemistry-I

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 i.e., 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, substrate and some reagents.
5. To study interconversion of functional group and their applications.
6. To study methods of determination of structure of molecules.

Course Contents:

UNIT- I

Aromatic molecules: Huckels rule of aromatic molecules, different classes of aromatic molecules, resonance.

Aromatic Electrophilic Substitution bimolecular reactions (ArSE2 reactions): Mechanism of ArSE2 reaction, Orientation of ArSE2 reaction in monosubstituted benzene, Mechanism and synthetic application of Nitration, Friedel-Craft's alkylation and acylation reactions, Gatterman-Koch reaction, Vilsmeier-Haack's reaction. (10)

UNIT-II

Aromatic amines: Methods of Preparation – benzyne mechanism, reduction of nitro aromatics, properties-basicity and application in synthesis.

Diazonium Salts: Preparation-diazotization reaction, chemical properties and reactions such as coupling, synthesis of azo dyes, replacements-Sandmeyer's reaction and deamination. Ullman's reaction and Benzidine rearrangement. (10)

UNIT-III

Reagents and Green solvents in organic synthesis:

Complex Metal hydride-DIBAL-H, Lithium dimethyl cuprate, applications in synthesis. Introduction to organoboron-diborane, organosilicon-silane. H_2O_2 and O_3(Ozone) application in organic synthesis. Introduction to Green reactions, Green and hazardous solvents. (10)

UNIT-IV

Sulphonic acids: Methods of preparation, application of sulphonic acids in synthesis.

Heterocyclic compounds: Introduction, Methods of synthesis and ArSE2 reactions such as nitration, sulphonation, halogenations, acylation and mercuration of Furan, Pyrrole and Pyridine. (10)

UNIT-V

Spectroscopy: Basic principles and applications of IR, UV-VIS and ^{1}H NMR spectroscopy to structure determination of small molecules. (10)

Text/ Reference Books:

1. S. H. Pine, Organic Chemistry, Tata McGraw-Hill Education India, 5th Revised edition-1987
2. M. B. Smith, Jerry March, March's Advanced Organic Chemistry: Reactions, Mechanism and Structure, Wiley-Interscience, 6th Edition2007.
3. R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, Organic Chemistry, Pearson, 7th Edition 2011.
4. Jonathan Clayden, N. Greeves, S. Warren, P. Wothers, Organic Chemistry, Oxford University Press, 2000.
5. W. Carruthers, I. Coldham, Modern Methods of Organic Synthesis, Cambridge University Press, 4th Edition 2012.
6. P. S. Kalsi, Spectroscopy of Organic Compounds, New Age International Pvt Ltd Publishers, 6th Edition, 2006.
7. Elementary Organic Spectroscopy, Y. R. Sharma, S. Chand & Co. 4th Edition 2007.

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.

Chemistry-II Lab

Course Code: BSC-206 (PR)

Practical: 03 Hours/ week **Total Credits: 1.5**

Course Prerequisite: Chemistry-I practical

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 are takes place differently in different environments i.e., reaction mechanism.
3. To inculcate the laboratory skills.

Course content:

1. Qualitative analysis of organic binary mixture through type determination, separation. Elemental analysis, functional group determination and physical constant of any one component (at least Two mixtures)
2. Single step preparation involving greener approach, purification and characterization (m.p.) of product (at least Three)
   - i) Preparation of dibenzalpropanone using NaOH or LiOH as base
   - ii) Preparation of p-nitro aniline from p-nitroacetanilide
   - iii) Bromination of acetanilide by CAN, KBr in water
   - iv) Preparation of Osazone from Glucose
   - v) Preparation of Sudan-I from aniline
   - vi) Preparation of p-nitrobenzoic acid from p-nitrotoluene
   - vii) Oxidation of alcohol to ketone by sodium hypochlorite (NaOCl)
3. Determinations/Estimations (Any Two)
   - i) Determination of total hardness of water
   - ii) Determination of Molecular Weight of a monobasic/ dibasic acid by volumetric method.
   - iii) Estimation of amide by hydrolysis
   - iv) Study of kinetics of hydrolysis of methyl acetate
4. Laboratory Techniques (any Three)
   - i) Thin Layer Chromatography (TLC)
   - ii) Hydrogenation of organic compound-a demonstration
   - iii) Interpretation of IR and UV-VIS Spectra
   - iv) Interpretation of ^{1}H NMR spectra

Text/ Reference Books

1. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, Vogel's Textbook of Practical Organic Chemistry, Pearson, 5th Edition 2005.
2. R. K. Bansal, Laboratory Manual of Organic Chemistry, New Age International (P) Limited, 5th Revised Edition 2008.

