Syllabus of 3rd Year
B. Tech.(Plastics) Technology
w.e.f. 2016-17

3rd Year B. Tech.(Plastics) Technology Syllabus w.e.f. 2016-17

Fifth Semester							
Subject Code	**Subject Title**	**Teaching Hours**	**Tutorial**	**Credits**	**Practical Hours**	**Credits**	**Total Credits**
CHL 308	Mass Transfer Operations	04	-	04	-	-	04
CHP 309	Mass & Momentum Transfer Theory	-	-	-	03	1.5	1.5
CHL 310	Instrumentation and Process Control	04	-	04	03	1.5	5.5
PLL 301	Chemistry and Technology of Polymers - I	04	-	04	-	-	04
PLL-302	Chemistry & Technology of Polymers-II	04	-	04	-	-	04
PLP 303	Polymer Synthesis and Analysis	-	-	-	03	1.5	1.5
PLP 304	Synthesis of Thermosets	-	-	-	05	2.5	2.5
ELECTIVE	Elective-I	04	-	04	-	-	04
Total		**20**		**20**	**14**	**07**	**27.0**
Sixth Semester							
CHL-311	Reaction Engineering	04	-	04	-	-	04
HML 301	Industrial Management & Economics	03	-	03	-	-	03
HML-302	Managerial Behaviour: Psycho-social Dimensions	03	-	03	-	-	03
PLC-305	Processing of Plastics - I	04	-	04	03	1.5	5.5
PLL-306	Mould and Die Design	04		04	-	-	04
PLP-307	Self Study Report	-	-	-	03	1.5	1.5
ELECTIVE	Elective - II	04	-	04	-	-	04
Total		**22**		**22**	**06**	**03**	**25.0**

Department	**: Department of Plastic Technology**
Course code	**: CHL-308**
Course Title	**: Mass Transfer Operations. (TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Objective:

At the end of the course student will understand the basic fundamental of mass transfer operations carried out in chemical industries, design of plate and packed column used for mass transfer operations, Distillation, Liquid-liquid extraction, Solid-liquid operation, Crystallization and Adsorptiondrying operation.

Course Content:

Unit-I

Diffusion

Principles of diffusion, Fick's law, diffusion in binary mixture, equimolecular counter diffusion, mass transfer through stationary gas, mass transfer velocities, gas phase mass transfer cases, thermal diffusion, Maxwell law, diffusion in solids, Diffusion in liquids: Mass transfer across phase boundary, penetration theory, two film theory, surface renewal theories, film-penetration theory of mass transfer, mass transfer coefficients & correlation,

Unit-II

Distillation

Distillation methods,Vapour liquid equilibria, ideal and non-ideal systems, relative volatility, partial vaporisation/condensation,calculation of number of theoretical plates by McCabe Thiele method. Importance of reflux ratio, minimum reflux ratio, optimum reflux ratio. Murphree plate efficiency and overall plate efficiency. Effect of feed condition of 'q' line.

Unit-III

Absorption

Mechanism of absorption, choice of solvent for absorption, rate of absorption & material balance over absorption tower, minimum gas-liquid ratio for absorber,The absorption with & without chemical reaction,

Packed towers: General construction & working, types of packing merits & demerits, operational difficulties, pressure drop & limiting gas-liquid flow rates, Determination of height of columns, transfer units, capacity.

Plate towers: General construction & working, types of plates merits & demerits, operational difficulties

Unit-IV

Extraction

Liquid-Liquid Extraction: Principle, selection of solvent for extraction, estimation of mass transfer coefficients, triangular diagram representation,Equipment for liquid-liquid extraction. (Mixer settler, Rotating Disc Contractor, Packed column, spray column). Single stage extraction calculation.

Adsorption: Fundamentals, adsorbent, adsorption equilibria and isotherms.

Unit-V

Drying:

Drying characteristics of material, theory and mechanism of drying, Performance of batch and continuous dryer, time of drying.

Crystallization

Crystallization:- Principle, Super saturation, methods of achieving super saturation, phenomenon of crystal formation, crystal structure, material & heat balance over crystalliser& related problems

References:

1. Treybal R.E. “Mass Transfer Operations” McGraw Hill Book Co., New York 1980
2. McCabe W.L. and Smith J.C. & Harriot, “Unit Operations of Chemical Engineering”, McGraw Hill Book Co., New York 1980
3. Principles of Unit Operations: Foust A.S.
4. Coulson J.M. and Richardson J.F., “Chemical Engineering Vol. I, II & III”, Pergamon Press, New York 1977
5. Unit Operation: Mc Cetta Vol. I
6. Badger W.L. and Banchero J.T., “Introduction to Chemical Engineering”, Tata McGraw Hill Book Co.
7. Chattopadyay P., “Unit Operations of Chemical Engineering”, Vol. 1 & 2, Khanna Publishers, New Delhi.

Course Outcomes:

1. Students will learn about the fundamentals of diffusional mass transferin solids and fluids.
2. Student will understand the application of mass transfer theories in various unit operations.
3. Student will understand the mechanism and operation of absorption/stripping column.
4. Student will understand the design of binary plate and packed distillation column.
5. Student will understand the designliquid-liquid and solid-liquid extraction column.
6. Student will understand the design crystallization and adsorption column.

