Syllabus of Third Year

B. Tech. (Plastics Technology)

(Overall Structure and 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)

B. Tech. (Plastics Technology) 3rd Year Revised Syllabus w.e.f. 2020-21							
Fifth Semester B. Tech. (Plastics Technology)							
Course Code	**Title of Course**	**Teaching Hours**	**Tutorial**	**Credits**	**Practical Hours**	**Credits**	**Total Credits**
CHL-314	Mass Transfer Operations	03	-	03	-	-	03
CHP-315	Mass & Momentum Transfer Operations	-	-	-	03	1.5	1.5
CHL-312	Process Design and Project Management	03	-	03	-	-	03
PLC-301	Plastic Materials and Applications-I	03	-	03	03	1.5	4.5
PLC-302	Processing of Plastics-I	03	-	03	03	1.5	4.5
Elective- I	Open Elective	03	-	03	-	-	03
NC-303	Essence of Indian Traditional Knowledge	-	-	-	-	NC	NC
						Total	**19.5**

Sixth Semester B. Tech. (Plastics Technology)							
Course Code	**Title of Course**	**Teaching Hours**	**Tutorial**	**Credits**	**Practical Hours**	**Credits**	**Total Credits**
CHL – 316	Chemical Reaction Engineering	03	01	04	-	-	04
HML-309	Psycho-social Dimensions of Industrial Management	03	-	03	-	-	03
PLC-303	Plastic Materials and Applications-II	03	-	03	06	03	06
Elective-II	Open Elective	03	-	03	-	-	03
Elective-III	Professional Core Elective	03	-	03	-	-	03
						Total	**19**

List of Electives

Elective I (Open Elective)

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

Elective II (Open Elective)

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

Elective III (Professional Core Elective)

PLL-306 Mould and Die Design
PLL-307 Technology of Elastomers and Additives

FIFTH SEMESTER

Course Code	**: CHL-314**
Course Title	**: Mass Transfer Operations**
Course Type	**: Theory**
Total Hrs/week	**: 03 hr (TH)**
Course Credit	**: 03**

Course objectives:
Objective of this subject is to expose students to understand the basic mass transfer operation like diffusion, absorption, drying, humidification distillation, liquid-liquid extraction, adsorption, leaching and crystallization and its application to chemical engineering.

Pre-requisites:
Material and energy Balances Computations (CHL-206)

Course Content:

Unit-I
Constitutive laws of diffusion: Equimolecular counter diffusion and diffusion in stationary gas; Diffusivities in liquid, vapor and gases; Local and average overall mass transfer coefficients
Interphase mass transfer process: Mass transfer equilibrium, Mass transfer theories, Mass transfer and chemical reaction
Material balance: Steady state co-current and counter current processes, stage wise and differential contacts, Number of theoretical stages, Stage efficiency, Height of transfer units.

Unit-II
Distillation of binary mixtures: Vapor–liquid equilibria, Raoult's law, X-Y, T-X-Y & H-X-Y diagrams, Boiling point diagram and azeotropes
Types of distillation, Fractionating column and multistage column, MaCabe-Thiele method, Operating and feed lines, feed conditions, reflux ratio, minimum and optimum reflux ratio, Tray and column efficiency.

Unit-III
Absorption: Solubility, choice of solvent, concept of driving force and mass transfer coefficient, Material balance for transfer of one component -counter current and concurrent flow, minimum gas-liquid ratio for absorber. absorption with & without chemical reaction. Determination of height of columns, transfer units and HETP.
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 IV
Liquid-Liquid Extraction: fundamentals, solvent selection, triangular diagram representation, Single stage extraction- maximum and maximum solvent, 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, triangular diagram representation, single stage operation,

Unit-V

Crystallization: Theory of solubility and crystallization, phase diagram (temp/solubility relationship), methods of achieving Supersaturation, phenomenon of crystal formation, crystal structure. Material & heat balance over crystallizer & related problems.

Drying: Drying mechanism, Constant rate and falling rate periods, drying rate curves, estimation of drying time, moisture contents, drying equipments- rotary dryers, drum dryers, vacuum dryers, Spray dryer, fluidized bed dryers.

Text/ Reference Books

1. Dutta, Binay K. *Principles of mass transfer and seperation processes*. PHI Learning Pvt. Ltd., 2007.
2. Treybal, Robert E. "Mass transfer operations." *New York* 466 (1980).
3. Cussler, Edward Lansing, and Edward Lansing Cussler. *Diffusion: mass transfer in fluid systems*. Cambridge university press, 2009.
4. Foust, Alan S., Leonard A. Wenzel, Curtis W. Clump, Louis Maus, and L. Bryce Andersen. *Principles of unit operations*. John Wiley & Sons, 2008.
5. Geankoplis, Tansport. "Processes and unit Operations, 3rd Editions Prentice hall." *Englewood Cliffs, NJ* (1993).