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.

Course Title: Thermodynamics II

Course Code: CHL – 201

Theory: 03 Hrs + 01 Tutorial / Week **Credits: 04**

Course Pre-requisite: Thermodynamics I

Course Objective: To introduce the concepts of fugacity, activity and their coefficients, Phase equilibria and Chemical reaction equilibria.

Course Contents:

Unit - I

Review of basic laws of thermodynamics, intensive and extensive properties, state and path function, calculation for work, enthalpy and entropy changes. Efficiency calculation to heat engine, heat pumps. Refrigeration cycle & Carnot cycle, Throttling Process. (10)

Unit – II

Properties of pure substances: T-V, P-V, P-T diagram. Ideal gas law, compressibility factor, Van der waals equation, Viral equation, Redlich Kwong equation, Redlich Kwong Soave equation of state. P-V-T relation for isothermal, isobaric, isochoric, adiabatic & polytropic processes. (10)

Unit – III

The Maxwell relations, method of Jacobians, Gibbs & Helmotz relations, the Clapeyron equation. The general relations for du, dh, C_v, & C_p; Mayer relation. Isothermal compressibility, volume expansivity, coefficient of linear expansion, adiabatic compressibility & adiabatic bulk modulus. The Joule Thomson Coefficient. (10)

Unit – IV

Phase Equilibria: Chemical potential, Kay's rule, Phase rule for reacting system, Duhem's theorem, boiling point and equilibrium diagram, fugacity and activity coefficient, activity coefficient equations (Wohl's three-suffix equations; Margules equation; Van Laar equation; Wilson equation; Non-random two-liquid (NRTL) equation; Universal quasi-chemical (UNIQUAC) equation; Universal functional activity coefficient (UNIFAC)), Azeotropes, consistency tests for VLE data, modified Roult's law, liquid-liquid equilibria. (10)

Unit – V

Chemical Reaction Equilibria: Chemical equilibrium criteria, Equilibrium constant, chemical equilibria for simultaneous reactions, Feasibility of a reaction, Effect of temperature and pressure on equilibrium constant, Heterogeneous reaction equilibria. (10)

Text/ Reference Books

1) J.M.Smith, H.C.Van Ness and M.M.Abbott, "Introduction to Chemical Engineering Thermodynamics", 7th edition, McGraw-Hill International Edition, 2005.
2) K.V.Narayanan, "A textbook of Chemical Engineering Thermodynamics" PHI, New Delhi, 2010.
3) Y.V.C.Rao, "Chemical Engineering Thermodynamics" , University Press, Hyderabad,1997.
4) S.Sandler, " Chemical, Biochemical and Engineering Thermodynamics" , 4th edition, Wiley, India,2014.

Course Outcomes:

On completion of the course,

1.Students would be familiar with Basics of thermodynamics

2.Students would be familiar with various thermodynamics relations

3.Students will be able to solve problems of phase equilibria

4. Students will be able to solve problems of chemical equilibria

Course Title: Mechanical Operation

Course Code: CHC-207

Theory: 03 Hours/week **Total Credits: 03**

Pre-requisites: Material and energy balance computations, Fluid Mechanics

Course Objectives

The objective of this course is to make student well acquainted with basic principles of various mechanical operations, construction and working of the equipment.

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. Size Reduction: Size reduction equipment for coarse, intermediate & fine size reduction; energy & power requirement; open & closed loop circuit. (8)

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. (8)

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. (8)

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. (8)

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 equipment. Washing of filter cake. (8)

Text/ Reference Books

1. Mc Cabe W. L. & Smith J. C. " Unit Operation for Chemical Engg." 5th Edition.
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

After learning the course, the students should be able to

1. To build basic knowledge of various mechanical operations.
2. To review the practical importance and relevance of unit operations used for crushing, grinding and size separation in chemical industry.
3. To define the properties of solid and to select suitable size reduction equipment
4. To analyze mixing processes and solid-solid separation method
5. To understand fluid particle system, solid liquid separation process.