Department	**: Department of Plastic Technology**
Course code	**: CHP-309**
Course Title	**: Mass and Momentum Transfer Operations. (PR)**
Course Type	**: Practical**
Total Hrs	**: 03**
Course credit	**:1.5**

Course Content:

(Minimum10 experiments)

1. Determination of vapour diffusivity
2. Study of Liquid –liquid diffusion through porous pot.
3.Batch/Tray drying.
4. Wetted wall column.
5. To verify Rayleigh's equation,
6. To study boiling point diagram/ vapour-liquid equilibria.
7. To study distribution coefficient in liquid-liquid. Extraction.
8. To Construct bimodal curve for ternary system.
9. Laboratory Batch Crystallisation,
10. To Study Burnoullistheorem
11. To calculate coefficient of discharge of Venturimeter, orifice meter.
12. To study the type of flow using Reynold's experiment.
13. To calculate various losses through pipe fittings
14. To calculate coefficient of discharge through triangular/trapezoidal/rectangular notches.

Department	**: Department of Plastic Technology**
Course code	**: CHC-310**
Course Title	**: Instrumentation and Process Control (TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Course Objectives:

To study the different Instruments like temperature , pressure, level and flow measuring instruments and their working and applications. The utilization of chemical process control and dynamics in automatic , advanced chemical process and study of response of various forcing functions for first, second and higher order control system and study of various types of control mechanism for optimize control of chemical process and their stability

Course Content:

Unit- I **(10hrs)**

Measuring instruments:

Elements of measuring instruments, Static and dynamic characteristics of measuring instruments

Temperature measurement: Temperature scales, Thermocouples, bimetallic thermometer, resistance thermometer, vapour pressure thermometer, mercury in glass thermometer, constant volume gas thermometer, radiation and optical pyrometers.

Pressure measurement: Manometers, Elastic pressure transducers: Bourdon tube, diaphragm, and bellows; Electrical pressure transducer.

Unit -II (**10hrs)**

Level measurement: Direct and indirect methods, float type, bubbler systems, air purgemethod.

Laplace transform: Inversion by Partial Fractions, first order control system, Mercury thermometer, development of transfer function and response, forcing functions- step, impulse, ramp, sinusoidal and their responses.

Unit -III **(10hrs)**

Physical examples of first order systems – Liquid level and mixing process, Interacting and non interacting systems and their transient response and numericals based on theory.

Unit -IV **(10hrs)**

Second order control systems- transfer function of damped vibrator and U-tube manometer and development of step response equations for underdamped overdamped and critical damped system,

Unit -V **(10hrs)**

Linear closed loop system, simple control system negative feedback vs. positive feedback, Servo problems, regulator problem, development of Block diagrams representing transfer functions.

Pneumatic and electronic controllers and final control elements, choice of controllers, On off, Proportional, PI, PID & PD.

Reference Books

1. Process Systems Analysis and Control: Donald R. Coughanowr
2. Industrial Instrumentation: Eckman
3. Process Control and Instrumentation: R.P. Vyas

Course Outcomes:

1. Students will able to know the construction, working, application and advantages and disadvantages of temperature, pressure, level and flow measuring instruments.
2. From the course the students will able to know the complete dynamics of the chemical process and understand the different kinds of forcing function and responses.
3. The student will understand the method for obtaining the transfer function, response equation and physical behavior of first, second and higher order control system.
4. Students understand feedback control system and various types of control actions like ON OFF, P, PI, PD, PID and their applications and usefulness in the different chemical process and Industries.

Department	**: Department of Plastic Technology**
Course code	**: CHC-310**
Course Title	**: Instrumentation and Process Control. (PR)**
Course Type	**: Practical**
Total Hrs	**: 03**
Course credit	**: 1.5**

Course Objectives:

To study the basic controls systems through the experiments of first order and second order control systems. How the systems responds to change in inputs.

Course Content:

Experiments:

1. To study the Dynamic study of mercury thermometer and determine time constant
2. To study step response in Single tank liquid level system
3. To Study the liquid level two tank Non-interacting systems
4. To Study the liquid level two tank Interacting systems
5. To Study the control system of mixing Process and to determine time constant
6. To study linear and equal control valve characteristics
7. To study the dynamic response of second order system (U-Tube manometer etc.)
8. To study response of mercury thermometer and bimetallic thermometer
9. To determine the time constant and damping coefficient of second order system (U-Tube manometer etc.)
10. To study impulse response in Single tank liquid level system

Course Outcome:

Students come to know by performing various practical, how the basic control systems and instruments are applicable in chemical process industries.

Department	**: Department of Plastic Technology**
Course code	**: PLL-301**
Course Title	**: Chemistry and Technology of Polymers-I(TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Pre-requisites:PLL-201, PLL-203

Course Objectives:

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

Course Content:

Unit- I Polyolefins **(10 hrs)**

Brief idea of preparation, properties and applications of polypropylene (PP), polyethylene (PE), and polystyrene (PS) and poly (vinyl chloride) (PVC)

Unit- II Acrylics **(10 hrs)**

Brief idea of preparation, properties and applications of Polyacrylates, Polymethyl methacrylates, polyacrylamide, acrylic adhesive and fibers.

