Harcourt Butler Technical University

DEPARTMENT OF CHEMICAL TECHNOLOGY - PLASTIC TECHNOLOGY

SCHOOL OF CHEMICAL TECHNOLOGY

I. Vision

The department of plastic technology aspires to be globally recognized center to develop professionals with technical knowledge and skills, leadership qualities and strong ethical values for successful career in plastic and allied industries, research and development organizations.

II. Mission

The mission of the Department of Chemical Technology- Plastic Technology is

M1 : To develop state-of-the-art facilities to impart technical knowledge and skill to the graduate and post graduate students for plastic and allied industries and research organizations.

M2 : To be a center of research and development for betterment of society in sustainable manner.

M3 : To develop state-of-art the technologies for testing and consultancy for industry and society.

M4 : To cultivate strong ethical values to be a successful professionals and to become life-long learners.

III. Program Educational objectives (PEOs) for B.Tech. Chemical Technology-Plastic Technology

The educational objectives of B.Tech. Chemical Technology-Plastic Technology program are:

PEO1 : To produce globally competent technical manpower in the field of polymers, resins, processing and allied areas to cater the need of country

PEO2 : To impart knowledge for development of innovation designs production materials and processes for sustainable development of society

PEO3 : To serve the industry to meet the challenges in terms of quality assurance and standardization to with stand the global competiveness

PEO4 : To be able to discharge duties with professional attitudes and ethics

Program outcomes (POs) of B.Tech. Chemical Technology - Plastic Technology

Graduating Students of B.Tech. Chemical Technology- Plastic Technology program will be able to:

Program Outcomes (POs)		Graduate Attributes(GAs)
PO1	Apply the knowledge of mathematics, science engineering fundamentals and Engineering concepts for the solution of complex engineering problems	Engineering Knowledge
PO2	Identify formulate, review literature and analyze complex problems related to Chemical Technology- Plastic Technology reaching substantiated conclusions using first principles of mathematics and engineering sciences	Problem Analysis
PO3	Design solution for complex problems in Chemical Technology- Plastic Technology and design system components or process that meet the specified needs with appropriate consideration for the public health and safety, and cultural, societal and environmental considerations	Design/ Development of solutions
PO4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions	Conduct Investigations of complex problems
PO5	Create, select and apply appropriate techniques, resources and modern engineering tools such as optimization techniques, simulations, including predication and modeling to complex process engineering problems with an understanding of their limitations.	Modern Tool Usage
PO6	Apply contextual knowledge with justification to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to engineering and Chemical Technology- Plastic Technology professional practice	The Engineer & Society
PO7	Understand the impact of the professional engineering and Chemical Technology- Plastic Technology solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development	Environment and sustainability
PO8	Apply ethical principles and commit to professional ethics adhering to the norms of the engineering and Chemical Technology- Plastic Technology practice	Ethics
PO9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings	Individual and team work

PO10	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	Communication
PO11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	Project management and finance
PO12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	Life-long learning

Program specific outcomes (PSOs) for B.Tech. Chemical Technology - Plastic Technology program are:

Graduating Students of B.Tech. Chemical Technology- Plastic Technology program will be able:

PSO1 : to apply practical skills, technical knowledge in major streams such as chemistry, manufacturing, processing, and applications areas of engineering and technology in plastic and allied industries

PSO2 : to take-up career in research organizations or to pursue higher studies in plastic technology and interdisciplinary programs with high regard for ethical values, environmental and social issues.

TPL – 201 : POLYMER CHEMISTRY

L	T	P	C
3	0	6	5

OBJECTIVE: The objective of this course is to enable the students

- To understand the mechanism of polymerization.
- To understand various techniques of polymerization.
- To understand the characterization of polymers by molecular weight.
- To understand the reactions and degradation of polymers.