Mechanical Operation Lab

Course Code: CHC – 207 (PR)

Practical: 04 Hours/week **Total Credits: 02**

Course Contents:

1. Study of the properties of solid.
2. Calculation of critical speed of ball mill and grinding of given sample.
3. Calculation of power consumption for crushing operation in Hammer mill.
4. Study of relationship between drag coefficient and modified Reynolds number for spherical body falling through fluid for Stokes law region.
5. Study of Batch sedimentation process.
6. Calculation of efficiency of cyclone separator.
7. Study of sigma mixture.
8. Study of filtration process in basket centrifuge.

Text/ Reference Books

1. Mc Cabe W. L. & Smith J. C. " Unit Operation for Chemical Engg." 5th Edition.
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

1. Ability to calculate the properties of solid
2. Analysis of the performance of size reduction equipment
3. Ability to analyze separation process for solid liquid system.
4. Ability to analyze separation process for Gas solid system.

Course Title: Engineering Workshop

Course Code: ESC – 206

Theory: 01 Hrs / Week **Credits: 01**

Course Objective:

In workshop practice, students will get familiar with use of different workshop practices like fitting, welding, tin smithy, black smithy, foundry and computer hardware workshop. Students will also get familiar with different tools, machines, equipment, and job holding devices, job drawing, job material, job manufacturing operations and processes in different workshops.

Course Contents:

Unit - I

Manufacturing Methods: Casting: Pattern Making, pattern materials, pattern allowances, Types of sand. Moulding hand tools, defect in casting.

Forming: Hot working and Cold working, forging, Drawing, Rolling, Extrusion

Machining: Lathe machine, Its major parts & operations (5)

Unit – II

Joining: Welding: (Arc welding, TIG, MIG & Gas welding, types of flames), Brazing, riveting & fastening

Advance manufacturing methods: Electrical discharge machine(EDM), laser beam welding(LBM)CNC machining: Introduction.

Fitting operation: Marking, measuring, filling, drilling, tapping, Power tool: Power hacksaw machine, Bench grinder Machine. (5)

Unit – III

Carpentry: Timber, Measuring & Marking tools, cutting tools, planning tools, boring tools, striking tools, holding tools. Use of plastics & composites as engineering materials.

Plastic Moulding: Injection moulding.

Metal casting: die casting, its advantages & dis advantages, (5)

Text/Reference Books

1. ’Elements of Workshop Technology Vol I & Vol II: Hajara Chaudhari S. K, Hajara Chaudhari A. K, Nirjhar Roy S. K, Media promoters & publishers pvt. Ltd., Mumbai
2. Manufacturing Engineering &Technology: Kalpakjin S. & Steven S. Schmid, 4th addition Pearson education India. Edition,2002
3. ’Manufacturing Technology: Gouri E. Hariharan & A. Suresh Babu, I Pearson education 2008
4. ’Processes & Material of manufacture’s: Roy A. Lindber, 4th edition, Prentice hall India 2008
5. Manufacturing Technologies I & II: Rao P. N. Tata McGraw-Hill house 2017

Course Outcomes:

Upon completion of this course, the students will gain knowledge of the different manufacturing processes which are commonly employed in industries, to fabricate components using different materials.

Course Title: Engineering Workshop Lab

Course Code: ESC – 206

Practical: 04 Hrs / Week **Credits: 02**

Workshop Practice: (Any Five)

1) Machine Shop: Turning- Facing, plain turning, Step turning & Taper turning.
2) Fitting: Filling, Drilling & Tapping
3) Carpentry: (Halving, Mortise & Tenon, Bridle, Butt, Dowel, Dovetail) any one.
4) Electrical & Electronics: Common house wiring connection
5) Welding Shop: (Butt, Lap, Corner, T) Any one
6) Piping (Any Joint)
7) Plastic Moulding: Injection moulding

Examination could involve the actual fabrication of simple components, utilising one or more of the techniques covered above.

