Syllabus of Third Year

B. Tech. (Chemical Engineering)

(Revised Syllabus w. e. f. 2020-2021)

Faculty of Science and Technology

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

(Academic Year 2020 – 21)

Third Year B.Tech.(Chemical Engineering)
Revised Syllabus w.e.f. 2020-21
Semester-V

Course Code	Course Title	Teaching Hours	Tutorial	Credits	Practical Hours	Credits	Total Credits
CHC-307	Particle & Fluid Particle Processing	03	-	03	03	1.5	4.5
CHC-308	Mass Transfer – I	03	01	04	03	1.5	5.5
CHC-309	Chemical Reaction Engineering – I	03	01	04	03	1.5	5.5
HML-309	Psycho-Social Dimensions of Industrial Management	03	-	03	-	-	3.0
Elective–I	Open Elective	03	-	03	-	-	3.0
CHC-310	Numerical Method in Chemical Engineering	02	-	02	02	01	3.0
NC-303	Essence of Indian Traditional Knowledge	-	-	-		NC	NC
Total Credit							**24.5**

Semester-VI

Course Code	Course Title	Teaching Hours	Tutorial	Credits	Practical Hours	Credits	Total Credits
CHC-311	Chemical Reaction Engineering – II	03	01	04	03	1.5	5.5
CHL-312	Process Design and Project Management	03	-	03	-	-	3.0
CHC-313	Mass Transfer–II	03	01	04	03	1.5	5.5
Elective II	Open Elective	03	-	03	-	-	3.0
Elective III	Professional Elective Courses	03	-	03	-	-	3.0
Total Credit							**20.0**

List of Electives

Elective I (Open Elective)

FTL-305 Advanced Technology in Food Packaging
OTL-305 Technology of Perfumery and cosmetics
PTL-305 Specialty Pigments and Additives in Coatings
PLL-304 Polymer Rheology
CHL-320 Nanoscience and Nanotechnology

Elective II (Open Elective)

FTL-306 Treatment and Disposal of Food Industrial Waste
OTL-306 Biochemistry & Biotechnology of Lipids
PTL-306 Technology of Printing Inks
PLL-305 Plastics Waste Management
CHL-321 Water Conservation and Management

Elective III (Professional Core Elective)

CHL-322 Environmental Pollution and Control
CHL-323 Petroleum Refining Engineering

Course Title: Particle and fluid particle processing

Course Code: CHC-307

Theory: 03 Hours/ week (Teaching Hours: 03, Tutorial: 00) **Total Credits: 03**

Course Prerequisite: Material and energy balance computations, Fluid Mechanics Course

Course Objectives:

The objective of this course is to make student well acquainted with basic principles of various operations used for fluid particle processing, 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: Law of crushing, Size reduction equipment for coarse, intermediate & fine size reduction; Numerical based on energy & power requirement; open & closed loop circuit.

UNIT - II

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

UNIT -III

Flow Past Immersed Bodies: Drag coefficient, Stokes law, Cozeny- Carman equation. Flow of Solids Through Fluids: Calculation of terminal settling velocity for various Re Number region, maximum settling velocity, free & hindered settling conditions. Fluidization: Minimum fluidization velocity, types of fluidization, application of fluidization such as catalytic cracking, drying, etc.; Relation between pressure drop gradient with fluidizing velocity.

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.

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.

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 Outcomes:

After learning the course, the students should be able

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

Particle and fluid particle processing Lab

Course Code: CHC-307 (PR)

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

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.

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 and Gas solid system.

Course Title: Mass Transfer – I
Course Code: CHC – 308

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

Course Pre-requisite: Transport Phenomena

Course Objective:

Objective of this subject is to expose students to understand the basic mass transfer operation like diffusion, absorption, drying, humidification and its application to chemical engineering

Course Contents:

Unit - I

Constitutive laws of diffusion; unsteady state diffusion, equimolecular counter diffusion, diffusion in stationary gas. Diffusivities in liquid, vapor and gases. Maxwell's law of diffusion, mass transfer velocities, thermal diffusion.

Unit – II

Interphase mass transfer process - Mass transfer theories/models, Mass transfer and chemical reaction. Dimensional analysis in mass transfer and analogies. Local and average overall mass transfer coefficients, mass transfer correlations. Simultaneous heat and mass transfer.

Unit – III

Absorption: Solubility, choice of solvent, concept of rate approach and stagewise approach, Rate of absorption and mass transfer coefficient, steady state co current and counter current processes: stage wise and differential contacts. Stage efficiency, Number of theoretical stages.

Material balance for transfer of one component - minimum liquid-gas-ratio for absorber. Absorption with & without chemical reaction. Determination of height of columns, transfer units (NTU, HTU) and HETP.

Unit – IV

Gas–Liquid operations - Sparged vessels (bubble columns), mechanically agitated vessels for a single phase and gas liquid contact. Liquid dispersed scrubbers, venturi scrubbers, wetted towers packed towers.

Packed towers: General construction & working, types of packing merits & demerits, operational difficulties, pressure drop & limiting G-L flow rates.

Plate towers: General construction & working, types of plate, merits and demerits, operational difficulties.

Unit – V

Humidification: Wet bulb, dry bulb and adiabatic saturation temperatures, humidification terms and usage of psychometric chart, humidification & dehumidification methods, design procedures and selection criteria along with mass transfer calculations. Types of cooling towers, cooling tower operational characteristics. Drying: Drying mechanism, drying rate curves, estimation of drying time, moisture contents. Drying equipment's- rotary dryers, drum dryers, vacuum dryers, Spray dryer, fluidized bed dryers.

Text/ Reference Books

1. Coulson J.M. and Richardson J.F., "Chemical Engineering Vol. I, II & III", Pergamon Press, New York 1977
2. J. D. Seader and E. J. Henley, Separation Process Principles, Second Edition, Wiley Asia Student Edition.
3. A. L. Hines, R. N. Medox, Mass Transfer: Fundamental and Application.
4. B. K.Dutta, Principles of Mass Transfer and Separation Processes,2nd edition, Prentice Hall of India,2007
5. R. E.Treybal, Mass Transfer Operations, 3rd Edition, McGraw Hill, New Delhi, 1983.
6. A. S. Foust, Principles of Unit Operations, 2nd Edition, Wiley, New York, 1980.
7. W. L. McCabe, J. Smith and P. Harriot, Unit Operations of ChemicalEngineering, 7th Edition, Tata McGraw Hill, India, 2014.
8. C. J. Geankoplis, Transport Processes and Unit Operations, 3rd Edition,Prentice Hall, India, 1993.

Course Outcomes:

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

1. **Recognize** laws of diffusion, **apply** them in mass transfer operation.
2. **Analyse** inter phase mass transfer operation and its design aspects.
3. **Understand** the fundamentals of gas absorption and **estimate** the number of stages in absorption column.
4. **Evaluate** drying rates and moisture content for drying operation and design approach to dryers, cooling towers and humidifiers.

Mass Transfer – I Lab

Course Code: CHC-308 (PR)

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

Objectives:

To provide the hand-in-hand experience of lab-scale experiments on various types of equipment based on the theoretical understanding and its application learned in theory course.

Course Contents:

1. Determination of diffusivity of acetone in air
2. Determination of diffusivity of naphthalene in air.
3. Determination of diffusivity of Acetic acid in water.
4. Determination of rate of drying of given sample
5. Determination of Mass transfer coefficient in wetted wall column.
6. Determination of humidity of air using of psychometric chart.
7. Study the physical absorption in packed bed (HTU/NTU/HETP)
8. Determination of loading and flooding point in packed column.
9. Study Absorption of CO_2 in alkaline solution.

Text/ Reference Books

1. Coulson J.M. and Richardson J.F., "Chemical Engineering Vol. I, II & III", Pergamon Press, New York 1977
2. J. D. Seader and E. J. Henley, Separation Process Principles, Second Edition, Wiley Asia Student Edition.
3. A. L. Hines, R. N. Medox, Mass Transfer: Fundamental and Application.
4. B. K.Dutta, Principles of Mass Transfer and Separation Processes,2nd edition, Prentice Hall of India,2007
5. R. E.Treybal, Mass Transfer Operations, 3rd Edition, McGraw Hill, New Delhi, 1983.
6. A. S. Foust, Principles of Unit Operations, 2nd Edition, Wiley, New York, 1980.
7. W. L. McCabe, J. Smith and P. Harriot, Unit Operations of ChemicalEngineering, 7^{th} Edition, Tata McGraw Hill, India, 2014.
8. C. J. Geankoplis, Transport Processes and Unit Operations, 3rd Edition,Prentice Hall, India, 1993.