Course Outcome

On the successful completion of the course, students will be able to

CO1	understand the fundamentals types and properties of polymers.	Understand
CO2	understand the chain growth polymerization and it's kinetics.	Understand
CO3	understand the step growth polymerization, its kinetics, and crosslinking.	Understand
CO4	analyze polymerization components for determination of molecular weight and molecular weight distribution of polymers, copolymerization, etc.	Apply
CO5	copolymerization and its types, ring opening polymerization.	Understand
CO6	apply knowledge of chemistry for analyzing polymerization components.	Apply

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3											3	3	3
CO2	3					2						3	3	3
CO3	3	2										3	3	3
CO4	3	2										3	3	3
CO5	3	2	2	2								3	3	3
CO6	3	2	2	2		2			2			3	3	3
Total	**3**	**2**	**2**	**2**		**2**			**2**			**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Polymers and their characteristics.
2. Transitions in Polymers.
3. Functionality requirements for Polymer synthesis.

Course Outcome 2 (CO2)

1. Classification of Polymers on various basis.
2. Concepts of thermoset and thermoplastic Polymers.

3. Applications of different Polymers.

Course Outcome 3 (CO3)

1. Mechanism of chain growth polymerizations.
2. Kinetics of chain growth polymer.
3. Modes of Initiation and Termination.

Course Outcome 4 (CO4)

1. Concept of step growth polymerization.
2. Determination of kinetics of Step growth polymerization.
3. Relation between molecular weight and extent of conversion.

Course Outcome 5 (CO5)

1. Concept of molecular weight averages for polymers.
2. Molecular weight distribution and polydispersity.
3. Types of molecular weight averages and their determination.

Course Outcome 6 (CO6)

1. Analyze components of polymerization with specific role.
2. Copolymerization reaction and selection of monomers.
3. Types of copolymerization.

Syllabus

Module-I:Basics of Polymer formation

Basic concepts and terminology such as monomer, polymer, functionality and structure of polymers. Transitions in polymers.

Module-II: Introduction to Polymers & polymerizations

Overview of polymer/ Petrochemical Industries with reference to application, classification of polymers, stereochemistry of polymers, General theory of chain growth polymerization. Free radical polymerization, types of Initiators. Kinetics of free radical polymerization, Autoacceleration.

Module -III: Condensation Polymerizations

General characteristics of condensation polymerization, kinetics and mechanism. Carother's equation , development of cross-linked structures. Step polymerization and its utility.

Module-IV: Molecular Weight and its Control

Concept of Molecular weight of polymers ,Factors affecting molecular weight and molecular weight distribution. Chain transfer reactions, retarders, inhibitors, Effect of temperature on polymerization

Module-V:Copolymerization and other Reactions

Copolymerization reactions and its utility. Kinetics of copolymerization, copolymerization behavior and types of copolymers. Stereo-chemistry of polymerization. Ring-opening polymerization.

Module-VI: Laboratory Experiments

Determination of refractive index of organic compounds, purification, determination of yield and refractive index of monomers and solvents, determination of percentage purity of initiator, viz. benzoyl peroxide, potassium persulphate, AIBN, raw materials, viz. phenol and formaldehyde, determination of density of plastic sample, identification of known and unknown polymer (unprocessed and processed) samples.

Reference Books and Suggested Readings :

1. F. W. Billmeyer, "Text Book of Polymer Science ", John. Wiley & Sons, 1990.
2. Vasant R. Gowariker, "Polymer Science", New Age International, 1986.
3. Premamoy Ghosh, " Polymer Science and Technology ", Tata McGraw-Hill Education, 1990.
4. George Odian, " Principles of Polymerization ", Wiley, 1981.
5. Paul J. Flory, " Principles of Polymer Chemistry ", Cornell University Press, 1953.
6. Robert W. Lenz, " Organic Chemistry of Synthetic High Polymers ", John Wiley & Sons Inc, 1967.
7. D. Margerison, " An Introduction to Polymer Chemistry ", Pergamon, 1967.