Unit -III Polyvinyl **(10 hrs)**

Brief idea of preparation, properties and applications of polyvinyl acetate (PVAc), Polyvinyl alcohol (PVA), Polyvinyl butyral, Polyvinyl carbazole, Polyvinyl pyrrolidene

Unit -IV Polyesters **(10 hrs)**

Brief idea of preparation, properties and applications of polyethylene terephthalete, polybutylene terephthalete, cellulose esters, unsaturated polyesters, polycarbonates, cellulose and its derivatives.

Unit -V Special polymers **(10 hrs)**

Brief idea of preparation, properties and applications of liquid crystal polymers, conducting polymers and light emitting polymers.

Reference books

1. Plastics materials: J. A. Bridson
2. Encyclopedia of PVC vol I, II, II: E L Nass
3. Manufacture of plastics: Maya Smith
4. Plastic Materials Handbook: Athylye
5. Handbook of Plastics Materials and Technology: Rubin
6. Polymer Science: Gowarikar

Course Outcomes:

Upon completion of the course the students learn about:

1. Preparation /manufacturing techniques of different polymers.
2. The structure-property relation of different polymers.
3. The applications of different polymers.

Department	**: Department of Plastic Technology**
Course code	**: PLL-302**
Course Title	**: Chemistry and Technology of Polymers-II (TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Pre-requisites:PLL-201, PLL-203

Course Objectives:

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

Course Content:

Unit- I: Polyurethane resin **(10 hrs)**

Structures and characteristics of differentIsocyanate, Isocyanurate prepolymers, polyols and catalysts for PU polymers, polyurea, Urethane oils and alkyds, polyols adducts, blocked isocyanates, Curing mechanism for PU resin, safety aspects of handling of isocyanates, applications in surface coating and plastics

Unit- II Epoxy resins **(10 hrs)**

Use of epichlporhydrin, bis phenol A/F and novolac derivatives, glycidal metacrylate, p-amino phenol in epoxy resins suitable for surface coatings, chemistry of synthesis, Plants and processes for manufacture, Use of hardeners and their selection. One pack and two pack systems, Epoxy ester, applications in surface coating and plastics

Unit- III Thermoplastic and Thermosetting Acrylics **(10 hrs)**

Structure & properties of Acrylic monomers, Role of initiators, solvents, chain transfer agents, & catalysts study of chemical reactions involved in polymerization, Mechanism of polymerisation (free radical/ anionic /cationic/ thermal / redox etc)

Methods of acrylic and vinyl polymerization: Bulk, solution, Emulsion, suspension, nonaqueous dispersion, Plant and process with due emphasis on heat transfer. properties and applications in surface coating

Unit- IV Polyamides **(10 hrs)**

Polyamides: structure and properties of polybasics acids and polyamines- dimer acids, adipic acid, sebacic acid, ethylene diamine, DETA, TETA, TEPA, caprolactam, hexamethylene diamine etc., study of chemical reactions involved in polymerization, Manufacture of reactive & non-reactive polyamides, Nylon 6, nylon 66, nylon 610, nylon 11, nylon 12; properties and applications in surface coating and plastics.

Unit- V Cellulose Esters and Inorganic Polymers **(10 hrs)**

Cellulose Esters**:** Manufacturing of cellulose nitrate with detail plant and process setup, classification and characterization of cellulose nitrate, solvents and plasticizers for cellulose lacquers, Modifying resins for cellulose nitrate, Cellulose acetate and cellulose acetobutyrate, Formulation of lacquers for automotive and furniture coating, Evaluation of lacquers, safety regulations.

Inorganic Polymers:Formulation, Properties and uses of silicone rubbers and resins, water glass coatings, alkyl silicates, Orthosilicates, Reactive Silanes, silicone and silicate modified resin for coatings, moisture cure silicone resin, thermosetting Fluorinated resins, Sol-Gel Coatings

Course Outcomes:

Upon completion of the course the students learn about:

1. Preparation /manufacturing techniques of different polymers.
2. The structure-property relation of different polymers.
3. The applications of different polymers.

Department	**: Department of Plastic Technology**
Course code	**: PLP-303**
Course Title	**: Polymer Synthesis and Analysis (PR)**
Course Type	**: Practical**
Total Hrs	**: 03**
Course credit	**: 1.5**

Pre-requisites:PLL-201, PLL-203

Course Objectives:

a. To provide experimental knowledge to the students on synthesis of various homopolymers and copolymers by different polymerization techniques.

b. To get understand the analysis techniques for characterization of different polymers.

Course Content:

Synthesis of following polymers by micro-emulsion

Homopolymers- Polystyrene, Polymethyl methacrlate, polyacrylonitirle, polyethylmethacrylate

Co-polymers- Polystyrene- Polymethyl methacrlate, Polystyrene-polyacrylonitirle

Analysis of above synthesized polymers-

Amine value, hydroxyl value, acid value, saponification value

Course Outcomes:

At the end of the course students has the knowledge of ,

1. Synthesis of various homopolymers and copolymers by different polymerization techniques.
2. Effect of reaction parameters and reactant concentration on the polymer formed.
3. Analysis techniques for characterization of different polymers.

Department	**: Department of Plastic Technology**
Course code	**: PLP-304**
Course Title	**: Synthesis of Thermosets (PR)**
Course Type	**: Practical**
Total Hrs	**: 05**
Course credit	**: 2.5**

Pre-requisites:PLL-201, PLL-203

Course Objectives:

a. To provide experimental knowledge to the students on synthesis of various thermosets.
b. To carry out analysis of thermosets synthesized in the laboratory.