Course Outcomes:

1. **Develop** the ability regarding analytical and data interpretation skills.
2. **Understand** the scaling approach of understanding from Experimental to Industry applications.
3. **Plan** an appropriate approach to experiment work and **justify** plans in the light of preliminary findings.
4. **Demonstrate** safe working in the choice of method and apparatus.

Course Title: Chemical Reaction Engineering-I

Course Code: CHC-309

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

Course Pre-requisite: Material and Energy Balance calculations

Course Objective:

1. This course will highlight basic concepts of kinetics and rate laws along with interpretation of rate data.
2. The course will deal with problems involving design & rating of ideal reactors including heat effects, multiple reactions and analysis of non-ideal flow behaviour in the reactors.

Course Contents:

UNIT I:

Reactions and reaction rates - stoichiometry, extent of reactions, conversion, Selectivity
Reaction rate fundamentals - elementary reaction sequences, steady state approximation and rate limiting step theory.

UNIT II:

Analysis and correlation of experimental kinetic data - data collection & plotting, linearization of rate equations, differential and integral method of analysis.

UNIT III:

Ideal reactors - generalized material balance, design equations, graphical interpretation.
Sizing and analysis of ideal batch, mixed (CSTR), plug flow and recycle reactors – solving design equations for constant and variable density systems, reactors in series and parallel.

UNIT IV:

Multiple reactions - conversion, selectivity, yield, series, parallel, independent and mixed series-parallel reactions.

UNIT V: A: RTD theory and analysis of non-ideal reactors.

Text/ Reference Books

1. Elements of Chemical Reaction Engineering by H. Scott Fogler, 2nd Edition, Prentice Hall 2001.
2. Chemical Reaction Engineering by Octave Levenspiel, 3rd Edition, John Wiley & Sons 2001

Course Outcomes:

On completion of the course, Students will be able to

1. **Design** chemical reactors involving heat effects optimally using minimum amount of data
2. **Understand** & Interpret Kinetics data.
3. **Operate** reactors in a safe manner for single and multiple reactions
4. **Analyse** the non-ideality in the reactors

Chemical Reaction Engineering-I Lab

Course Code: CHC-309 (PR)

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

Objectives:

1. This laboratory course provides students, experimental skills of kinetics and rate laws along with interpretation of rate data.
2. The course will deal with experiments involving design & rating of ideal reactors including heat effects.

Course Contents:

1. To study the Rate Law K Determination
2. To study the Rate Law n order
3. To study the Semi Batch Reactor.
4. To study the CSTR – Effect of Volume.
5. To study the CSTR – Effect of Flow Rate.
6. To study the PFR – Effect of Flow Rate.
7. To study the Fluid Bed Reactor.
8. To study 2nd Order Reaction Analysis.
9. To study Reactor in Series.
10. To study the Recycle Reactor

Text/ Reference Books

1. Elements of Chemical Reaction Engineering by H. Scott Fogler, 2nd Edition, Prentice Hall 2001.
2. Chemical Reaction Engineering by Octave Levenspiel, 3rd Edition, John Wiley & Sons 2001

Course Outcomes:

On completion of the course, Students will be able to

1. **Design** chemical reactors involving heat effects optimally using minimum amount of data
2. **Understand** & Interpret Kinetics data.
3. **Operate** reactors in a safe manner for single and multiple reactions

Course Title: Psycho-Social Dimensions of Industrial Management

Course Code: HML – 309

Theory: 03 Hrs / Week **Credits: 03**

Course Objective:

1. To prepare and develop the students for successful career that meets the global Industrial and Corporate requirements.
2. To guide the students about perception and attitude development to excel in organisation setting
3. To provide an environment for students to work on Multidisciplinary projects as part of different teams to develop their team building capabilities like leadership, motivation, teamwork etc.
4. To introduce professional ethics and codes of professional practices in Industry.

Course Contents:

Unit - I

Concept and meaning of organisation behaviour, features & foundations of organisation behaviour, the role of organisation behaviour, theories of organisation behaviour, the behaviour process, innovation & creativity in organization.

Unit – II

Perception: meaning and definition, factors influencing the perception process, perception process, perception and Individual decision making, nature of attitudes, components of attitude, formation of attitudes, functions of attitudes, work related attitudes: job satisfaction & organisational commitment, attitudes, values & organisation behaviour.

Unit – III

Motivation-nature & Importance, Theories of Motivation, Content Theories and Process theories-evaluation & criticism, self-motivation.

Unit IV

Leadership- Nature, Leadership and management, Importance, leadership styles and their implications, trait and behavioural approach of Leadership, decision making-nature, types & conditions of decisions, decision making process & styles.

Unit IV

Nature and sources of ethics, ethical dilemmas, resolving dilemmas, ethical decision making, ways of managing ethics, corporate social responsibility.

Text/Reference Books

1. Organisational Behaviour –K Aswathapa- Himalaya Publishing House
2. Organizational Behaviour – John Martin- International Thomson Business press
3. Organisational behaviour- Mirza S Saiyadain-tata Mcgraw-Hill publishing Co. Ltd

4. Organisational Behaviour –MN Mishra Vikas Publishing House Pvt Ltd
5. Organisation Behaviour- Stephen Robbins-Pearson Publication
6. Management- 6th edition- James A.F.Stoner- Pears Education

Course Outcome:

The successful completion of this course enables the students to:

1. **Develop** the process of individual behaviour and perpetual process along with conditioning of thinking process
2. To **identify** the concept and process of motivation and leadership
3. **Correlate** human behaviour, social skills, innovations, and creativity to improve workplace dynamics.
4. **Develops** the knowledge of ethical considerations and administrative regulations by applying the theories and principles of Management in practice to improve performance of individual employee at a workplace.

Course Title: Advanced Technology in Food Packaging (Open Elective-I)

Course Code: FTL-305 (Open Elective-I)

Theory: - 3 Hrs./week. **Total Credits: - 3.0**

Course objectives:

1. To study basic packaging materials, their properties, types of packaging, sealing and lamination process.
2. To study newer packaging technologies used for food products.
3. To estimate shelf life of packaged products.
4. To study packaging of soft drink and alcoholic beverages.

Course Contents:

Unit I:

Packaging as a method for conservation and protection of foods, different packaging material and their properties including barrier properties, strength properties, optical properties etc. Glass, Aluminium, tin, paper, plastic and composites. Sealing of metallic and plastic containers. Types of food packaging.

Unit II:

Flexible packaging, laminated packaging and retortable pouches and biodegradable packaging material. Concept and calculation of shelf life of laminate, wine in PET, glass bottle; shelf life based on browning, vitamin loss and microbial count in food container. Safety and testing of packaging containers.

Unit III:

Active packaging system: - Packaging requirement for different moisture level food products, Aseptic processing and packaging of fruits & vegetables, milk and milk products.

Unit IV:

Product- Package compatibility: - Microwavable Packaging, MAP of fresh fruit and vegetable, vacuum and MAP of meat and meat products. Packaging of breakfast cereals, bakery and confectionary products.

Unit V:

Packaging of soft drink, alcoholic beverages, distilled spirits, frozen food, future trends in food packaging: intelligent/ smart packaging.

Text/Reference Books:

1. Handbook of food packaging by F. A Paine and H.Y paine., Publisher: Blackis and Son Ltd London (1983)
2. Food Packaging Principles and Practice: Gordon L. Robertson
3. Modern processing and distribution system for food edited by F. A Paine

4. Food and packaging interaction by Risch. S. H., Publisher: American chemical Society, Washington (1991)
5. Packaging materials and containers by Paine . F. A., Publisher: Blackis and sons Ltd, London (1983)
6. Food packaging and preservation: theory and practice by Mathlauthi: M. Publisher
7. Packaging media by Paine F. A., Publisher: Blackis and son Ltd; Bishop Briggs (1977)
8. Food packaging technology (vol. 1.92) by G. Bureau and J. L. Multon., Publisher: Veh New York (1996)
9. Chemistry of Food Packaging by Swalam C.M., American Chemical Society, Washington D. C. 1974.
10. Packaging by Neubaner R.G. Van Nostrand Co. New York.