Laboratory outcomes:

1) Upon completion of this laboratory course, students will be able to fabricate components with their own hands.
2) They will also get practical knowledge of dimensional accuracies & dimensional tolerances possible with different manufacturing processes.
3) By assembling different component, they will be able to produce small devices of their interest

Course Title: Technology of Pigments
Course Code: PTC-202 (TH)

Theory: 03 Hours/week **Total Credits: 03**

Course Prerequisite: Introduction to Coating Technology

Course Objective:
The Technocrat will learn the chemistry and technology of manufacture, characterizations 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, vapor 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 color striking, toners and lake formation. Intermediates: A 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. (8 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, zinc phosphate, white molybdate, calcium plumbate, etc. Green approaches (8 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 pigments. (8 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, monoazometallized pigments, lithol reds, perinone and perylene reds, BON acids coupled with diazo compounds, Naphthol reds, alizarine red, thioindigo red, etc. (8 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. Indathroneblue, Pigment Green B, Carbazole/ Dioxazineviolet, 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. (8 hrs)

Text/ Reference books:

1. Braun, J. H., White Pigments, Federation of Societies for Coatings Technology, Blue Bell, PA, 1995.
2. Herbst, W.; Hunger, K., Industrial Organic Pigments, 3rd ed., Wiley-Interscience, New York, 2004.
3. Lewis, P. A., Ed., Pigment Handbook, 2nd ed., Vol. I, Wiley-Interscience, New York, 1988.
4. Lewis, P. A., Organic Pigments, FSCT, Blue Bell, PA, 1995.
5. Gunter Buxbaum, Industrial Inorganic Pigments, Wiley VCH; 1998
6. Hugh M. Smith, High Performance Pigments, Wiley-VCH Verlag GmbH 2013
7. E B Faulkner and R J Schwartz (Ed), High Performance Pigments Wiley-VCH, Weinheim 2009

Course Outcomes:

On completion of this course, the technocrat will exhibit

1. An acquaintance of raw materials, general methods of processing and testing of inorganic pigments, organic dyestuffs and extenders.
2. Understanding of chemical constitution and polymorphism in relation to color development and visualization.
3. In-depth knowledge of methods of manufacture of important pigments.
4. Awareness of recent developments, eco-friendly trends, good manufacturing practices and future challenges in relation to prime pigments.

Technology of Pigments Lab
Course Code: PTC-202 (PR)

Theory: 03 Hours/week **Total Credits: 1.5**

Course Prerequisite: Introduction to Coating Technology

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 the following:

1. Identification of pigments, spot tests for organic pigments,
2. Evaluation of following pigmentary properties: Hiding power, Oil absorption, Refractive Index, Tinting Strength, Reducing power, Mass-tone, color permanence, resistance to bleeding in solvents, oils and resins, particle size, specific gravity and bulking value, resistance against acids, alkalis and different chemicals, Shade matching, etc.
3. 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, Phthalocyanine blue, Toluidine Red, carbon black, $CaCO_3$, $BaSO_4$, etc. Synthesis of nanopigments.

Text/ Reference books:

1. Braun, J. H., White Pigments, Federation of Societies for Coatings Technology, Blue Bell, PA, 1995.
2. Herbst, W.; Hunger, K., Industrial Organic Pigments, 3rd ed., Wiley-Interscience, New York, 2004.
3. Lewis, P. A., Ed., Pigment Handbook, 2nd ed., Vol. I, Wiley-Interscience, New York, 1988.
4. Lewis, P. A., Organic Pigments, FSCT, Blue Bell, PA, 1995.
5. Gunter Buxbaum, Industrial Inorganic Pigments, Wiley VCH; 1998
6. Hugh M. Smith, High Performance Pigments, Wiley-VCH Verlag GmbH 2013
7. E B Faulkner and R J Schwartz (Ed), High Performance Pigments Wiley-VCH, Weinheim 2009

Course Outcomes:
On completion of this course, the technocrat will develop laboratory skills and good practices related to

1. The techniques of purification of pigments and extenders
2. Empirical skills for the synthesis of inorganic pigments, organic dyestuffs, and extenders.
3. Analytical skills for characterization and testing of inorganic pigments, organic dyestuffs, and extenders.