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Basics of Polymer formation**	
1.1	What are polymers and their development history	01
1.2	Salient features of polymers with advantages/ disadvantages	01
1.3	Formation of polymers of various types and it's relations to functionality	02
1.4	Glam transition Temp and its signification, Tm	01
1.5	Different type of monomers and polymers obtained with formula's	01
1.6	Degree of polymerization and mot. wt. Calculation with examples	01
2.	**Introduction to Polymers and Polymerizations**	
2.1	Overview of Plastic Industry	01
2.2	Applications with reasons in various sectors for popular Plastics Materials	02
2.3	Classification of Polymers on Various basis	02
2.4	Differences in major categories of plastics	02
2.5	Stereochemistry of polymers with examples	01
2.6	Kinetics of free radical polymerization	02
2.7	Different modes of initiation	02
3.	**Condensation Polymerization**	
3.1	Mechanism of condensation polymerization with examples	02

3.2	General characteristics of condensation polymerization	01
3.3	Kinetics of condensation polymerization	02
3.5	Carothers's equation	01
3.7	Crosslinking reactions and their significance	01
4.	**Molecular weight and it's control**	
4.1	Concept and types of molecular weight averages	02
4.2	Factors affecting molecular weight and its distribution	01
4.3	Effect of temperature on polymerization	01
4.4	Chain transfer reactions, retarders, inhibitors and their role	02
4.5	Control of molecular weight during polymer production	01
5.	**Co-polymerizations and other reactions**	
5.1	Concepts of Co-polymerization, suitability and significance	02
5.2	Important Co-polymer applications	01
5.3	Types of Co-polymers & their structures	02
5.4	Co-polymerization mechanism and kinetics	01
5.5	Ring opening Co-polymerization with examples and applications	01
	Total Hours	**40**
6.	**Laboratory Experiments**	
6.1	Determination of refractive index of organic compounds	03
6.2	Purification of monomers and determining the yield and refractive index of the purified monomer	06
6.3	Purification of solvent by washing and determination of yield	06
6.4	Determination of percentage purity of initiators, viz. benzoyl peroxide, AIBN, etc.	06
6.5	Determination of percentage purity of potassium persulphate	06
6.6	Determination of percentage purity of phenol	06
6.7	Determination of percentage purity of phenol for maldehye	06
6.8	Determination of density of given polymer sample that sinks in water	03
6.9	Determination of specific gravity of given moulded sample of plastic	03
6.10	Identification of known and unknown polymer (unprocessed and processed) samples	12
	Total hours	**57**
	G. Total:	**97**

TPL – 202 : POLYMERIZATION ENGINEERING - I

L	T	P	C
3	0	3	4

OBJECTIVE: The objective of this course is to enable the students

- To understand various polymerization techniques and catalysts used to produce addition polymers.
- To understand the copolymerization technique to produce important co-polymers.
- To learn the manufacturing of thermosetting molding powders from phenol formaldehyde and melamine.

Course Outcome

On the successful completion of the course, students will be able to

CO1	understand industrial methods of polymerization, different aspects of a polymerization plant, reactors, safety and plant automation.	Understand
CO2	understand stereo specific catalyst and polymerizations.	Understand
CO3	understand the production process for commodity thermoplastics.	Understand
CO4	understand the production process for common thermoset polymers.	Understand
CO5	understand and analyze production technology, properties and applications of polymers and their copolymers.	Understand and Analyze
CO6	apply techniques of polymerization for synthesis of polymers at lab scale.	Apply

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3					2						3	3	3
CO2	3					2						3	3	3
CO3	3	3				2						3	3	3
CO4	3	3				2						3	3	3
CO5	3	3	3	2		2						3	3	3
CO6	3	3	2	2		2			2			3	3	3
Total	**3**	**3**	**2.5**	**2**		**2**			**2**			**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Different parts of a polymerization plant.
2. Problems associated with polymerization.
3. Measurement and control in polymerization.

Course Outcome 2 (CO2)

1. Stereospecific catalysts.
2. Mechanism of stereospecific polymerizations.
3. Metallocene catalysts.

Course Outcome 3 (CO3)

1. Production and properties of Low density polyethylene (LDPE).
2. Production and properties of High density polyethylene (HDPE).
3. Production and properties of Poly propylene.