Course Outcomes:

1. Students will be able to **recognize** and **classify** food packaging materials and their **use**.
2. Students will be able to **differentiate**, Active packaging, Aseptic packaging, MAP, vacuum packaging, smart packaging., microwavable packaging.
3. Students will be able to **estimate** of Shelf life of food packaged.
4. Students will be able to **state** Packaging of, soft drink, alcoholic beverages, frozen food.

Course Title: Technology of Perfumery and Cosmetics (Open Elective-I)

Course Code: OTL– 305 (Open Elective-I)

Theory: - 3 Hrs./week . Total Credits: - 3.0

Course objectives: This course provides a thorough knowledge about different essential oil, perfumery synthetics and cosmetic ingredients. Students shall acquire various extraction methodologies in recovery of essential oils, their physio-chemical properties and applications. Also, the course will cover raw material for different cosmetic preparations.

Course Contents:

Unit I:

Essential oils: Chemistry, source materials, production methods
Production, properties and applications of essential oils (Rose, Jasmine, Khus, Sandalwood, Palmarosa, Lemongrass, Peppermint, Orange).

Unit II:

Physio-chemical properties of essential oils: Colour, specific gravity, refractive index, optical rotation, solubility, congealing point, evaporation residue, acid value and ester value.
Analysis of essential oils: Alcohol, Aldehyde, Ketones and Phenol content.

Unit III:

Grading and standardization of essential oils; common adulterants and their detection.
Perfumery: History and its function, mechanism of smelling, classification & blending of perfume ingredients, perfumery isolates (Menthol, Geraniol and Musk).

Unit IV:

Synthetic perfumery materials and fixatives (Camphor, Thymol, Citral, Vanillin, Cumarin, Benzyl acetate, Benzyl benzoate)
Production, properties and applications: Hair oil & dyes, Shaving creams and Depilatories.

Unit V:

Production, function and properties of cosmetic products: Face cream, Face powder, Talcum powder, Toothpaste/powder, Shampoo, Lipsticks and Nail polish.

Text/Reference Books:

1. Valerie Ann Worwood "The Complete Book of Essential Oils and Aromatherapy"
2. Ernest Guenther "The Essential Oils" Volume-I
3. Sonia Malik "Essential Oil Research" Springer International Publishing
4. "Hand Book of Perfumes with Formulations" Engineers India Research Institute.
5. Nigel Groom "The Perfume Handbook" Springer
6. Steffen Arctander "Perfume and Flavor Materials of Natural Origin"
7. S.K. Singh "Handbook on Cosmetics (Processes, Formulae with Testing Methods)"
8. H. W. Hibbott. "Handbook of Cosmetic Science" 1st Edition

Course Outcomes:

1. **Understand** the fundamental of essential oils and **propose** methods of their production.
2. **Differentiate** the principles behind the physio-chemical analytical techniques in estimation of quality parameters of essential oils.

3. **Devise** the concepts of perfumery, blending of perfumes and **outline** the use of synthetic perfumery materials.
4. **Propose** the production techniques and **illustrate** the functions of ingredients in cosmetics products.

Course Title: Specialty Pigments and Additives in Coatings (Open Elective-I)

Course Code: PTL-305 (Open Elective-I)

Theory: - 3 Hrs./week . Total Credits: - 3.0

Course objectives:

The Paint Technocrat will have in depth exposure to Specialty Pigments and Additives in Coatings.

1. The student will learn about the metallic and pearl effect and changes in pigmentary properties in reference to nano size.
2. The Technocrat will have exposure to Mechanism, dosing and Trade information of coating additives and surfactants.

Course Contents:

Unit I:

Metallic, Interference and Cholesteric Pigments

Aluminum, copper, zinc dust, bronze, nickel stainless steel, lead powders and pastes, Nacreous, luminescent (fluorescent/phosphorescent) pigments-optical principles, substrate free pearlescent pigments, Special effect pigments based on mica (pigments formed by coating of substrates), pigments based on liquid crystal polymer

Unit II:

Functional and Nano Pigments

Antifouling pigments-cuprous oxide, other copper compounds, mercuric oxide, barium metaborate, organotin pigments, Manufacture and properties of nanopigments: alumina, silica, titanium dioxide, iron oxides, zinc oxides, silver, $CaCO_3$, etc. on Nano scale; variables affecting particle size aggregation and crystal structure. Their use as spacing extenders / functional pigments in paints, reinforcing agent in polymers, heat & wear resistant materials, etc.

Unit III:

Surfactants and Surface Additives

Anionic, cationic, non-ionic and amphoteric surfactants; polymeric surfactants, Gemini surfactants, HLB value, CMC, Kraft point. Role of surfactants as- emulsifier, wetting agents, dispersing agents. Surface additives, role of silicone and Fluro surfactants as surface additives flow and levelling control agents, slip additives

Unit IV:

Specialty additives in Solvent Borne Coatings

Antisettling agents, additives for rheology control, adhesion promoters, antiskinning agents, light stabilizers (UV absorbers, antioxidants, HALS), moisture scavengers, hammer and wrinkle finish additives, conductivity control additives etc.

Unit V:

Specialty additives for Water Borne Coating

Auxiliary and coalescing solvents, neutralization agents, thickeners, antifoam, antifreeze-thaw, Preservatives (In- can/film)-fungicides, mildew agents, corrosion inhibitors etc.

Text/Reference Books:

1. Jones, Frank N., Mark E. Nichols, and Socrates Peter Pappas. *Organic Coatings: Science and Technology*. John Wiley & Sons, 2017.
2. Swaraj, Paul. *Surface Coatings: Science and Technology*. J. Wiley & sons, 1985.
3. Karsa, D. R.; Davies, W. D., Eds., *Waterborne Coatings and Additives*, Royal Society of Chemistry,Cambridge, 1995.
4. Buxbaum, Gunter, ed. *Industrial inorganic pigments*. John Wiley & Sons, 2008.
5. Berte, J. N. "*High Performance Pigments*, ed Smith HM." (2002): 27-40.
6. Bieleman, Johan, ed. *Additives for coatings*. John Wiley & Sons, 2008.
7. Herbst, Willy, and Klaus Hunger. *Industrial organic pigments: production, properties, applications*. John Wiley & Sons, 2006.
8. Calbo, Leonard J. *Handbook of coatings additives*. 1987.

Course Outcomes:

Upon completion of the course, the students will learn about:

1. Optical effects and **evaluation** of Metallic, Interference and Cholesteric Pigments in coatings.
2. **Synthesis**, properties and applications of Functional and Nano pigments.
3. **Constructive,** corrective and **comparative** role of various additives in solvent borne, waterborne and other coatings.
4. Dosing and trade information of Additives in Coatings.

Course Title: Polymer Rheology (Open Elective-I)

Course Code: PLL-304 (Open Elective-I)

Theory: - 3 Hrs./week . **Total Credits: - 3.0**

Course objectives:

1. To understand the flow properties of polymers in terms of various models to study viscoelastic behavior of the polymers.
2. To know the thermo viscoelastic behavior of polymers during processing and selection of design of processing device.
3. To understand the processing of various types of polymers, selection of device for processing on the basis of flow properties

Course Contents:

Unit I:

Rheological Principles: Rheological Parameters, relationship between rheological parameters, Rheological systems: purely elastic, viscous, Types of fluids: Newtonian and Non Newtonian fluids, Viscoelastics fluids, Rheological or Constitutive equations.

Unit II:

Viscoelastic Nature of Polymers: Elasticity moduli and their time dependence, static and dynamic experiments to understand the time dependence , tan, its significance and method of determination, models of viscoelasticity, mechanical models such as Maxwell, voight, combinations of Maxwell and voight models to simulate viscoelastic behavior, salient features of molecular theories of viscoelasticity.

Unit III:

Glass Transition, Theories to determine the glass transition i.e. Dillatometric, Heat capacity, measurement, Thermomechanical, Measurement of modulus of elasticity, effect of Tg on molecular mass, kinetic chain flexbility and chemical constituent, Importance of Tg and Tm.

Unit IV:

Viscoelastic behavior of Polymer solution and melts stress-strain curves for Polymers, creep curves of Polymeric material, elastic deformation, irrecoverable follow deformation.
Rubber like deformation, Time-temp superposition (WLF Equation)

Unit V:

Methods to determine shear viscosity by capillary, parallel plate and cone and plate Rheometer, Measurement of normal stresses. Application of rheology to polymer processing.