Course Content:

Synthesis of following polymers by condensation

Polyester, polyurethane, epoxy, amino resins and alkyd resin and its derivatives

Analysis of above synthesized polymers-

Amine value, hydroxyl value, acid value, saponification value, Iodine value, Isocynate value

Course Outcomes:

At the end of the course students has the knowledge of:

1. Synthesizing different thermosets.
2. Effect of reaction parameters and reactant concentration on the polymer formed.
3. Analytical methods for their characterization of synthesised polymers.

Department	**: Department of Plastic Technology**
Course code	**: Elective-I, PLL-308**
Course Title	**: Technology of Elastomers and Additives (TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Pre-requisites:PLL-201, PLL-203

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.

Course Content:

Unit-I **(10 hrs)**

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 **(10 hrs)**

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.

Section-B

Unit-III **(10 hrs)**

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 **(10 hrs)**

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

Unit-V **(10 hrs)**

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, proofed fabrica, moulded goods etc.

Reference books

1) Chemistry and Technology of Rubber: Morton
2) Polymer Chemistry of Synthetic Elastomers Vol: I &II: Kennedy
3) Chemistry of Rubber: Mounten

Course Outcomes:

1. The Students will be able to understand the various application of additives for improvement in mechanical, chemical, physical and environmental properties of the product.
2. This course abreast the students with collection of latex, processing of latex and its characterization for classification of natural rubber.
3. The synthetic rubber and their synthesis, processing and properties are also known to the students at the end of the course

Department	**: Department of Plastic Technology**
Course code	**: Elective-I, PLL-309**
Course Title	**: High Performance Polymers (TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Pre-requisites:PLL-201, PLL-203

Course Objective:

a. To have knowledge about different high performance polymers.

b. To understand about structure-property relation of different high performance polymers.

c. To have knowledge about applications of high performance polymers**.**

Course Content:

Unit-I **(10 hrs)**

Ionic Polymers: Ionic Polymers, synthesis, physical properties and applications, Ion-exchange, Hydrophilicity, lonomers based on polyethylene, elastomeric ionomers. Ionomers based on polystyrene, ionomers based on PTFE, polyelectrolytes for ion exchange, polyelectrolytes based on carboxylates

Unit-II **(10 hrs)**

Conducting Polymers: Conducting polymers, polyacetylene, polyparaphenylene polypyrrole, organometallic polymers, photo conducting polymers, polymers with piezpelectric ferroelectric and pyroelectric properties, liquid crystalline polymers.(10 hrs)

Unit-III **(10 hrs)**

High Temperature Resistant Polymers: High temperature and fire resistant polymers improving low performance polymers for high temperature use – polymers for low fire hazards

Unit-IV **(10 hrs)**

Polymers for high temperature resistance – Fluoropolymers. Aromatic polymers, polyphenylene sulphide, polysulphones, polyesters, polyamides, polyketones, Heterocyclic polymers.

Unit-V **(10 hrs)**

Polysilanes and related polymers

Introudction, synthesis and chemical modification of polysilanes, physical properties of polysilanes, electronic properties and confirmations, photodegradation of polysilanes, structure of polysilanes.

Text books

1. H.F.Mark, (Ed), Encyclopedia of polymer Science & Engineering, John Wiley & Sons, New York, 1989.

2. Matrin.T.Goosey, Plastics for Electronics, Elsevier, Applied Science, 1985.

3. R.W. Dyson, Specialty Polymers, Chapman & Hall, 2nd edition, 1998.

Reference books

1. Manas Chanda, Salil.K.Roy, Plastics Technology Hand book, 2nd edition, Marcel Dekker, New York, 1993

2. Sanjay Palsule, Aerospace Polymers and composites, Fundamentals and Aerospace Applications, John Wiley & Sons, NY, 1995.

3.G.F.Dalelio, J.A.Parker (Eds), Ablative Plastics, Marcel Dekker, 1971.

Course Outcomes:

Upon completion of the course the students learn about:

1. Different types of high performance polymers like Ionic polyers, heat resistance polymerse, conducting polymers.
2. The structure-property relation of different high performance polymers.
3. The applications of high performance polymers.

Department	**: Department of Plastic Technology**
Course code	**: Elective-I, PTL/PLL-310**
Course Title	**: Physicochemical Characterization of Polymers (TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Pre-requisites:PLL-201, PLL-203

Course Objective:

a. To understand working principle of different physicochemical characterization techniques used for polymers.
b. To have knowledge of sample requirement for different techniques.
c. To have knowledge of result analysis and its interpretation obtained by particular characterization method.

Course Content:

Unit- I **(10 hrs)**

Sample Preparation, Solubility and swelling, concept of average molecular weight, determination of number average, weight average, viscosity average and Z-average molecular weights, Molecular wt and Molecular wt Distribution Determination by Dilute solution viscometry, GPC/SEC with a RI/ Light scattering detector, Vapor phase osmometry.