Course Outcomes (COs):

Upon completion of the course students will be able to:

1. **Recognize** laws of diffusion, **apply** them in mass transfer operation and **estimate** the number of stages in distillation.
2. **Interpret** the fundamentals of gas absorption and **evaluate** the height of packed column for absorption.
3. **Analyze** liquid–liquid extraction and **solve** problems on single stage extraction.
4. **Understand** the basics of crystallization and drying technology.

Course Code	**: CHP-315**
Course Title	**: Mass & Momentum Transfer Operations**
Course Type	**: Practical**
Total Hrs/week	**: 03 hr (PR)**
Course Credit	**: 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.

Experiments:

1. Determination of diffusivity of Acetone in air; Acetic acid in water.
2. Determination of rate of drying of given sample.
3. Determination of Mass transfer coefficient in wetted wall column.
4. Determination of loading and flooding point in packed column.
5. Validation of Rayleigh equation (Differential distillation).
6. Determination of distribution coefficient of Single stage liquid -liquid extraction for Acetic acid- water-benzene system.
7. Determination of Reynolds Number & prediction of flow behavior.
8. Determination of coefficient of discharge of Venturimeter and Orifice Meter.
9. Determination of the coefficient of discharge for Triangular, Rectangular and Trapezoidal Notch.
10. Study of characteristics of pumps & compressors (Centrifugal & Reciprocating)

Reference Books

1. Departmental Practical Manual.

Course Outcomes (COs):
Upon completion of the course students will be able to:

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 Code	**: CHL-312**
Course Title	**: Process Design and Project Management**
Course Type	**: Theory**
Total Hrs/week	**: 03 hr (TH)**
Course Credit	**: 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.

Prerequisites:
Industrial Management and Economics (HML-202)

Course Content:

Unit -I
Project identification and its feasibility; project testing based on viability, risk & cost estimation; 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, vi) Break even chart; evaluation of project by different methods on the basis of risk i) Profitability index, ii) Demand fore casting, iii) Standard deviation approach; 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
New developments in management, CPM & PERT, principle and objective of CPM and PERT network diagram for calculation time duration.
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
Cost analysis, fixed capital, working capital, preparation of store ledger account by pricing issue methods, LIFO, FIFO, simple average, weighted average.
Depreciation, significance of inadequacy and obsolescence, and depreciation methods.

Unit -IV
Layout and location, objective, principle; layout and location factors, equipment layout diagram (ELD); 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. S.D. Dawande*Process equipment Design*. Denett and Co Fifth Edition
2. B.V. Pathak & amp; M.S. Mahajan *Industrial Organization & amp; Management,* Nirali Prakashan First Edition 1986
3. Peters, Max Stone, Klaus D. Timmerhaus, Ronald Emmett West, Klaus Timmerhaus, and Ronald West. *Plant design and economics for chemical engineers*. Vol. 4. New York: McGraw-Hill, 1968.
4. Shreve, Randolph Norris, and Joseph A. Brink Jr. *Chemical Process Industries*. No. 4th Edition. McGraw-Hill Book Co., 1977.
5. Drydens*Outlines of Chemical Process Technology*, Third Edition, 1997
6. D.B.Dhone*Plant Utilities*NiraliPrakashan, First Edition 2008.

Course Outcomes (COs):

Upon completion of the course students will be able to:

1. **Evaluate** feasibility of project.
2. **Apply** various methods of profitability evaluation.
3. **Identify** the new development in project management and optimization techniques.
4. **Apply** HAZOP analysis for safety of the process.

Course Code	**: PLC-301**
Course Title	**: Plastic Materials and Applications - I**
Course Type	**: Theory**
Total Hrs/week	**: 03 hr (TH)**
Course Credit	**: 03**

Course Objectives:

a. To understand preparation/manufacturing techniques of different materials.
b. To understand structure-property relation of different polymers.
c. To understand the applications of different polymers.

Pre-requisites:

Chemistry – I (BSC-103)
Introduction to Polymer Technology (PLC – 201)
Chemistry and Technology of Polymers (PLC – 202)

Course Contents:

Unit-I

Polyolefins: Brief Idea of Preparation/Manufacturing methods, structure-properties relationship, processing and applications of PE (LDPE, HDPE, LLDPE etc.) and PP and its Copolymers of PE, PP

Styrenics: Manufacturing methods, structure-properties relationship, processing and applications of PS, SAN, ABS, HIPS, and expandable PS, important copolymers of styrene maleic anhydride and styrene acrylics copolymers, toughing mechanism of impact modified plastics.

Unit-II

Acrylics: Manufacturing methods, structure-properties relationship, processing and applications of PAN, PMMMA, Polyacrylamide and their copolymers.

Manufacturing methods, structure-properties relationship, processing and applications of PVAlcohol, Polyvinyl acetate and poly vinyl acetal.

Unit-III

Engineering Polymers: Manufacturing methods, structure-properties relationship, processing and applications of PC, PET, PBT, PTT.