Text/Reference Books:

1. P.N.Cogswell, Polymer Melt Rheology, A guide for Industrial Practice, George Godwin, Second Edition, 1981.
2. Richard C. Progelhof and James L. Throne, Polymer Engineering Principles, Hanser Publishers, New York, 1993.
3. John M. Dealy and Kurt F. Wissburn, Melt rheology and its role in plastics processing, Chapman, London, 1995.
4. R.S. Lenk, Polymer Rheology, Applied Science, London, 1978.
5. J.D. Ferry, Viscoelastic Properties of Polymers, john Wiley & Sons, New York, 1986.
6. Chang Dae Han. Rheology in Polymer Processing, Academic Press, New York, 1976.
7. R.J. Crawford, Plastics Engineering, Butterworth - Heinemann, Oxford, 1998
8. B.R. Gupta, Applied Rheology in Polymer Processing, Asian Books Pvt. Ltd. 1st Edition, 2005.

Course Outcomes:

At the completion of the course, the student will be well acquainted with the following

1. Flow behavior of the polymers and various models used for **determination** of flow properties.
2. **Design** features of the processing device on the basis of processing parameter as temperature, pressure, shear rate.
3. Proper **selection** of processing equipment with respect to change in polymer, polymer flow properties.

Course Title: Nanoscience and Nanotechnology (Open Elective-I)

Course Code: CHL-320 (Open Elective-I)

Theory: - 3 Hrs./week. **Total Credits: - 3.0**

Course objectives:

The objective of the course is to introduce students about emerging field of Nanoscience and Technology. Students will learn about properties of nanomaterials and their applications.

UNIT-I

Quantum chemistry, Solid state Physics, Nanomaterial & Manufacturing, Renewable energy generation, Nanotechnology in drug delivery, Nanotechnology in cosmetics, Bio-nanotechnology, Nanotechnology & information technology, Nanotechnology in agriculture and food industry, Environmental nanotechnology, Nanotechnology Health risk.

UNIT-II

Synthesis methods of nanostructures: Top-Down and Bottom-up approach of synthesis, Chemical Routes for Synthesis of Nanomaterials: Chemical precipitation and co-precipitation; Sol-gel synthesis; Microemulsions or reverse micelles; Solvothermal synthesis.

UNIT-III

Nanostructures and its applications: Carbon Nanotubes (CNT), Graphenes, Fullerenes, Nano Peapods, Quantum Dots and Semiconductor Nanoparticles Metal-based Nanostructures (Iron Oxide, Silver, Copper Nanoparticles) Nanowires Polymer-based Nanostructures including dendrimers, nanofillers like clay, $CaCO_3$, $CaSO_4$.

UINT-IV

Nanocatalysis: Nanomaterials as catalysts for a variety of homogeneous and heterogeneous catalysis applications. Impact of the intrinsic properties of nanomaterials on catalysis, Various methods like Chemical Reduction Method, Thermal, Photochemical and Sonochemical Reduction Method, Applications of Nanocatalysis in Chemical Industry.

UNIT-V

Characterization techniques in analysing Nanomaterials: Scanning/transmission electron microscopy (SEM/ TEM), XRD, Atomic Force Microscopy, Particle size analyser (PSA) and their applications.

Text/Reference Books:

1. Nanochemistry: A Chemical Approach to Nanomaterials, Geoffrey A. Ozin, Andre C. Arsenault, Royal Society of Chemistry, Cambridge, UK, 2005.
2. Chemistry of nanomaterials: Synthesis, properties and applications C. N. R. Rao, Achim Muller, A. K Cheetham, Wiely-VCH, 2004.
3. Metal Nanoparticles: Synthesis Characterization & Applications, Daniel L. Fedlheim, Colby A. Foss, Marcel Dekker, 2002.
4. Nanostructures and Nanomaterials - Synthesis, Properties and Applications - Cao, Guozhong, Ying Wang, World Scientific, 2011.

5. Nanoparticles and Catalysis: Didier Astruc (Editor), Wiley-VCH Verlag GmbH & Co. KGaA, 2008

Course Outcomes:

Upon completion of the course the students will be able to:

1. **Choose** appropriate synthesis technique to synthesize nanostructures of desired size, shape and surface properties.
2. **Correlate** properties of nanostructures with their size, shape and surface characteristics.
3. **Select** appropriate analytical tools for characterization of nanomaterials.
4. **Appraise** on application of nanomaterials as catalyst.

Course Title: Numerical Method in Chemical Engineering

Course Code: CHC-310

Theory: 02 Hours/ week (Teaching Hours: 02, Tutorial: 00) **Total Credits: 02**

Course Prerequisite: Material and energy balance computations, Fluid Mechanics

Course Objectives:

The objective of the course is to introduce students for formulating and solving mathematical equations of engineering problems using numerical methods and computer programming. Optimization of variables using numerical techniques.

Course Contents:

UNIT- I

Solution of Simultaneous Linear Equation: Gauss Elimination Method, Matrix Inversion Method, Gauss Jordan Method, Jacobi's Iteration Method, Gauss Seidal Method, Relaxation Method, Root finding methods for solution on non-linear algebraic equations: Bisection, Newton Raphson, Regula falsi etc.

UNIT - II

Numerical integration: Trapezoidal rule, Simpson's rule, integration with unequal segments,

Ordinary Differential Equations: Taylor' series method, Runga-Kutta method, Piccard's method, Euler's method

UNIT -III

Size and parameter optimization of Chemical Engineering problems using various numerical techniques.

Reference Books:

1. Gupta, S. K., "Numerical Methods for Engineers, New Academic Science, 2012.
2. S.C. Chapra & R.P. Canale, "Numerical Methods for Engineers with Personal Computer Applications", McGraw Hill Book Company, 1985.
3. R.L. Burden & J. D. Faires, "Numerical Analysis", 7th Ed., Brooks Coles, 2000.

4. Atkinson, K. E., "An Introduction to Numerical Analysis", John Wiley & Sons, 1978.
5. Press, W. H. et al., "Numerical Recipes in C: The Art of Scientific Computing, 3rd Edition, Cambridge University Press, 2007.

Course Outcomes:
On completion of the course students will able to

1. **Develop** and convert chemical engineering problem in terms of mathematical equation and solve those set of equations using various mathematical techniques.
2. Learn about optimization techniques for optimization of various parameters of unit operations and processes.

Numerical Method in Chemical Engineering Lab

Course Code: CHC-310 (PR)

Practical: 02 Hours/ week **Total Credits: 1.0**

Course Objective: The objective of the course is to solve problems in different areas of chemical engineering e.g. fluid flow, heat and mass transfer, chemical reaction engineering etc. using tools like Polymath, excel, Matlab etc.

Course Contents:
Introduction to use of computer for numerical calculations
Solving following types of mathematical equation using tools like Polymath, Excel:

1. Solution of linear algebraic equation
2. Solution of a non-linear equations using bracketing and Newton-Raphson method
3. Numerical integration
4. Solution of system of ODEs /PDEs
5. Parameter optimization and validation through mathematical tools

Reference Books

1. Gupta, S. K., "Numerical Methods for Engineers, New Academic Science, 2012.
2. S.C. Chapra & R.P. Canale, "Numerical Methods for Engineers with Personal Computer Applications", McGraw Hill Book Company, 1985.
3. R.L. Burden & J. D. Faires, "Numerical Analysis", 7th Ed., Brooks Coles, 2000.
4. Atkinson, K. E., "An Introduction to Numerical Analysis", John Wiley & Sons, 1978.
5. Press, W. H. et al., "Numerical Recipes in C: The Art of Scientific Computing, 3rd Edition, Cambridge University Press, 2007.

Course Outcome
After completion of the course student will able to **solve** chemical engineering problems involving Linear and non-linear equations, Ordinary and partial differential equations using mathematical tools.

Course Title: Essence of Indian Traditional Knowledge

Course Code: NC – 303

Course Objectives:

1. The course aims at imparting basic principles of thought process, reasoning and inferencing. with emphasis on sustainability connecting society and nature.
2. To facilitate the students with the concepts of Indian traditional knowledge and to make them understand the Importance of roots of knowledge system.
3. To focus on Indian Knowledge System, Indian perspective of modern scientific worldview and basic principles of Yoga and holistic health care system.

Course Contents:

Unit-I

Introduction to traditional knowledge: Traditional knowledge, nature and characteristics, scope and importance, kinds of traditional knowledge, the physical and social contexts in which traditional knowledge develop, the historical impact of social change on traditional knowledge systems. Indigenous Knowledge (IK), characteristics, traditional knowledge vis-à-vis indigenous knowledge, western knowledge. Indian personalities in traditional knowledge, Linking Science and the Rural

Unit-II

Protection of traditional knowledge: The need for protecting traditional knowledge, Significance of TK Protection, Global Mechanisms of Protection and Sharing, recognition and protection value of TK in global economy, Role of Government to harness TK.