Unit -II **(10 hrs)**

Polymer crystallinity, morphology analysis of polymers using XRD; thermal characteristics of crystalline/ amporphous polymer- differential thermal analysis (DTA), differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), Analysis polymer nanocomposite using Atomic Force Microscopy (AFM), scanning electron microscopy (SEM), Transmission electron microscopy (TEM)

Unit -III **(10 hrs)**

Identification of the type of functional groups present in a polymer using IR, Attenuated total reflection (ATR) attachement, qualitative and quantitative analysis with respect to monomer composition and the average configuration of the polymer chain using NMR, assignment of the structure using Pyrolysis-gas chromatography, Mass Spectrometry (time-of-flight matrix-assisted

laser desorption/ ionization (TOF-MALDI) mass spectroscopy) analysis of polymers, Electrospray mass spectroscopy (ESMS)for biopolymers

Unit -IV **(10 hrs)**

Mechanical-static and dynamic tensile, flexural, compressive, abrasion, endurance, fatigue, hardness, tear, resilience, impact, toughness; Dynamic mechanical thermal analysis (DMTA)

Unit -V **(10 hrs)**

Conductivity-thermal and electrical, dielectric constant, dissipation factor, power factor, electric resistance, surface resistivity, volume resistivity, permeability, swelling, stability and ageing resistance, environmental stress cracking resistance, Flammability

Reference books

1. R. A. Pethrick and J. V. Dawkins, eds., Modern Techniques for Polymer Characterization, John Wiley & Sons, Inc., New York, 2003
2. D. Campbell, R. A. Pethrick, and J. R. White, Polymer Characterization: Physical Techniques, Stanley Thornes (Publishers) Ltd., Cheltenham, U.K., 2000

Course Outcome:

Upon completion of the course the students learn about:

1. Methods of sample preparation required for different techniques of polymer characterization.
2. Working principal and technology of different characterization techniques.
3. Result analysis and interpretation of data obtained by particular characterization method.

SEMESTER VI

Department	**: Department of Plastic Technology**
Course code	**: CHL-311**
Course Title	**: Reaction Engineering (TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Objective:

At the end of the course student will understand the basic fundamental of reaction engineering, design and performance of batch, CSTR and plug flow reactor, methods of analysis of reactor data to solve the problem aroused in chemical industry.

Course Content:

Unit -I **(10 hrs)**

Kinetics: Rate of reaction, types of reactions, Variables affecting the rate of reaction, order and molecularity,Temperature and concentration dependency of rate equation, theories of temperature dependency- Arrhenius theory, Bimolecular theory and Transition state theory, comparison between various theories of temperature dependancy of rate equation.

Unit -II **(10 hrs)**

Interpretation of kinetic data in batch and flow systems, integral and differential methods of analysis, kinetics of unimolecular, bimolecular reactions, series, parallel, reversible, autocatalytic reactions, constant volume batch reactor, variable volume batch reactor. Rate equation.

Unit -III **(10 hrs)**

Introduction to reactor design. Single ideal reactors: Ideal batch reactor, space time and space velocity, steady state mixed flow reactor, steady state plug flow reactor. Holding time & space time for flow systems.Comparison between mixed and plug flow reactor advantages and limitation in application.

Unit -IV **(10 hrs)**

Plug flow reactors in series and or in parallel, equal size mixed reactors in series, mixed flow reactors of different sizes in series. Reactors of different types in series, recycle reactor, autocatalytic reactions.Principles of reactor stability and optimization. Residence time distribution: Residence time function and relation amongst their application to ideal reactors.

Unit -V **(10 hrs)**

Catalysis:

Concept of catalyst selection, classification and characteristics of catalyst, preparation of a catalyst and its deactivation, poisoning of catalyst and regeneration. Different types of isotherms, determination of catalyst surface area By BET method.

Solid-catalyzed reaction:

Rate equations, diffusion within porous catalyst, experimental methods for finding rates, product distribution in multiple reactions.

Reference Books:

1. Chemical Reaction Engineering,Wiley Eastern : O. Levenspiel
2. Chemical Reaction Engineering. : Fogler
3. Chemical Reaction Engineering. : S. D. Dawande
4. Chemical Reaction Kinetics. : J.M. Smith

Course Outcome:

1. To enhance the ability of students to understand the classification of reactions, effects of various parameters on rate of reactions with different reaction rate theories.
2. To get the students well acquainted with collection and analysis of rate data using integral, differential, half-life method of analysis of rate data. To understand the kinetics of fast reactions.
3. To enhance the knowledge of students about ideal reactors, autocatalytic reactor, various parameters affecting the reactor performance, combine reaction system and comparison of various reactors.

4. The get the students well acquainted with thermal characteristics of reactors, residence time distribution, catalysis and modeling of real systems.

5. To enhance the ability of students to identify and solve various engineering problems during product optimization.

Department	**: Department of Plastic Technology**
Course code	**: HML-301**
Course Title	**: Industrial Management and Economics (TH)**
Course Type	**: Theory**
Total Hrs	**: 03**
Course credit	**: 03**

Objective

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

1. Identification and selection of management & administration with aspect towards the Production planning and management Quality control and maintenance. Processes/operations according to job requirement in various departments.

2. Identification, selection and understanding of Financial Management capital structure Sources of Industrial finance including institutional feature inside the organisation as well as outside the organisation.