Unit-IV

Polyamides: Manufacturing methods, structure-properties relationship, processing and applications of Nylon 6, Nylon 6, 6, Nylon 11, aromatic Polyamide such as Kevlar etc.

Unit-V

PVC: Manufacturing methods, structure-properties relationship, processing and applications of PVC and its copolymers

Brief Idea of materials like PES, PAES, PEEK, PEAK, Liquid crystalline polymers, Light Emitting Polymers, Conducting Polymers, Biodegradable polymers.

Reference books:

1. Plastics Materials, Seventh Edition, Heinemann/Elsevier Pblication, 2005 : J. A. Brydson

2. Encyclopedia of PVC vol I, II, III: L.I. Nass and Charles A. Heiberger Eds, Marcel Dekker, New York, 1988.
3. Manufacture of plastics: W.S.Mayo, Reinhold Publishing Corporation, Chapman and Hall Ltd., London, 1964.
4. Plastic Materials Handbook: A.S.Athylye, Multi Tech Publisher Mumbai, third edition, 1995
5. Handbook of Plastics Materials and Technology: Irvin. Rubin, John Wiley and sons Inc. New York 1990.
6. Polymer Science: V.R.Gowarikar, N. V. Viswanathan and J. Sreedhar, John Wiley & Sons, 1986:

Course Outcomes:

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

1. **Discuss** Preparation /manufacturing techniques of different polymers.
2. **Illustrate** structure-property relation of polymers.
3. **Compare** different materials for their structural features.
4. **Select** an appropriate polymer for the required applications.

Course Code	**: PLC-301**
Course Title	**: Plastic Materials and Applications - I**
Course Type	**: Practical**
Total Hrs/week	**: 03 hr (PR)**
Course Credit	**: 1.5**

Course Objectives:

a. To provide experimental knowledge to the students on synthesis of various homopolymers and copolymers by different polymerization techniques.
b. To understand the analysis techniques for characterization of different polymers.

Pre-requisites:

Chemistry – I (BSC-103)
Introduction to Polymer Technology (PLC – 201)
Chemistry and Technology of Polymers (PLC – 202)

Course Contents:

- Synthesis of polystyrene and its copolymers.
- Synthesis of acrylic polymers by bulk, solution, suspension and emulsion polymerization and study the effect of various process variable like time, temperature, initiator concentration, etc,
- Synthesis of thermoplastics polyester resin.
- Synthesis of polystyrene by ATRP.
- Analysis of molecular weight of different thermoplastic materials by solution viscosity method.
- Determination of acid value, hydroxyl value, solid content, etc.

At least eight experiments.

Text/ Reference Books:

1. D.Braun, Identification of Plastics, Hanser Gardner Publications, FourthEdition
2. D.G. Hundiwale, U.R. Kapadi,V.D.Athawale,V.V. Gite, "Experiments in Polymer Science", Published by New Age International (P) Limited(2008)
3. Kuruvilla Joseph, Gem Mathew. "Advanced Practical Polymer Chemistry" Polymer Publication, Kottayam second edition,2004
4. British standard methods of Analysis of Oils and Fats, B.S.684:1958 General Council Publication, June1958

Course Outcomes:

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

1. **Demonstrate** the laboratory synthesis of various polymers and copolymers.
2. **Design and conduct** experiment by altering various process variables.
3. **Analyse** the materials for their physicochemical properties.
4. **Exhibit** the team work and problem solving skills.

Course Code	**: PLC - 302**
Course Title	**: Processing of Plastics - I**
Course Type	**: Theory**
Total Hrs/week	**: 03 hr (TH)**
Course Credit	**: 03**

Course Objective:

a. To provide knowledge about various compounding techniques used in processing.
b. To understand the principle and working of different processing techniques.
c. To understand various processing parameters and material aspects responsible for product quality.
d. To learn advances in processing techniques used for plastic moulding

Pre-requisites:

Introduction to Polymer Technology (PLC – 201)
Chemistry and Technology of Polymers (PLC – 202)

Course Contents:

Unit-I

Compounding : Basic Concept of Compounding and Processing, Principle and practice of compounding of polymers, brief idea of type and nature of additives, mixing of polymers, master batches, roll mills, internal batch mixer, motion less mixers, kneaders, sigma blade mixers, high speed mixers, Extruders, blenders etc.

UNIT II

Compression Moulding: Moulding process equipments and auxiliary equipment, type of compression moulding, moulding materials and properties of materials relevant to moulding process, moulding cycle, interrelation between flow properties of polymers, effect of process parameters and moulding design on product quality, process defect and other remedies, limitations of compression moulding. Comparision with other processes etc.

UNIT III

Transfer Moulding: Basic Principle and transfer moulding cycle, types of transfer moulding-intergral and auxially mould process control, compression of transfer moulding and compression moulding, choice of material for transfer moulding effect of process parameters and moulding design on product quality, process defects and other remedies, limitations of transfer moulding.