Unit-III

Legal framework and TK: The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006, Plant Varieties Protection and Farmer's Rights Act, 2001 (PPVFR Act); The Biological Diversity Act 2002 and Rules 2004, the protection of traditional knowledge bill, 2016. Geographical indicators act 2003.

Unit-IV

Traditional knowledge and intellectual property: Systems of traditional knowledge protection, Legal concepts for the protection of traditional knowledge, Certain non IPR mechanisms of traditional knowledge protection, Patents and traditional knowledge, Strategies to increase protection of traditional knowledge, global legal FORA for increasing protection of Indian Traditional Knowledge.

Unit-V

Traditional knowledge in different sectors: Traditional knowledge and engineering, Traditional medicine system, TK and biotechnology, TK in agriculture, Traditional societies depend on it for their food and healthcare needs, Importance of conservation and sustainable development of environment, Management of biodiversity, Food security of the country and protection of TK.

Reference Books:

1. Sengupta, Nirmal, Nirmal Sengupta, and Ghosh. *Traditional Knowledge in Modern India*. Springer India, 2019.
2. Jha, Amit. *Traditional knowledge system in India*. Atlantic Publishers & Distributors, 2009.
3. Basanta Kumar Mohanta and Vipin Kumar Singh *Traditional Knowledge System and Technology in India*, Pratibha Prakashan 2012.
4. Kapoor, Kapil, and Michel Danino. "Textbook of" Knowledge Traditions and Practices of India"." *Ancient Science of Life* 32, no. 1 (2012): 59.

E-Resources:

1. https://www.youtube.com/watch?v=LZP1StpYEPM
2. http://nptel.ac.in/courses/121106003/

Course Outcomes:

After completion of the course, the students are expected to:

1. Ability to understand, connect and explain basics of Indian Traditional knowledge modern scientific perspective
2. Know the need and importance of protecting traditional knowledge.
3. Know the various enactments related to the protection of traditional knowledge.
4. Understand the concepts of Intellectual property to protect the traditional knowledge.

Semester-VI (Third Year)

Course Code	Course Title	Teaching Hours	Tutorial	Credits	Practical Hours	Credits	Total Credits
CHC-311	Chemical Reaction Engineering – II	03	01	04	03	1.5	5.5
CHL-312	Process Design and Project Management	03	-	03	-	-	3.0
CHC-313	Mass Transfer–II	03	01	04	03	1.5	5.5
Elective II	Open Elective	03	-	03	-	-	3.0
Elective III	Professional Elective Courses	03	-	03	-	-	3.0
Total Credit							**20.0**

Course Title: Chemical Reaction Engineering - II

Course Code: CHC – 311

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

Course Pre-requisite: Chemical Reaction Engineering - I

Course Objective:

1. This course provides basic understanding of catalysis along with kinetics and mechanistic aspects of catalysis.
2. The course will deal with problems involving Design and Rating of Catalytic Reactors and Gas-Liquid Reactors.

Course Contents:

Unit - I

Introduction to Catalysis, homogeneous and heterogeneous catalysis. Preparation and characterisation of catalysts. Physical and chemical adsorption, Adsorption isotherms, Determination of BET surface area and pore volume of the Catalyst.

Unit – II

Kinetics of solid catalyzed gas phase reaction, Laboratory reactors for catalytic gas solid reactions. Design concepts.

Unit – III

Mass transfer, Diffusion and Chemical reactions in catalysts. Effects of external mass transfer and heat transfer, Effectiveness factor (Thiels Modulus). Design aspects of catalytic reactors.

Unit – IV

Non-catalytic gas-solid reactions, different model for gas-solid reactions.

Unit – V

Gas liquid reactions, film and penetration theories, enhancement factor in gas-liquid reactions, gas-liquid reactors using emfrical indices.

Text/ Reference Books

1. Elements of Chemical Reaction Engineering by H. Scott Fogler, 2nd Edition, Prentice Hall 2001.
2. Chemical and Catalytic Reaction Engineering, Carberry, J. J., Dover Books on Chemistry, 2001.
3. Chemical Reactor Analysis and Design Gilbert F. Froment, Kenneth B. Bischoff, Juray De Wilde, John Wiley & Sons, Incorporated, 2010

Course Outcomes:

On completion of the course, Students will be able to

1) **Understand** basics involved in catalysis for reaction mechanism
2) **Design** catalytic reactors
3) **Identify** regions of mass transfer control and reaction rate control and calculate conversion

Chemical Reaction Engineering - II Lab

Course Code: CHC-311 (PR)

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

Course Objective:

1. This laboratory course provides basic understanding of catalysts along with kinetics and mechanistic aspects of catalysis.
2. The course will deal with problems involving analysis of non-ideal reactors and catalytic reactors.

Course Contents:

1. To study the RTD in CSTR - Pulse.
2. To study the RTD in CSTR - Step.
3. To study the RTD in PFR - Pulse.
4. To study the RTD in PFR - Step
5. To study the Rate of Catalytic Reaction.
6. To study Characterization of Catalysts.
7. To study Non-Catalytic (S/L) Reaction.
8. To Study Differential Reactor Analysis.
9. To study Carberry Type Reactor.
10. To study the Packed Bed Reactor.

Text/ Reference Books

1. Elements of Chemical Reaction Engineering by H. Scott Fogler, 2nd Edition, Prentice Hall 2001.
2. Chemical and Catalytic Reaction Engineering, Carberry, J. J., Dover Books on Chemistry, 2001.
3. Chemical Reactor Analysis and Design Gilbert F. Froment, Kenneth B. Bischoff, Juray De Wilde, John Wiley & Sons, Incorporated, 2010

Course Outcomes:

On completion of the course, Students will be able to

1. **Understand** basics involved in catalysis for reaction mechanism
2. **Interpret** non-ideal behaviour of real reactors.

Course Title: Process Design and Project Management

Course Code: CHL-312

Theory: 03 Hours/ week (Teaching Hours: 03, Tutorial: 00) **Total Credits: 03**

Course Objectives

The objective of the course is to provide students with a firm grasp of the essential principles of Management, Project identification project feasibility and Project Scheduling Technique with Suitable Examples. Students will able to understand HAZOP design and read the PID of the plant. Students will able to understand economics for chemical processes.

Course Contents:

UNIT I

1. Project identification, project feasibility,
2. Project testing based on viability, risk & Cost estimation,
3. Evaluation of project by different methods on the basis of Visibility i) Net Present Value method. ii) Method of Rate of Return on Initial Investment iii) Pay out Period iv) Method of Discount Cash Flow v) Capitalized cost method vi) Internal rate of return method vii) Break Even Chart
4. Evaluation of project by different methods on the basis of Risk i) Profitability Index ii) Demand fore casting iii) Standard Deviation Approach
5. Evaluation of project by different methods on the basis of Cost i) Preparation of Cost sheet and statements ii) Preparation of Profit Loss Statement.

UNIT II

1) New developments in management, CPM & PERT, Principle and Objective of CPM and PERT Network Diagram for calculation Time Duration
2. Linear Programming Problem (Numerical based on each method) i) General simplex method ii) Primary & Dual technique method iii) Direct simplex method iv) Graphical Method.

UNIT III

1. Cost analysis, fixed capital, working capital, Preparation of store ledger account by pricing issue methods. LIFO, FIFO, Simple average, weighted average
2. Depreciation, significance of inadequacy and obsolescence, and depreciation methods.

UNIT IV

1. Layout and location, objective, principle
2. layout and Location factors.
3. Equipment layout diagram (ELD)
4. Tank firm cum utility block diagram for different processes.

UNIT V

HAZOP: Introduction and guide word, application of HAZOP to processes with examples.
PID: Basic symbols for various piping and instruments. Development of PFD, P&ID, PDS for different processes.

Text/ Reference Books

1. Process equipment Design by S.D. Dawande.Denett and Co Fifth Edition
2. Industrial Organization &Management B.V. Pathak & M.S. Mahajan, Nirali Prakashan First Edition 1986
3. Plant Design & Economics for Chemical Engineering by M.S. Peters & K.D.Timmerhaus. Fifth Edition
4. Shreves Chemical Process Industry George J, Fifth Edition 2017
5. Outlines of Chemical Process Technology by Drydens, Third Edition, 1997
6. Plant Utilities by D.B.Dhone Nirali Prakashan, First Edition 2008.