3. Understanding Cost Analysis Cost statement and sheet Cost control and various type of approach of the Industrial relation Quality management techniques Entrepreneurship Development Management information

4. Identification, understanding Micro and Macro economics Demand and Supply factors of market economy Functions of money w.r.t. organisation

Course Content:

Unit-I

Introduction meaning management & administration Functions of Management Planning and ,Organising staffing c monitoring and leading co-ordinating & communication tool Functional of management Production Material Finance personnel Marketing Management concept of productivity wages .Production planning and management Quality control and maintenance.

Unit-II

Types of management Different approaches of management Functional areas of management Forms of business organisation production management work study productivity measurement

material management Inventory analysis Financial Management capital structure Sources of Industrial finance including institutional feature.

Unit-III

Marketing management consumer satisfaction sales and advertising Marketing Research personnel management Industrial relation Quality management techniques Entrepreneurship Development Management information system Information technology In Management Cost Analysis Cost statement and sheet Cost control , Cost projection.

Unit-IV

Nature and significance of Economics Basic problem in Economics Introduction of Micro and Macro economics Demand and Supply factors of market economy Functions of money Banking types and Functions

Unit-V

Indian Economy Liberalisation privatisation and Globalisation Mixed Economy Public Sector Reforms National income determinants Economic planning nature and Entrepreneurship small scale Industries and SSI.

References:

1) Modern Economics by H.L.Ahuja.
2) Modern economics theory by K.K.Dewett.
3) Monitory economics by M.L.Seth.
4)Industrial Management by I.K. Chopde, A.M. Sheikh.
5) Business Organisation and Management by S.A. Sherlekar.
6) Marketing Management by Philip Kotler

Outcomes:

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

1. Identification and selection of management & production management work study productivity with aspect towards the material management &Inventory analysis Production planning Quality control and maintenance. Processes/operations according to job requirement in various departments in organisation.

2. Identification, selection and understanding the meaning and utility of Marketing management, consumer satisfaction, sales and advertising Marketing Research personnel management features of the organisation.

3. Understand the importance of Cost Analysis Cost statement and sheet Cost control and various type of approach of the Industrial relation Quality management techniques Entrepreneurship Development Management information system

4. Identification, understanding Micro and Macro economics Demand and Supply factors of market economy National income determinants Economic planning nature and Entrepreneurship Functions of money w.r.t. organisation

5. Identification, selection and understanding according to requirement in

Different organisation Financial Management, capital structure Sources of Industrial finance including institutional feature. Understanding of the working principle of Entrepreneurship Development and S.S.I.

Department	**: Department of Plastic Technology**
Course code	**: HML-302**
Course Title	**: Managerial Behaviour and Psychosocial Dimension (TH)**
Course Type	**: Theory**
Total Hrs	**: 03**
Course credit	**: 03**

Course Objectives:

This subject aims at developing students with the required commitment and competencies for working towards the objectives within an organizational framework in order to improve both individual and organizational performance.

Course Content:

Unit-I

Psychosocial dimension of work in organisation Introduction and background

Unit-II

Approaches in Organisational analysis Organisational behaviour approach

Unit-III

Early practises in Management Theories of Organisation Organisational process and Function The structural variables context. Environment of work organisation Socio-cultural Environment Its impact on Organisation Social dimension of organisational and Behaviour Formal and Informal organisation Group Dynamics and terms

Unit-IV

Motivational Process and Theories Communication Technology and Interpersonnel process Leadership process and style. and T.Q.M.

Unit-V

Decision making behaviour, Decision making techniques creativity.

References:

1) Psychosocial Dimensions for managementby T.V.Rao

2) Appraising and Developing Managerial Performance Management and Organisational Behaviour by Laurie J. Mullins

3) Managerial Behaviour and Effectiveness by E Ananda Raja, N R V Prabhu, P Kameshwara Rao
4) Managerial Behaviour by O.P. Khanna

Course Outcome:

1) It emphasis on understanding of the issues, problems and practice of managing, working and organising across cultures in organisations.
2) It develops the understanding of psychosocial dimensions in people of organization to sustain relationship.
3) It contributes in developing interpersonal behaviours.
4) The subjects helps students to learn organizational whesiveness, pursuing goal and understand behaviour.

Department	**: Department of Plastic Technology**
Course code	**: PLC-305**
Course Title	**: Processing of Plastics I (TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Pre-requisites:PLL-201, PLL-203, PLL – 301, PLL- 302

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 advance in processing techniques used for plastic moulding

Course Content:

Unit-I **(10 hrs)**

Compounding of polymers

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.

Unit-II **(10 hrs)**

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.

Unit-III **(10 hrs)**

Transfer Moulding

Principle, types of transfer moulding, transfer moulding cycle, 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 **(10 hrs)**

Injection Moulding

Fundamentals of injection moulding, types of injection moulding, typical injection moulding cycle, effect of material properties and process variable on product quality, runnerless and hot injection moulding, types of clamping systems, injection moulding of thermoset, system capacity, project area, shot weight, process defects and remedies.

Unit-V **(10 hrs)**

Advance injection moulding

Principle, necessity of reaction injection moulding, Criteria for material selection for reaction injection moulding, material used for RIM, process defects and remedies, study of gas assisted injection moulding process, materials used for GAIM, process defects and remedies.