Unit-IV

Injection Moulding: Fundamentals of injection moulding, Moulding cycle, Specification of injection moulding machine. Injection unit, Clamping unit, two plate and three plates type injection mould , venting, runner and gates, Various Components of injection mould, effect of material properties and process variables on product quality, runnerless and hot injection moulding, Types of clamping systems, orientation in injection moulding and its effects, Trouble shooting of injection moulding

Unit-V

Advanced Injection Moulding: Principle, Need of Reaction injection moulding, material selection for RIM, Process defects and remedies. Gas assist injection moulding. Injection moulding of thermosets and elastomers. Process defects and remedies.

Reference books:

1. Fundamentals of Polymer Processing, Stanley Middleman, Mc Graw-Hill, 1977**.**
2. Injection moulding theory and practice, Irvin Rubin II, John Wiley and Sons. Inc., New York, 1972.
3. Plastics engineering Handbook of SPI: Joel Fredos, Wiley & Sons, Incorporated, John 1976.
4. Plastics moulding engineering: Deorle D. A. Chemical Pub. Co.
5. Principles of polymer processing: Z.Tadmorz &C. G. Gogos C. G. Wiley Inter Science, New York,. 1979.

Course Outcomes:

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

1. **Employ** the thorough knowledge of different polymer processing techniques.
2. **Interpret** the effect of various processing parameters.
3. **Illustrate** the factors responsible for product defects and **appraise** on suitable remedies.
4. **Select** the proper processing method for desired application.

Course Code	**: PLC - 302**
Course Title	**: Processing of Plastics - I**
Course Type	**: Practical**
Total Hrs/week	**: 03 hr (PR)**
Course Credit	**: 1.5**

Course Objective:

a. To provide experimental knowledge to the students on various compounding and processing techniques used for plastics moulding.
b. To understand various processing parameters and material aspects responsible for product quality.
c. To learn about processing defect, their probable causes and remedies

Pre-requisites:

Introduction to Polymer Technology (PLC – 201)
Chemistry and Technology of Polymers (PLC – 202)

Course Contents:

List of Experiments:

- Compounding of polymers using two roll mill.
- Mastication of elastomers with different ingredients on two roll mill
- Study the operation and processing parameters of Compression Moulding machine.
- Study the operation and processing parameters of Transfer moulding technique.
- Study the operation and processing parameters of Injection moulding machine by preparing different items.
- Scrap grinding
- Sheet casting of polymer solutions.

Source: Instrument manuals, Lab manuals

Course Outcomes:

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

1. **Operate** different plastic processing equipments with required safety and precautions.
2. **Setup** the processing parameters for different materials.
3. **Identify** processing defect and **illustrate** the factors responsible for them.
4. **Appraise** on suitable remedies to overcome the defects.

Elective-I (Open Elective)

Course Code : PLL-304
Course Title : Polymer Rheology
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

Course Objectives:

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

Course Content:

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, 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 (COs):

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

1. **Recognize** 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. **Select** the processing equipment with respect to change in polymer, polymer flow properties.
4. **Differentiate** the transition behavior of various polymeric materials.

Elective-I (Open Elective)

Course Code : OTL-305
Course Title : Technology of Perfumery and Cosmetics
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

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.

Prerequisites: ----Not Applicable----

Course Content:

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, Tooth paste/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 (COs):

Upon completion of the course students will be able to:

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.

Elective-I (Open Elective)

Course Code : FTL-305
Course Title : Advanced Technology in Food Packaging
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

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.

Prerequisites: ----Not Applicable----

Course Content:

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. Mathlouthi, M. Food Packaging and Preservation. Gaithersburg: Aspen, 1999
7. Paine F. A . Packaging media Publisher: Blackis and son Ltd; Bishop Briggs (1977)
8. Bureau, G., and J. L. Multon. Food Packaging Technology. New York, n.d. (1996)
9. Chemistry of Food Packaging by Swalam C.M., American Chemical Society, Washington D. C. 1974.
10. Packaging. Rockport, MA: Rockport Publishers, 1995.

Course Outcomes (COs):

Upon completion of the course students will be able to:

1. **Recognize** and **classify** food packaging materials and their use.
2. **Differentiate** active packaging, aseptic packaging, MAP, vacuum packaging, smart packaging, microwavable packaging.
3. **Estimate s**helf life of food packaged.
4. **State** packaging of, soft drink, alcoholic beverages, and frozen food.

Elective-I (Open Elective)

Course Code : PTL-305
Course Title : Specialty Pigments and Additives in Coatings
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

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.

Prerequisites: ----Not Applicable----

Course Content:

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,

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, slip additives,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 (COs):

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

1. **Understand** the optical effects and **evaluate** Metallic, Interference and Cholesteric Pigments in coatings.
2. **Propose** synthesis methods of Functional and Nano pigments, and their applications in specialty coatings.
3. **Understand** constructive, corrective and comparative role of various additives in solvent borne, waterborne and other coatings.
4. **Assess** dosing and trade information of Additives in Coatings.