Course Outcome

On completion of course students will be able

1. To **evaluate** feasibility of project.
2. To apply various methods of profitability **evaluation**.
3. To **identify** the new development in project management and optimization techniques.
4. To carry out HAZOP **analysis** for safety of the process.

Course Title: Mass Transfer - II

Course Code: CHC – 313

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

Course Pre-requisites: Mass Transfer – I

Course Objective: Objective of this subject is to expose students to understand the basics of distillation, liquid-liquid extraction, adsorption, leaching and crystallisation and its application to chemical engineering

Course Content:

Unit- I

Distillation of binary mixtures: Vapour – liquid equilibria, governing law's, X-Y, T-X-Y and P-X-Y, H-X-Y diagrams, relative volatility, minimum and maximum boiling azeotropes, Types of distillation, Rayleigh Equation and Rayleigh Equation in terms of relative volatility, azeotropic and extractive distillation.

Unit- II

Lewis-Sorel, McCabe Thiele methods: Multiple feed, side stream, estimation of number of stages required in distillation column. Operating and feed lines, feed conditions, Importance of ratio reflux, minimum and optimum reflux ratio, Underwood-Fenske equation for minimum reflux ratio and Fenske's method for number of plates at total reflux. Tray and column efficiency. Batch distillation-continuous binary fractionation, Packed column distillation: rate-based methods: HETP, HTU, Ponchon Savarit method.

Unit- III

Liquid-Liquid Extraction: fundamentals, solvent selection, triangular diagram representation, Single stage extraction and multistage cross current and counter current extraction Equipment for liquid-liquid extraction. (Mixer settler, Rotating Disc Contractor, Packed column, spray column) equipment selection criteria.

Solid– Liquid Extraction fundamentals, Solvent selection, equilibrium relationship, rectangular diagram representation, calculation of number of stages. Equipment's for solid – liquid extraction, design selection criteria.

Unit- IV

Adsorption and Ion exchange: Types of adsorption, adsorbent, Breakthrough Curves, isotherms, Ion-Exchange Equilibria, Equilibria in Chromatography.

Crystallization: Theory of solubility and saturation, phase diagram (temp/solubility relationship), Supersaturation, Nucleation, Crystal Growth, Population balance analysis, method of moments for rate expressions. evaporative and cooling (rate expressions), Process design of crystallizers and their operation, Crystallisation equipment's.

Unit- V

Special topics in separation: Mechanism of solute/solvent rejection in the process, Types of membrane separation processes, reverse osmosis, ultrafiltration, gas separation, vapour permeation and pervaporation, dialysis, electrodialysis, nanofiltration.

Transport Through Porous Membranes, Resistance Models, Liquid Diffusion through Pores, Gas Diffusion through Porous Membranes, Transport Through Nonporous Membranes.

Text/Reference books:

1. Coulson J.M. and Richardson J.F., "Chemical Engineering Vol. I, II & III", Pergamon Press, New York 1977
2. J. D. Seader and E. J. Henley, Separation Process Principles, Second Edition, Wiley Asia Student Edition.
3. A. L. Hines, R. N. Medox, Mass Transfer: Fundamental and Application.
4. Binay K. Dutta, "Principles of Mass Transfer and Separation Processes", 2nd edition, Prentice Hall of India,2007
5. R. E. Treybal, "Mass Transfer Operations", 3rd Edition, McGraw Hill, New Delhi, 1983.
6. A.S. Foust, "Principles of Unit Operations", 2nd Edition, Wiley, New York, 1980.
7. W.L. McCabe, J. Smith and P. Harriot, Unit Operations of Chemical Engineering, 7th Edition, Tata McGraw Hill, India, 2014.
8. C.J. Geankoplis, "Transport Processes and Unit Operations", 3rd Edition, Prentice Hall, India, 1993.

Course Outcomes

Students will be able to

1. **Analyze** liquid–liquid extraction and **solve** problems on single and multistage extraction.
2. **Interpret** the fundamentals of distillation and **Estimate** the number of stages for distillation column.
3. **Evaluate** adsorption, ion exchange and crystallization technology.
4. **Understand** novel separation techniques

Mass Transfer - II Lab

Course Code: CHC-313 (PR)

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

Course Objectives:

To provide the hand-in-hand experience of lab-scale experiments on various types of equipment based on the theoretical understanding and its application learned in theory course.

Couse Contents:

1. Study Vapour -liquid equilibria (T-X-Y) for given system
2. Verify Rayleigh equation (Differential distillation)
3. Study Steam Distillation
4. Study of operating parameters of fractionating column. (ethanol-water syster)
5. Construct binodal curve for Acetic acid- water-benzene system.
6. Determination of distribution coefficient of Single stage liquid -liquid extraction for Acetic acid- water-benzene system.
7. Single stage solid-liquid extraction for sand -oxalic acid system
8. Study Batch adsorption for acetic acid-water-activated carbon/charcoal
9. Determination of yield crystallisation.
10. Study ion exchange equilibria

Course Outcome

1. **Develop** the ability regarding analytical and data interpretation skills.
2. **Understand** the scaling approach of understanding from Experimental to Industry applications.
3. **Plan** an appropriate approach to experiment work and **justify** plans in the light of preliminary findings.
4. **Demonstrate** safe working in the choice of method and apparatus.

Text/Reference books:

1. Coulson J.M. and Richardson J.F., "Chemical Engineering Vol. I, II & III", Pergamon Press, New York 1977
2. J. D. Seader and E. J. Henley, Separation Process Principles, Second Edition, Wiley Asia Student Edition.
3. A. L. Hines, R. N. Medox, Mass Transfer: Fundamental and Application.
4. Binay K. Dutta, "Principles of Mass Transfer and Separation Processes", 2nd edition, Prentice Hall of India,2007
5. R. E. Treybal, "Mass Transfer Operations", 3rd Edition, McGraw Hill, New Delhi, 1983.
6. A.S. Foust, "Principles of Unit Operations", 2nd Edition, Wiley, New York, 1980.
7. W.L. McCabe, J. Smith and P. Harriot, Unit Operations of Chemical Engineering, 7th Edition, Tata McGraw Hill, India, 2014.
8. C.J. Geankoplis, "Transport Processes and Unit Operations", 3rd Edition, Prentice Hall, India, 1993.

Course Title: Treatment and Disposal of Food Industrial Waste (Open Elective-II)

Course Code: FTL-306 (Open Elective-II)

Theory: - 3 Hrs./week. **Total Credits: - 3.0**

Course objectives:

1. To study composition, sources, permissible and health hazards of industrial wastewater pollutants
2. To study various techniques of wastewater treatment by physical chemical and biological methods
3. To study, design and operational problems of biological treatment and value addition to waste
4. Estimation of kinetic coefficients for treatment with design problem.

Course Contents:

Unit I:

Physical, chemical and biological characteristics of food industry waste. Composition of typical industry waste. BOD /COD and characterization of effluent. Typical BOD of some food industrial effluents and their discharge limit, types and point sources of industrial pollutants and adverse effect by their discharge.

Unit II:

Primary treatment, secondary and tertiary treatments by physical, chemical and biological methods. Process design criteria. Sanitary disposal of sludge.

Unit III:

Role of micro-organisms in food industry waste. Application of kinetics to biological treatment. Determination of kinetic coefficients with some design problems.

Unit IV:

Activated sludge process and modified activated sludge process. Nitrification and denitrification, Aerobic lagoons, aerated aerobic lagoons, aerated facultative lagoons, Design criteria for A.S.P and stabilization ponds

Unit V:

Trickling filters, Rotating biological contactors, design criteria and problem on RBC and trickling filter design. By product recovery and value addition to the waste.

Text/Reference Books:

1. Environmental Pollution Control Engineering – C.S. Rao
2. Wastewater treatment and pollution control -Soli Arceivala and Shyam R Asolekar
3. Food Processing Waste Management – J.H.Green and A. Kramer
4. Wastewater treatment; Bartlett RE; Applied science publication Ltd
5. Wastewater Engineering: Treatment, Disposal and Reuse by Metcalf & Eddy (Second Edition)
6. Handbook of Waste management and co-product recovery in Food Processing – Vol.1- Keith Waldron
7. Food industry waste: Disposal and recovery; Herkza A & Booth RG;1981; Applied science publication Ltd.
8. Environmental Biotechnology; Bhattacharyya B C & Banerjee R; Oxford University press.