Course Outcome 4 (CO4)

1. Production and properties of phenol formaldehyde resins.
2. Production of molding powders and resins.
3. Synthesis of urea formaldehyde and Melamine formaldehyde resins and molding powder.

Course Outcome 5 (CO5)

1. Production of Polystyrene & PVC.
2. Properties of common Plastics.
3. Commercially important Copolymers.

Course Outcome 6 (CO6)

1. Learn and conduct bulk and solution polymerization techniques.
2. Learn and conduct emulsion and suspension polymerization techniques.
3. Learn about other polymerization techniques, Determination of molecular weight.

Syllabus

Module-I:Industrial Polymerization

Industrial methods of polymerization such as bulk, solution, suspension, emulsion. Layout and arrangement of polymer plant. Types of polymer production processes and reactors. Safety and plant automation.

Module-II: Sterospecific Polymerizations

Concept of stereo-chemistry of polymers, stereo-specific polymerization. Catalyst – their utility in polymer manufacture, Zeigler Natta, Metallocene and other catalyst systems.

Module-III: Production of Commodity Thermoplastics

Manufacturing processes, properties and applications of various polyethylenes such as LDPE, HDPE, and their copolymer grades, polypropylene and it's copolymer grades.

Module-IV: Production of thermoset resins

Manufacturing details, properties and applications of various thermosetting resins such as phenol-formaldehyde, urea-formaldehyde and melamine-formaldehyde and preparation of molding powders.

Module-V: Production of polymers and copolymers of styrene & Vinyl chloride
Production technology, properties and application of Polystyrene, Polyvinylchloride, and their copolymer grades.

Module-VI: Laboratory Experiments
Application of polymerization techniques to synthesize polymers at lab scale, determination of molecular weight of polystyrene and K-value of PVC by Ostwald Viscometer.

Reference Books and Suggested Readings :

1. J. A. Brydson, " Polymer Materials ", Butterworth-Heinemann, 1990.
2. Mark &Overberger, " Encyclopedia of Polymer Science & Tech. " Wiley-Interscience, 1986.
3. J. Scheries& W. Kaminsky, " Metallocene based Polymers ", Wiley, 2000.
4. Vasant R. Gowariker, "Polymer Science ", New Age International, 1986.
5. Christopher C. Ibeh, " Thermoplastic Materials: Properties, Manufacturing Methods, and Applications ", Taylor and Francis Group, 2011.

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Industrial Polymerization**	
1.1	Part of a polymerization on plant	02
1.2	Polymerization reactors and related problems	01
1.3	Separation process	01
1.4	Types of production processes	01
1.5	Industrial techniques of Polymerization and applicability	01
1.6	Bulk & Solution	02
1.7	Emulsion & Suspension	02
2.	**Sterospecific Polymerizations**	
2.1	Sterospecific Polymerizations	02
2.2	Their types and mechanisms	02
2.3	Examples of Industrial importance	01
2.4	Supported catayst and their working and significance	01
2.5	Metallocene Catalysts	02
3.	**Production of Commodity Thermoplastics**	
3.1	Manufacturing process, properties and application for low density, polyethylene	02
3.2	Manufacturing process, properties and application for high density, polyethylene	02
3.3	Manufacturing process, properties and application for Polypropylene	02
3.4	Copolymers of Ethylene and propylene	01
4.	**Production of polymers and copolymers of styrene & Vinyl chloride**	
4.1	Production technology, properties and applications of polystyrene	02