Elective-I (Open Elective)
Course Code : CHL-320
Course Title : Nanoscience and Nanotechnology
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

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.

Prerequisites: ----Not Applicable----

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 analysingNanomaterials: 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 (COs):

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 Code	**: NC-303**
Course Title	**: Essence of Indian Traditional Knowledge**
Course Type	**: Audit**
Total Hrs/week	**: ----**
Course Credit	**: NC**

Course Objectives:

1. The course aims at imparting basic principles of thought process, reasoning 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.

Prerequisites: ----Not Applicable----

Course Content:

Unit-I

Introduction to traditional knowledge: Traditional knowledge, nature and characteristics, scope and importance, kinds of traditional knowledge, physical and social contexts in which traditional knowledge develop, 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: Need for protecting traditional knowledge (TK), 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: Scheduled Tribes and Other Traditional Forest Dwellers (Recognition Of Forest Rights) Act (2006); Plant Varieties Protection and Farmer's Rights Act (2001) (PPVFRAct); Biological Diversity Act (2002) and Rules (2004); Protection of Traditional Knowledge Bill (2016); Geographical Indicators Act (2003).

Unit-IV

Traditional knowledge and intellectual property: Systems of TK protection, Legal concepts for the protection of TK, Certain non IPR mechanisms of traditional TK, Patents and TK, Strategies to increase protection of TK, 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, Food and healthcare needs of Traditional societies, Importance of conservation and sustainable development of environment, Management of biodiversity, Food security of the country and protection of TK.

Text/ 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 (COs):

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

1. **Understand**, **correlate** and **explain** basics of Indian Traditional knowledge modern scientific perspective
2. **Recognize** the need and importance of protecting traditional knowledge.
3. **Propose** the various enactments related to the protection of traditional knowledge.
4. **Describe** the concepts of Intellectual property to protect the traditional knowledge.

SIXTH SEMESTER

Course Code	**: CHL-316**
Course Title	**: Chemical Reaction Engineering**
Course Type	**: Theory**
Total Hrs/week	**: 03 hr (TH) and 01 hr (Tutorial)**
Course Credit	**: 04**

Course objectives:

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.
3. The course will also provide basic understanding of catalysts and their applications to industrial processes.

Pre-requisites:

Material and Energy Balance Calculations (CHL-206)
Chemistry-I (BSC-103)

Course Content:

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

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

Text/Reference Books

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

Course Outcomes (COs):

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

1. **Design** chemical reactors involving heat effects optimally using minimum amount of data
2. **Fix** some problems related to operability and productivity.
3. **Apply** methods of Catalysts' synthesis and catalyst characterization
4. **Understand** and **interpret** kinetics data.

Course Code	**: HML-309**
Course Title	**: Psycho-Social Dimensions of Industrial Management**
Course Type	**: Theory**
Total Hrs/week	**: 03 hr (TH)**
Course Credit	**: 03**

Course Objectives:

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.

Pre-requisites:

Industrial Management and Economics (HML-202)

Course Content:

Unit –I

Concept and meaning of organisation behaviour, Features & foundations of organisation behaviour, Role of organisation behaviour, Theories of organisation behaviour, Behaviour Process, Innovation & creativity in organization

U Unit –II

Perception: Meaning and definition, Factors influencing 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 & organizational commitment, Attitudes, values & organization 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. Aswathappa, Kalupally, and G. Sudarsana Reddy. *Organisational behaviour*. Vol. 20. Himalaya Publishing House, 2009.

2. Martin, John. *Organizational behaviour and management*. Cengage learning EMEA, 2005.
3. Saiyadain, Mirza S. *Organisational behaviour*. Tata McGraw-Hill Education, 2003.
4. Mishra, MahaNarain. *Organisational behaviour*. Vikas Publishing House Pvt Ltd, 2001.
5. Robbins, Stephen P. *Organisational behaviour: global and Southern African perspectives*. Pearson South Africa, 2001.
6. Stoner, *Management-II*. Pearson Education India.

Course Outcomes (COs):

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

1. **Develop** the process of individual behaviour and perpetual process along with conditioning of thinking process
2. **Identify** the concept and process of motivation and leadership
3. **Correlate** human behaviour, social skills, innovations, and creativity to improve workplace dynamics.
4. **Develop** 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 Code	**: PLC - 303**
Course Title	**: Plastic Materials and Applications - II**
Course Type	**: Theory**
Total Hrs/week	**: 03 hr (TH)**
Course Credit	**: 03**

Course Objectives:

a. To understand preparation/manufacturing techniques of different materials.
b. To understand structure-property relation of different polymers.
c. To understand the applications of different polymers.