Course Outcomes:

1. Student will be able to **explore** composition of industrial effluent and health hazards of pollutants in effluent
2. Student will be able to **recognize** Primary, secondary and tertiary treatment for industrial effluent treatment and **design** parameters
3. The students will be able to access principle, **design** and working of fixed film biological reactor efficiency
4. The student will able to manipulate industrial effluent for recovery of biological as value addition to waste.

Course Title: Biochemistry & Biotechnology of Lipids (Open Elective-II)

Course Code: OTL-306 (Open Elective-II)

Theory: - 3 Hrs./week. **Total Credits: - 3.0**

Course objectives:

This course is designed to gain the insights about various bio-simulated reactions, pathways, and mechanisms in natural way. Also, the use of enzymes for synthetic modification and applications several fatty products will be studied. Environmental issues from bio-technological industries will also be discussed.

Course Contents:

Unit I:

Biosynthesis of fatty acids and phospholipids; Mechanism of chain elongation and desaturation of acyl chains; Regulation of lipid metabolism; Biological role of fat in human nutrition; Atherosclerosis.

Unit II:

EFA, MUFA, PUFA –Sources and biological activities in human health; Biochemical aspects of vitamins in nutrition; Toxic constituents in oilseeds and oils: Sources, structures, toxicological effects and methods of detoxification.

Unit III:

Microbial production of fats and other lipids; Biotransformation of fats and lipids using whole microbial cells; General aspects of Microbial Lipases: Sources, isolation and purification and industrial applications

Unit IV:

Enzymatic Interesterification: Chemistry, reaction in (aqueous/organic) solvent systems, immobilization of enzymes, factors affecting enzyme activity, enzyme kinetics, reactor design.

Unit V:

Structured lipids: Synthesis, analysis and applications
Genetically modified lipids: Physical, chemical and nutritional functionality modifications.
Environmental biotechnology concept: Principles in bioremediation and biological water & waste treatment.

Text/Reference Books:

1. Lehninger's Principles of Biochemistry by David L Nelson; A.L.Lehninger and Michael M. Cox, 5th edition, Worth Publishing.
2. Outline of Biochemistry by Eric.E. Conn and P.K. Stumpf, 5thedition, Wiley India.
3. Lipids: Biochemistry, Biotechnology and Health, 6th Edition by Michael I. Gurr, John L. Harwood, Keith N. Frayn, Denis J. Murphy, Robert H. Michell, Wiley-Blackwell
4. Fatty Acids in Fish Oğuz Taşbozan and Mahmut Ali Gökçe http://dx.doi.org/10.5772/68048
5. Food Lipids Chemistry, Nutrition, and Biotechnology, Fourth Edition Edited Casimir C. Akoh Taylor & Francis Group

Course Outcomes:

1. **Acquire** the fundamental knowledge of scholarly discourse in lipid synthesis, **recognize** the biological roles vitamins and **examine** the toxicology of lipid components.
2. **Combine** the theories and concepts of microbial lipase in industrial applications.
3. **Illustrate** the critical skills in solving the reaction kinetics and optimizing the enzymatic process.
4. **Differentiate** between structured and genetically modified lipids and **identify** ethical issues in environmental bioremediation.

Course Title: Technology of Printing Inks (Open Elective-II)

Course Code: PTL-306 (Open Elective-II)

Theory: - 3 Hrs./week. **Total Credits: - 3.0**

Course objectives:

The Paint Technocrat will have in depth exposure to

1. Formulation and manufacture of Printing Inks.
2. Various techniques of printing processes.
3. Different applications of printing inks

Course Contents:

Unit I:

Nature of Printing ink, Visual characteristics of inks, Major printing systems, classification and characteristics of printing inks, mechanism of ink drying, adhesive nature of printing inks, resistance properties of printing inks, physical chemistry of printing inks, rheological properties of inks principles of printing

Unit II:

Description and schematic diagram of printing processes, press configuration and applications e.g. Flexographic, lithographic, gravure, letterpress, planographic, screen, Inkjet printing, substrate selection principles of ink formulations, colour matching and process printing.

Unit III:

Manufacture of inks, manufacturing process, mixing equipment such as High-speed impeller, butterfly mixer, Rotor and stator high speed mixer and milling equipments such as three roll mill, bead mill etc. handling, storage and manufacture of UV ink, newspaper inks, modern production trends and future of inks.

Unit IV:

Inks for various substrates: paper, plastic, fabric, leather, glass and metal. Testing & Evaluation of finished ink and raw materials for ink manufacture. Inks for Newspaper (rotary and well offset), publication work, posters, labels, and packaging materials, heat set and quick set inks for multicolor printing.

Unit V:

Metal decorating inks, after print varnishes and lacquers, magnetic inks, ceramic inks, inks for printed circuit boards, inkjet printing, laser printing, dot-matrix printing, and other miscellaneous inks. Identification of various ink troubles and remedial measures

Text/Reference Books:

1. Jones, Frank N., Mark E. Nichols, and Socrates Peter Pappas. *Organic Coatings: Science and Technology*. John Wiley & Sons, 2017.
2. Leach, Robert. *The printing ink manual*. Springer Science & Business Media, 2012.
3. Thompson, Robert. *Printing materials: science and technology*. Pira International, 2004.
4. Flick, Ernest W. *Printing ink and overprint varnish formulations*. William Andrew, 1999.

Course Outcomes:

Upon completion of the course, the students will learn about:

1. Nature, characteristics and classification of printing inks.
2. Principles of ink formulations and manufacture of Inks for various substrates
3. Press configuration and applications of printing inks
4. Comparison and selection of various printing processes

Course Title: Plastics Waste Management (Open Elective-II)

Course Code: PLL-305 (Open Elective-II)

Theory: - 3 Hrs./week. **Total Credits: - 3.0**

Course objectives:

1. To understand the concept of plastics recycling.
2. To understand about various sources of plastics waste.
3. To understand various identification and separation method for waste plastics.
4. To learn about different recycling methods for plastics recycling.

Course Contents:

Unit I:

Introduction, Sources of plastics waste (Industrial waste, post consumer waste, scrap waste and nuisance waste), Plastic identification and Separation techniques – (density - float sink and froth floatation methods, optical, spectroscopic, electrostatic, sorting by melting temperature, sorting by size reduction, sorting by selective dissolution and other methods), recycling codes.

Unit II:

Plastics Waste Management - 4R‟s approach (reduce, reuse, recycle – mechanical and chemical, recover),recycling classification- - primary - secondary - tertiary - quaternary recycling with examples. Energy from waste – incinerators-pyrolysis, factors affecting incineration.

Unit III:

Recycling of polyolefins - PVC, PET, polystyrene, polyamides-nylon-6 and nylon-6,6, polyurethanes, mechanical process, applications of recycled materials.

Unit IV:

Recycling of rubber – comparison of thermoset and thermoplastic composites, reclaiming of rubber – fuel source – pyrolysis, Depolymerisation of scrap rubber, tyre retreading, uses of recycled rubber – asphalt and other uses.

Unit V:

Recycling of plastics by surface refurbishing - coating application, influence on plastics properties by coating, polishing of the plastics surface, commercial process. Plastics aging - environmental aging, thermal aging, weathering of plastics, mechanical degradation, chemical degradation and environmental stress cracking, wear and erosion, influence of plastic aging in recycling, energy from waste - incinerators

Text/Reference Books:

1. John Scheirs., - "Polymer Recycling Science, Technology and applications" John Wiley and Sons, 1998
2. Nabil Mustafa – "Plastics Waste Management Disposal Recycling and Reuse" Marcel Dekker Inc., First Edition 1993.
3. Steven Blow, Handbook of Rubber Technology, Galgotia Publications Pvt. Ltd., New Delhi, 1998.
4. Chandra R. and Adab A., Rubber and Plastic Waste, CBS Publishers & Distributors, New Delhi, 1994.
5. Muna Bitter, Johannes Brandup, Georg Menges "Recycling and Recovery of plastics" 1996
6. Attilio.L.Bisio, Marino Xanthos, "How to manage plastics waste: Technology and market Opportunities" Hanser Publishers, 1994
7. Francesco La Mantia., "Handbook of Plastics Recycling" Chem Tec Publishing,2002

Course Outcomes:

At the end of the course students will have knowledge of:

1. Sources of plastics waste, its identification and separation methods.
2. Approaches of plastic waste management
3. Mechanical and chemical recycling of polymers.
4. Recycling of plastics by surface refurbishing.