Equipment study of following as applied to compression and injection moulding equipments

1) Headting systems
2) Control systems-mitro processors, statistical and logic control (Basic idea)

Reference books

1) Injection moulding theory and practice Rubin II, John Wiley and Sons.
2) Plastics engineering Handbook: joel Fredos and SPI
3) Plastics moulding engineering: Deorle D. A. Chemical Pub. Co.
4) Principles of polymer processing: Tadmorz & Gogos C. G. Wiley Inter Science.
5) Injection and transfer moulding and plastics mould design: John brown and Robinson I. D.

Course Outcomes:

At the end of the course students will have knowledge

1. About different processing techniques like compounding, compression moulding, transfermoulding, injection moulding, advance injection moulding.
2. About processing parameters with respect to material type and grade.

3. About suitability of processing technique for desired product.
4. About major manufacturing defects & remedies for them involved in the manufacturing of industrially important plastics.

Department	**: Department of Plastic Technology**
Course code	**: PLC-305**
Course Title	**: Processing of Plastics I (PR)**
Course Type	**: Practical**
Total Hrs	**: 03**
Course credit	**: 1.5**

Pre-requisites:PLL-201, PLL-203, PLL – 301, PLL- 302

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

Course Content:

Study Experiment

Reaction injection moulding machine.

Transfer moulding machine.

Gas assisted injection moulding machine.

Blown film machine.

Compounding of plastic resins (PP, PE, SBR, and PBR).

Mastication of elastomers with ingredients on two roll mill.

Mixing of polymer on internal banbary mixer.

Preparation of various items using compression moulding machine.

Preparation of various items using injection moulding machine.

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. Process different plastics materials.
3. Identify processing defect, their probable causes and remedies.

Department	**: Department of Plastic Technology**
Course code	**: PLL-306**
Course Title	**: Mould and Die Design (TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Pre-requisites:PLL-201, PLL-203, PLL – 301, PLL- 302

Course Objective:-

a. To understand workshop equipment's machine in terms of design and development of molds 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 molds of various aspects of polymer processing.
d. To acquaint with role of computer in machine design and product design.

Course Content:

Unit- I **(10 hrs)**

Mould Fabrication

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, electro 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 platting-

Unit- II **(10 hrs)**

Compression Mould

Type of compression mould, material used for compression mould, typical moulding cycle, punch and cavity arrangement, details of guide pins, pressure pads, cores etc-

Transfer Mould

Basic process, design of pot transfer mould, details of pot size, plunger, sprue, sprue-lock runner etc, heating systems and temperature controlled, transfer pressure and clamping pressure-

Unit III **(10 hrs)**

Injection Mould

Classification of injection mould, assessment number of cavities and layout, parting line, cavity and core location, locating ring and sprue bushing, type of inserts, type of runner and gate, there size and choice, types of injection systems shrinkage and venting, cooling systems for cavity and core plates, cooling systems for cavity and core inserts.

Unit -IV **(10 hrs)**

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.

Unit- V **(10 hrs)**

Dies

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 of dies.

Reference Books

1) Plastic mould engineering Handbook-Dubois and pribble, Van Nostrand Pub.
2) Injection mould design pye, George Goodwin Pub.
3) Mould making Handbook- Stoekhert, Hanser Pub.
4) How to make injection moulds- Menges, Hanser Pub.
5) Dies for plastics extrusion: M. V. Joshi.
6) Design of plastic mould and dies: Sors.
7) Inroduction to engineering materials by B. K. Agrawal, Tata McGraw Hill.
8) Material Science and Metallurgy by V. D. Kodgire, Everest Pub. House.

Course Outcomes:

At the end of the course the students will get well acquainted

1. With workshop equipment's /machine in terms of design and development of molds and dies.
2. With the tools used in design and developments of the molds and dies as well as

3. With various parameters of the molds and die related to temperature, pressure and flow properties of plastics while designing the mold or die.
4. Role of computer application in mold design.

Department	**: Department of Plastic Technology**
Course code	**: PLP-307**
Course Title	**: Self Study Report**
Course Type	**: Field Work**
Total Hrs	**: 03**
Course credit	**: 1.5**

Pre-requisites:PLL-201, PLL-203, PLL – 301, PLL- 302

Course Objectieve:-

a. To develop self-learning abilities in the students.
b. To develop report writing abilities in the students
c. To make students to use different sources for data collection.

Course Content:

Visit to local industry and prepare a detail report on materials, properties, and applications with history of visited industry.

Course Outcomes:

1. Students will be confident in preparing a report on new topics by collecting and analyzing the literature from various sources.
2. Will develop self-learning abilities in the students.
3. Will be able to use different sources for data collection

Department	**: Department of Plastic Technology**
Course code	**: Elective - II, PLL-311**
Course Title	**: Plastic Waste Management (TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Pre-requisites:PLL-201, PLL-203, PLL – 301, PLL- 302

Course Objective:

a. To understand the concept of plastics recycling.
b. To understand about various sources of plastics waste.
c. To understand various identification and separation method for waste plastics.
d. To learn about different recycling methods for plastics recycling**.**

Course Content:

Unit- I

1. Introduction, Sources of plastics waste (Industrial waste, post consumer waste, scrap waste and nuisancewaste), 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

2. 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

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

Unit- IV

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

Unit- V

5. 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 books

1. John Scheirs., - "Polymer Recycling" John Wiley and Sons,1998

2. Nabil Mustafa – "Plastics Waste Management" Marcel Dekker Inc.,1998.

3. Steven Blow, Handbook of Rubber Technology, Galgotia Publicatins Pvt. Ltd., New Delhi, 1998.

4. Chandra R. and Adab A., Rubber and Plastic Waste, CBS Publishers & Distributors, New Delhi, 1994.

Reference books

1. Muna Bitter, Johannes Brandup, Georg Menges "Recycling and Recovery of plastics" 1996

2. Attilio.L.Bisio,Marino Xanthos, " How to manage plastics waste: Technology and market Opportunities"
Hanser Publishers, 1994

3. 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.