Pre-requisite:

Chemistry – I (BSC-103)
Introduction to Polymer Technology (PLC – 201)
Chemistry and Technology of Polymers (PLC – 202)

Course Contents:

Unit-I

Unsaturated Polyester: Raw Materials, polybasic acids, polyfunctional glycols, curing of resin through unsaturation of the resin/polymer backbone. Curing systems, catalysts and accelarators. Water reducible polyesters, and high solids polyesters. Molding compositions, DMC, SMC compositions.

Unit-II

Phenolics Resins: Basic components of the resin, different kinds of aldehyde, phenols and their derivatives, Novolac and Resol formation, effect of phenol and aldehyde on the nature and property of the resin, details of resinification and effect of pH on the reaction mechanism and the reaction products along with the curing of phenolics resin and it's properties and applications.

Amino Resins: Basic Raw materials used like urea, melamine, aniline, formaldehyde. Synthesis of UF, MF resins and their properties and applications.

Unit-III

Epoxy: Basic raw materials like epichlorohydrin and di-hydroxy phenols, synthesis of epoxy resins Ratios of reaction components and their effect on the properties of reaction product, Plant and process of manufacturing resin, curing systems for epoxy (amines,anhydrides,acids etc.) One pack and two pack systems. Manufacturing of Epoxy esters, its properties and applications.

Unit-IV

Polyurethane: Structure and properties of different isocynates, diisocynates, diols. Reaction of isocynates with various other functional groups. Synthesis of PU Foams, One shot and two shot processes. Safety aspects of handling of Isocynates, Curing of PU, Applications of PU.

Unit-V

Cellulose and its derivatives:

Manufacturing and plant process of Cellulose esters like Cellulose nitrate, cellulose acetate, cellulose acetate butyrate and cellulose ethers like Ethyl cellulose, Methyl Cellulose, CMC along with their properties and applications.

Silicon Containing Polymers: Properties and Applications

Reference Books:

1. Encyclopedia of Polymer Science and Technology, Johan Wiley and Sons 1984.
2. Plastics Materials, Seventh Edition, Heinemann/Elsevier Publication, 2005: J. A. Brydson
3. Polymer and Resins, Their Chemistry and Chemical Engineering, Brage Golding, D.Van Nostrand Company Inc.1959.
4. Handbook of Coating Additives, volume 2 Leonard J.Calbo, King Industries, Inc.1992
5. Surface Coating, OCCA Publication.
6. Organic Coating Technology by H. F. Payne.
7. Organic Coating: Science and Technology by Z. Wicks.

Course Outcomes:

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

1. **Discuss** Preparation /manufacturing techniques of different polymers.
2. **Illustrate** structure-property relation of polymers.
3. **Compare** different materials for their structural features.
4. **Select** an appropriate polymer for the required applications.

Course Code	**: PLC - 303**
Course Title	**: Plastic Materials and Applications - II**
Course Type	**: Practical**
Total Hrs/week	**: 06 hr (Pr)**
Course Credit	**: 03**

Course Objectives:

a. To provide experimental knowledge to the students on synthesis of various thermosetting polymers
b. To get understand the analysis techniques for characterization of different polymers.

Course Contents:

Synthesis and analysis of following Polymers (Thermosets):

- Synthesis of amino resins (UF and MF)
- Synthesis of phenolic resins
- Synthesis of epoxy resins.
- Synthesis of polyesters resins/ Alkyd resins.
- Determination of Epoxy equivalent weight and Epoxy value.
- Determination of viscosity of polymers using Brookfield viscometer.
- Analysis of resins for amine value, acid value, hydroxyl value, Saponification value, Iodine value.

Text/ Reference Books:

1. D.Braun, Identification of Plastics, Hanser Gardner Publications, FourthEdition
2. D.G. Hundiwale, U.R. Kapadi,V.D.Athawale,V.V. Gite, "Experiments in Polymer Science", Published by New Age International (P) Limited(2008)
3. Kuruvilla Joseph, Gem Mathew. "Advanced Practical Polymer Chemistry" Polymer Publication, Kottayam second edition,2004
4. British standard methods of Analysis of Oils and Fats, B.S.684:1958 General Council Publication, June1958

Course Outcomes:

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

1. **Demonstrate** the laboratory synthesis of various polymers and copolymers.
2. **Design and conduct** experiment by altering various process variables.
3. **Analyse** the materials for their physicochemical properties.
4. **Exhibit** the team work and problem solving skills.

Elective-II (Open Elective)
Course Code : PLL-305
Course Title : Plastics Waste Management
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

Course Objective:

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.

Prerequisites: ----Not Applicable----

Course Content:

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 (COs):

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

1. **Identity** the sources of plastics waste and its separation methods.
2. **Choose** the sustainable approaches of plastic waste management.
3. **Propose** methods of mechanical and chemical recycling of polymers.
4. **Evaluate** recycling of plastics by surface refurbishing.

Elective-II (Open Elective)
Course Code : OTL-306
Course Title : Biochemistry & Biotechnology of Lipids
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

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.