Course Title: Water Conservation and Management (Open Elective-II)

Course Code: CHL-321 (Open Elective-II)

Theory: - 3 Hrs./week. **Total Credits: - 3.0**

Course objectives:

The Objective of this course is to

1. Understand current water scenarios
2. Need for water conservation and management
3. Strategies for water conservation from source to sink in different sector.

Course Contents:

Unit I:

Introduction: water cycle, water storage, water quality. Water conservation, Current Demand of water for Domestic, Irrigation and Industries.

Current supply available, Shortage of water, water conservation process and ways to conserve water.

Unit II:

Understanding water conservation and water quality parameter like TDS, pH, etc. Water management-water quality, controlling use and quality of water, water flow management, water quality control, testing water salinity, preserving water quality. Managing water quality in different sectors.

Unit III:

Water conservation in agriculture-Reuse of wastewater for irrigation (Methods, Precautions), Irrigation system (Components) and Water user's participation in irrigation system management. Current Supply, utilization and shortage of water

Unit IV:

Water conservation in construction industry: Importance of saving water in the construction industry in India, reduce and recycle water at construction sites, saving water during wall construction.

Unit V:

Water Conservation in process industry: Water treatment, recycling, and reuse

Water saving equipment, economics of water, minimising evaporation, water audits.

Text/Reference Books:

1. Irrigation Engineering-R.K. Sharma and T.K. Sharma, S.Chand & Company Ltd., New Delhi.
2. Water Resources Systems: Modeling Techniques and Analysis Vedula, S.and Mujumdar, (2005); Tata McGraw Hill, New Delhi.
3. Economics of Water Resources Planning, James, L.D., and Lee, R. R., Mc Graw Hill.
4. Agriculture and water management, P.Verma, Amiga Press Inc.
5. Industrial water treatment process technology, Parimal Pal, Elsevier Science.

Course Outcomes:

On completion of the course,

1. Students would able to **understand** the importance of water conservation and management in different sectors.
2. Students would able to **identify** the thrust area for water conservation and develop management strategies to achieve it.
3. Students would able to effectively implement the **developed** strategies.

Course Title: Environmental Pollution and Control (Professional Elective-III)

Course Code: CHL-322 (Professional Elective-III)

Theory: - 3 Hrs./week. **Total Credits: - 3.0**

Course objectives:

1. To provide detailed knowledge on the discharge of pollutants, either of natural or of anthropogenic origin, into the environment that can induce severe stresses on ecosystems and their inhabitants.
2. To train students to act as experts in the area of reducing and remediating the impact of wastewater and air pollution.
3. To introduce theoretical and practical principles of natural purification processes and technological processes to control discharges which drive purification and remediation technologies, with reference to the legislative framework concerned with safeguarding the environment and human health.
4. To impart knowledge to enable students to critically review modern technology and practices for the monitoring, prevention, treatment and disposal of wastewater and air pollutants.

Course Contents:

Unit I:

Sources and pathological effects of CO_2, SO_2, NO_2, H2S and volatile organic emissions; Classification of particulate matter on the basis of particle size ; standards for clean air; Mechanism and remedial measures of photochemical Smog, Green House Effect and Ozone layer depletion.

Unit II:

Factors affecting stability of Dispersion & temperature inversion; Methods for control of particulate matter Design, construction and operation of Gravity Settler, Cyclone separators, Electrostatic precipitators, Fabric Filters, Venturi scrubbers, Spray and Packed bed tower. Problems on Design, Comparative performance evaluation. Removal of gaseous pollutants by absorption by liquids and adsorption by solids, control of volatile organic emission.

Unit III:

Primary and secondary wastewater Treatment Techniques:

Physical characterization of wastewater (Colour, odour, turbidity, MLSS, Dissolved solids etc.); Principle and significance of determination of BOD, COD, DO, TOC; Use of electrochemical analyzer and atomic absorption spectrometer in determination of elements; estimation of phosphorous and nitrogen.

Primary Treatment Techniques (Neutralization, equalization, segregation, flocculation, micros trainers etc.) & Secondary Treatment techniques (Aerobic & Anaerobic using different filters/contactors).

Unit IV:

Tertiary/ Advanced Wastewater Treatment Techniques and Solid Waste Pollution:

Methods of sampling and analysis of SO_2, NO_2, & CO_2, ; Principle and utilization of Adsorption, Ion Exchange, Electrodialysis, reverse osmosis, ultra-filtration in wastewater treatment. Overall layout of

Municipal (Domestic) and Industrial Effluent Treatment Plant Techniques for handling, disposal and control of solid waste pollutants (Composting, dumping, incineration, physical and chemical recycling).

Unit V:

Pollution control strategies in selected Food, Pharmaceutical & Chemical Industries: Beverages, Distillery, Sugar, Canning, Dairy; Antibiotics (Penicillin, Cephalosporin; etc.), Sulpha Drugs, Petroleum Refinery and Petrochemical Industries.

Text/Reference Books:

1. "Pollution Control in Process Industries" by S.P. Mahajan MC Graw Hill
2. "Environmental Pollution Control Engineering" by C. S. Rao.
3. "Wastewater Treatment" M. Narayanrao & A.K. Dutta, IBH Publicaiton Co Pvt. Ltd., Delhi.
4. "Wastewater Engineering" Mc Catta , Mc Gvaw Hill.
5. "Air Pollution Control", P. Pratap Mouli and N. Venkata, Diva Jyoti Prakashan, Jodhpur.
6. Physico- Chemical Process for water quality control, W.J. Weber, Wiley Interscience- 1972.

Course Outcomes:

After successfully passing the course, graduate will be able to:

1. **Identify** sources, types and quantities of pollutants and determine their impact on the environment
2. **Identify** and propose strategies and techniques for the management and control of pollution.
3. **Design** equipment's for control of pollutants in various sectors.

Course Title: Petroleum Refining Engineering (Professional Elective-III)

Course Code: CHL-323 (Professional Elective-III)

Theory: - 3 Hrs./week. **Total Credits: - 3.0**

Course objectives:

1. To study about crudes, different petroleum products.
2. To study the basic petroleum properties, testing method, use and applications.
3. To study various distillation techniques, operations catalytic and thermal process.

Course Contents:

Unit I:

Occurrence, Origin and formation, Composition. Hydrocarbon group wise compositions of Petroleum & their structures, sulfur, nitrogen, oxygen & metal-organic compound in petroleum. Paraffins, olefins, acetylenes, naphthenes, aromatics and their general properties

Unit II:

Evaluation of petroleum, Characterization & properties of Crude oil, Gasoline and specifications, test for gasoline like ASTM Distillation, octane number, Reid vapor pressure.

Unit III:

Specifications of kerosene, Properties of kerosene flash and fire point, smoke point, aniline point, specifications of High Speed Diesel, properties like cetane number, diesel index, pour point, fire point, flesh point.

Unit IV:

Major petroleum products like Liquified Petroleum Gas , , Aviation turbine fuel, ,LDO, furnace fuels, lubricants, base oil, tar & biumen, asphalts, resin. Crude Distillation, Atmospheric Topping unit, arrangements of towers, top tray reflux, pump back reflux, pump around reflux and design aspects.

Unit V:

Vacuum distillation Unit, vacuum tower operating parameters. Catalytic Cracking and thermal cracking processes, Fluidised bed Catalytic Cracking, Catalytic Reforming process. Techno-economic aspects of optimum refining scheme.

Text/Reference Books:

1. J.H Gary, & G.E .Handwerk, Petroleum Refining: Technology& Economic 3rdedition, Marcel Dekker Inc.1994
2. Modern petroleum refining processes B.K.Bhaskara rao Oxford & IBH Publ.co.pvt.lt.
3. Equipment Design handbook for Refineries & chemical plants by Frank l. Evans, Gulf Publishing Company
4. Petroleum Refinery Engineering by W. L. Nelson, Mc Graw Hills
5. Petroleum Processing, Principles & Applications by R. J. Hengatabis, Mc Graw Hills

Course Outcomes:

After successfully passing the course, graduate

1. Students able to **understand** basic concepts of Petroleum Refining Engineering.
2. Students able to know different petroleum products, their properties and uses.
3. Students **understand** about major operations carried out in Petroleum industries.
4. This course provides the **knowledge** of various petroleum processes