Department	**: Department of Plastic Technology**
Course code	**: PLL-312/PT-2.3**
Course Title	**: Polymer Reaction Engineering (TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Pre-requisites:PLL-201, PLL-203, PLL – 301, PLL- 302

Course Objective:

a. To understand about different polymerization reactors.
b. To understand about reaction kinetics affecting molecular weight and MWD of polymers.
c. To understand kinetics of copolymerization.

Course Content:

Classification of polymerization reactions. addition polymerization reaction mechanisms and rate equations;Dead – end radical polymerization; molecular weight distribution in batch and continuous reactors; avg.molecular weight and experimental determination based on viscosity, osmotic pressure etc. semi-batch reactoroperation; Design of batch and continuous reactors. Heat removal from polymerization reaction.

Heterogeneous polyaddition reactions; Suspension and emulsion polymerization; Smith- Ewart's theory and Stock Mayer's equation; continuous emulsion polymerization; Anionic and Cationic poly addition; Copolymerization; Mayo's equation and reactivity ratio; Alfred- Price equation; Rate of co polymerization and y factor; Skiest's equation. Polycondensation reactions; Flory's equation and molecular weight distribution; Molecular weight regulations. Typical case studies of polymers like PE, PP and PS .

Reference books

1. G. M. Burnett, Mechanism of polymer Reactions, Interscience, 1954.
2. F. M. Bovey, A. K. Medalia, I. M. Kolthoff, Emulsion Polymerisation, Interscience, 1955.
3. G. E. Harn, Co polymerization, Intersicence, 1969.

4. F. W. Billemeyer, (Ed.) Encyclopaedia of Polymer science and Technology, Interscience, 1969.

Course Outcomes:

At the completion of the course, the student will have knowledge of:

1. Polymerization reactors.
2. Reaction kinetics
3. Parameters affecting molecular weight and MWD of polymers during synthesis.
4. Kinetics of copolymerization.

Department	**: Department of Plastic Technology**
Course code	**: PTL/PLL-313**
Course Title	**: Polymer Rheology (TH)**
Course Type	**: Theory**
Total Hrs	**: 04**
Course credit	**: 04**

Pre-requisites:PLL-201, PLL-203, PLL – 301, PLL- 302

Course Objectives:

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

Course Content:

Unit-I **(10 hrs)**

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-II **(10 hrs)**

Designing With Plastics

Creep curves, isochronus and isometric curves and their use in elementary designs using polymeric materials, temperature dependence of moduli of polymeric materials, effect of crystallinity, molecular weight, crosslinking, presence of plasticizer, time-temperature superposition principle, master curves, WLF equation.

Unit-III **(10 hrs)**

Transition in Polymers

Glass transitions, theories of glass transition, determination of Tg, dependence of Tg on various factors etc., transition and molecular motions responsible for those, flow in tension, tensile voiscosity, types of tensile elongational flows, flow in conivvlin-drical sections, in melt spinning and parison sagin blow moulding.

Unit-IV **(10 hrs)**

Polymeric Liquids and Their Shear Flow

Classification of liquids, nature of polymer melts, solution and dispersions, power law model used to represent nature of polymeric liquids. Flow of Newtonian fluids and power law. Fluids through capilliary, slit and annulus, methods to determine shear viscosity by capilliary rheometer, cone and plate type viscometer, rotational viscometers, etc., factors affecting viscous shear flow such as temperature, pressure, fillers, plasticizers, etc.

Unit-V **(10 hrs)**

Elastic nature of polymeric liquids, elastic behavior of polymer melts and its manifestations, in practice, calculation of die swell, application of rheology in polymer processing, use of torque rheometry to judge, the processability of polymers, flow properties of melt of important thermoplastics, application of rheology to injection moulding, flow encounter in metering section of extruder and output of extruder.

Reference books

1. Introduction to Polymer Viscoelsticity, Aklonis J.J. and Mcknight W.J., Wiley Interscience.

2. Plastics Engineering,, Crawford R.J.-Argammon Press, Oxford, England.
3. "Rheometry" Walters K., Chapman & Hall.
4. The Flow of High Polymer, Middleman S., John Wiley & Sons.
5. Flow Properties of Polymer Melts, Brydson J., George Goodwin Pub.
6. Polymer Melt Rheology, Cogswell F.N., John Wiley & Sons.
7. Processing of Thermoplastic Materials – Bernhardt E.C.: Reinhold Pub.
8. Dynamics of Polymeric Liquids, Vol.- 1&2 – Bird R.B., Armstrong R.C., Hassager O., John Wiley & Sons.

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. Physical and chemical parameters affecting the flow properties of the polymers.
3. Design features of the processing device on the basis of processing parameter as temperature, pressure, shear rate.
4. Proper selection of processing equipment with respect to change in polymer, polymer flow properties.