4.2	Copolymers of styrene	02
4.3	Production technology, properties and applications of Poly Vinyl chloride	02
4.4	Copolymers of Vinyl chloride	01
5.	**Production of thermoset resins**	
5.1	Chemistry involved in the production of both types phenol formaldehyde resins	02
5.2	Manufacture of Phenol formaldehyde resin & molding powder	02
5.3	Properties and applications of PF resins	01
5.4	Chemistry, production and properties of Urea formaldehyde resin	02
5.5	Chemistry, production and properties of melamine formaldehyde resin	01
	Total hours	**40**
6.	**Laboratory Experiments**	
6.1	Polymerization of given Technique. monomer by Bulk Polymerization	03
6.2	Polymerization of given monomer by Solution Polymerization Technique.	03
6.3	Polymerization of given monomer by Suspension Polymerization Technique.	06
6.4	Polymerization of given monomer by Emulsion Polymerization Technique.	06
6.5	Preparation of resole - type PF resin	03
6.6	Preparation of Novolac - type PF resin	03
6.7	Determination of molecular weight of polystyrene using Ostwald viscometer	03
6.8	Determination of K-value of PVC using Ostwald viscometer	03
	Total hours	**30**
	G. Total:	**70**

TPL –301 :POLYMER PROCESSING – I

L	T	P	C
3	0	0	3

OBJECTIVE: The objective of this course is to enable the students

- To understand the various processing techniques of plastic materials.
- To learn the fundamentals of Extrusion and different extrusion processes of thermoplastic.
- To learn the basic principle of compounding of thermoplastics and calendaring process.

Course Outcome

On the successful completion of the course, students will be able to

CO1	understand the concepts of Extrusion process of plastic materials.	Understand
CO2	understand the utility of the single screw and multiple screw extruder systems.	Understand
CO3	apply knowledge of extrusion process for manufacturing of different extruded plastic products.	Apply
CO4	understand compounding ingredients and methods for modification of polymer properties.	Understand
CO5	understand the concept utility of calendaring process for polymer/plastics.	Understand

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3					2						3	3	3
CO2	3					2						3	3	3
CO3	3	3	2			2						3	3	3
CO4	3	2	2	2		2	2					3	3	3
CO5	3	1	2			2						3	3	3
Total	**3**	**2**	**2**	**2**		**2**	**2**					**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Description of extrusion process and its components.
2. Melting mechanism and optimization of extruder performance , Die characteristics and screw characteristics curves.

Course Outcome 2 (CO2)

1. Different screw zones and their importance; specifications for extruder viz. compression ratio and L/D ratio.
2. Design of screws for different plastics like PE/PP, PVC, etc.
3. Types of twin screw extruder, importance and utility of co-extrusion process.

Course Outcome 3 (CO3)

1. Description of process operations for various extruded plastic products like film, pipe, wire coating etc.
2. Compassion of various post processing operations involved.
3. Reactive extrusion processing.

Course Outcome 4 (CO4)

1. Functions of various compounding additives used for plastics.
2. Effect of these additives on performance of plastics.
3. Compounding and blending equipments.
4. Methods for finishing of plastics.

Course Outcome 5 (CO5)

1. Description of various steps for calendaring process.
2. Process variables for calendaring of plastics and their effects on product.
3. Various calendar arrangements and their utility.

Syllabus

Module-I:Introduction to Polymer Processing and Extrusion

Concepts of Polymer Processing; Concepts of Extrusion process for plastics- basic operation and analysis, solids conveying, drag induced conveying, melting mechanism, power consumption in metering zone. Overall extruder performance, die and screw characteristics curves.

Module-II: **Fundamentals of Extrusion Process of Polymers**

Fundamentals of single screwextrusion, twin screw extrusion and co-extrusion operation; Construction of Barrel and screw for commodity, heat sensitive and engineering plastics.

Module-III: Extrusion Processes for plastic products

Extrusion process détails,basic principles, equipment used, and applications for plastic product formations viz. film, pipe, lamination, profiles, wire, cable, etc.;Casting process for films; Reactive extrusion :basic principles, equipment used and applications.

Module-IV: Compounding of Polymers

Importance and concept of Compounding of polymers; compounding additives viz. fillers, plasticizers, colorants, stabilizers, blowing agents, flame-retardants, antioxidants, etc. Mixing, blending and compounding equipments. Finishing of Plastics.

Module-V: Calendaring of plastics

Calendaring- description and features of calendaring process, calendar roll arrangements, application of calendaring.