Prerequisites: ----Not Applicable----

Course content:

Unit-I
Bio synthesis 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. Stump F, 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 (COs):

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

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.

Elective-II (Open Elective)
Course Code : FTL-306
Course Title : Treatment and Disposal of Food Industrial Waste
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

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 Content:

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. Byproduct recovery and value addition to the waste.

Text/ Reference Books

1. Rao, C. S. Environmental Pollution Control Engineering. New Delhi: New Age Internat., 2011
2. Arceivala Sol J., AsolekarShyam R. Wastewater Treatment for Pollution Control and Reuse Tata McGraw-Hill Education, 2006
3. Green, John H., and Amihud Kramer. Food Processing Waste Management. Westport, Conn: AVI Pub. Co, 1979
4. Bartlett, Ronald Ernest. Wastewater Treatment: Public Health Engineering Des In Metric., Applied Science Publishers Ltd, 1971

5. Metcalf, L., H. P. Eddy, and Georg Tchobanoglous. Wastewater Engineering: Treatment, Disposal, and Reuse. New Delhi: McGraw-Hill, 2010
6. Waldron Keith W.,Handbook of Waste Management and Co-Product Recovery in Food Processing, Elsevier, 2007
7. Herzka, A., and R. G. Booth. Food Industry Wastes, Disposal and Recovery. London: Applied Science Publishers, 1981
8. Bhattacharyya Bimal C., Banerjee Rintu, Environmental Biotechnology; Oxford University Press, 2007

Course Outcomes (COs):

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

1. **Explore** composition of industrial effluent and health hazards of pollutants in effluent.
2. **Recognize** primary, secondary and tertiary treatment for industrial effluent treatment and design parameters.
3. **Access** principle, design and working of fixed film biological reactor efficiency.
4. **Manage** industrial effluent for recovery of biological as value addition to waste.

Elective-II (Open Elective)
Course Code : PTL-306
Course Title : Technology of Printing Inks
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

Course Objective: 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

Prerequisites: ----Not Applicable----

Course Content:

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, it‟s 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 equipments such as High speed impeller, butterfly mixer, Rotar and stator high speed mixer and milling equipments such as three roll mill, bead mill etc. handling, storage and manufacture of UV ink, news paper 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 News paper (rotary and well offset), publication work, posters, labels, and packaging materials, heat set and quick set inks for multicolour 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 (COs):

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

1. **Understand** nature, characteristics and classification of printing inks.
2. **Recognize** principles of ink formulations and **propose** manufacturing of Inks for various substrates.
3. **Assess** press configuration and applications of printing inks.
4. **Compare** and **select** various printing processes.

Elective-II (Open Elective)
Course Code : CHL-321
Course Title : Water Conservation and Management
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

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.

Prerequisites: ----Not Applicable----

Course Content:
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 (COs):

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

1. **Understand** the importance of water conservation and management in different sectors.
2. **Identify** the thrust area for water conservation
3. **Develop** management strategies to achieve effective water conservation.
4. **Implement** the developed strategies effectively.

Elective-III (Professional Core Elective)
Course Code : PLL - 306
Course Title : Mould and Die Design
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

Course Objective:-

a. To understand workshop equipments machine in terms of design and development of moulds and dies with materials used.
b. To get knowledge for designing the dies for the processing various plastics products.
c. To understand the design and development of moulds of various aspects of polymer processing.
d. To acquaint with role of computer in machine design and product design.

Pre-requisite: Processing of Plastics – I (PLC – 302)

Course Contents:

Unit-I

Design and Fabrication of Moulds: Mould function, requirement, mechanical properties, tolerance-basic mould types, Mould construction nomenclature, Stress relieving, Heat treatment-mould steel requirements, Selection of steel for mould, Surface treatments, Alloy steels-Non Ferrous materials for moulds.

Design and Fabrication of Moulds: Machine Tools and Hand Tools used in mould making with special reference to grinding, milling, lathe, drilling, die sinking machine, casting, hobbing and polishing operations, eletro discharge machinery, electrolytic deposition process, different types of materials used for mould fabrication, methods of heat treatment and advantages, equilibrium diagram, non-ferrous alloy, chromium plating.

Unit-II

Compression moulds: Mould fabrication: steels for moulding tools and their treatment include processes used for mould fabrication, finishing processes.

Compression moulds: Positive, semi-positive and flash mould with horizontal and vertical flash, arrangement of loading shoes, simple two plate and three-plate moulds, split moulds.

Unit-III

Injection moulds and Transfer moulds: Two plate and three plates types, injection, venting, runner and gates, calculation of number of cavities, hot runner mould. Computer softwares used in designing of moulds & mould flow analysis.

Transfer moulds: Principles of integral pot, auxiliary ram and separated pot mould, calculation of number of cavities.

Unit-IV

Dies: Extrusion of simple shapes tubing, cable covering and sheeting dies heating systems for plates and moulds, measurement and control of temperature of moulds and dies, simple blow mould. Types of Blown film dies and their construction types of sheet dies and their construction, dies for specific profile and their construction, function of mandrel, die body, heating systems for dies.

Unit-V

Mould Design and Part Design: Study of computer aided design, computer aided manufacturing and computer aided Engineering steps for part and mould design, Factors affecting path design, Wall thickness, Fillets, Radii, Ribs, Undercuts, Bosses, Taper and draft angle, Tolerance External and internal thread, parting line, reason for failure of plastics part, Study of Hot runner system, limitation of Hot runner systems

Reference Books:

1. Plastics mold engineering handbook (4th edition), J. Harry DuBois and Wayne I. Pribble, Eds., Van Nostrand Reinhold, New York, 1987.
2. Plastic moulds and Dies Laszlo Sors. Van Nostrand Reinhold Co; First Edition edition 1981.
3. Injection mould Design by R.G.W. Pye, George Goodwin Pub. 3rd Revised edition ,1983.
4. Compression and transfer moulding of plastics by J. Butler interscience New York, Iliffe; First edition 1959
5. Extrusion dies design by M. V. Joshi, Hanser Publication, and Fourth Edition.
6. Plastic engineering data book by Glanvill.
7. Mould making Handbook- Stoekhert/Menning, Hanser Pub. Second Edition.
8. Material Science and Metallurgy by V. D. Kodgire, Everest Pub. House
9. Robert A. Malloy, "Plastic Part Design for Injection Moulding", Hanser Publishers, Munich Vienna, New York, 1994.
10. Paul A. Tres, "Designing Plastic Parts for Assembly", 2nd Revised Edition, Hanser Publishers, Munich Vienna New York, 1994.

Course Outcomes:

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

1. **Recognise** the type of metal/alloy suitable for mould manufacturing.
2. **Discuss** the types of mould required for plastics moulding.
3. **Explain** the design considerations of moulds and Die.
4. **Inspect** the suitability of mould design with respect to flow behavior of plastics materials.

Elective-III (Professional Core Elective)
Course Code : PLL - 307
Course Title : Technology of Elastomers and Additives
Course Type : Theory
Total Hrs/week : 03 hr (TH)
Course Credit : 03

Course Objectives:

a. To provide knowledge on various additives used in polymer for various applications.
b. To understand about the natural rubber with its history from latex collection to processing of various types of natural rubber.
c. To dessiminate knowledge of various types of synthetic rubber in terms of synthesis, processing, properties and applications.
d. To understand the physical properties of elastomers in terms of vulcanization and testing parameters.

Prerequuisite:

Chemistry and Technology of Polymers (PLC-202)

Course Contents:

UNIT-I

Additives in plastics, types of stabilizing additives (antioxidants, light emitting stabilizers, metal deactivators, heat stabilizers, flame retardance etc.), selection and properties of stabilizing additives, function and level of addition examples, types of processing aids (lubricants, high polymer impact mixture processing aids, slip, antislip, antiblock, mould release agent), their function and level of addition.

UNIT-II

Types of fillers and reinforcement, choice of fillers and properties theory of plasticizers, types of plasticizers, reinforcement of plasticizers, function of blowing agent and examples, pigments and dies.

UNIT-III

Sources and history of natural and synthetic rubber, natural rubber vs. synthetic rubber, significance of structure of natural rubber. Production of different grades of natural rubber from latex and its classification, mastication, compounding and processing of natural rubber synthetic rubbers, compounding ingredients and method of compounding.

UNIT-IV

Manufacturing processes, properties and application of elastomers based on butadiene and its copolymers, acrylonitrile, butyl, ethylenepropylene, silicons, and polycholoprene Rubbers etc.

UNIT-V

Mechanism of reinforcement of rubbers, chemistry and technology of vulcanization, processing of rubbers, physical testing of rubbers. Industrial fabrication of rubber articles such as transmission belts, hoses, tyres, tubes, etc.

Reference books:

1. Chemistry and Technology of Rubber: Morton,1999
2. Polymer Chemistry of Synthetic Elastomers, Vol: I &II. Joseph Paul Kennedy, Erik G. M. Törnqvist Snippet view – 1968
3. Plastics Additives, Geoffrey Pritchard, Rapra Technology ltd.UK 2005
4. Chemistry of Rubber: Mounten
5. Brydson, J.A., Rubber Chemistry, Allied science Publishers, London, 1978.
6. Franta, Elastomers and Rubber Compounding materials, Elsevier, 1989.
7. Klingender R.C, Handbook of speciality elastomers, CRC Press, 2008.

Course Outcomes:

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

1. **Explain** the types of additives used in polymer formulations.
2. **Illustrate the effect of different types of fillers on properties of polymers.**
3. **Categorize and discuss** different types of rubbers / elastomers and their manufacturing.
4. **Describe** the application of elastomers.