Reference Books and Suggested Readings :

1. Plastics Extrusion, by Allen Grief
2. Plastic Engineering Handbook (SPI), by Frados
3. Screw extrusion of Plastics, by Jacobi
4. Plastic materials and processes (a concise encyclopedia), by Charles Harper
5. Polymer Mixing and Extrusion Technology, by Nicholas Cheremisinoff
6. Plastics Extrusion Technology, Hanser SPE, 1996

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Introduction to Polymer Processing and Extrusion**	
1.1	Concept of plastic processing and short description of different processing techniques	01
1.2	Basic Extrusion process the types of extruders used, extruder design and construction	01
1.3	Different zones of extruders	02
1.4	Solid conveying and melting mechanisms of plastics during extrusion	03
1.5	Performance of extruder, die and screw characteristics curves	02
2.	**Fundamentals of Extrusion Process of Polymers**	
2.1	Design of screw for different types of plastics	03
2.2	Concepts of die Design and its utility in extrusion	01
2.3	Concept co-extrusion and variety of co-extruders used, operation of co-extruder	02
3.	**Extrusion Processes for plastic products**	
3.1	Extrusion Process for production of plastic film	02
3.2	Extrusion process for production of plastic pipe	02
3.3	Extrusion Process for production of plastic profiles	02
3.4	Extrusion Process for production for wire coating	02
3.5	Casting of films	01
3.6	Reactive extrusion	02
4.	**Compounding of Polymers**	
4.1	Importance of compounding in plastics	01
4.2	Compounding additives and their functions	02
4.3	Effect of compounding additives on performance and processing of plastics	02
4.4	Compounding equipments like Banbury mixer, etc.	02
4.5	Importance and methods of finishing of plastics	02

5.	**Calendaring of plastics**	
5.1	Basic concepts of Calendaring process	01
5.2	Preparation of plastic paste and plastisol for calendaring	02
5.3	Calendar roll arrangements	01
5.4	Description of process for making Calendared products	01
	Total hours	**40**

TPL –303 : RHEOLOGY AND TESTING OF POLYMERS

L	T	P	C
3	0	6	5

OBJECTIVE: The objective of this course is to enable the students

- To understand the fundamentals of polymer rheology and testing.
- To interpret the flow behavior of polymer melts by mechanical models.
- To learn testing of plastic materials on various testing equipments.

Course Outcome

On the successful completion of the course, students will be able to

CO1	understand the fundamentals of polymer rheology.	Understand
CO2	apply mathematical models to interpret the flow behaviour of polymer melts.	Apply
CO3	Understand the concept of measurement of viscosity.	Understand
CO3	apply knowledge in handling rheological instruments.	Apply
CO4	understand testing of plastics materials for its mechanical, electrical, optical, and thermal properties.	Understand
CO5	apply characterization techniques viz. FTIR, NMR, TGA & DSC to elucidate the properties of polymers.	Apply
CO6	analyze testing of plastic materials on different testing equipments.	Analyze

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3					3						3	3	3
CO2	3	3	3	2		3						3	3	3
CO3	3	3	3	2		3						3	3	3
CO4	3	3	3	2	2	3			3			3	3	3
CO5	3	3	3	2	2	3			3			3	3	3
CO6	3	3	3	2	2	3	3		3			3		
Total	**3**	**3**	**3**	**2**	**2**	**3**	**3**		**3**			**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Introduction to polymer rheology and importance of rheology on polymer processing techniques such as extrusion, injection moulding, etc.
2. Different view point of polymer rheology and it's correlation with theory of mechanics.
3. Newtonian and non-Newtonian fluids, concept of stress, strain-rate and viscosity, elastic and viscous responses.

4. Time-independent and time dependent fluids, concept of viscoelastic behavior, constitutive equations.

Course Outcome 2 (CO2)

1. Mechanical models – Maxwell and Kelvin models and it's correlation with deformation and flow of polymers, relaxation, creep and oscillatory experiments.
2. Concept of normal stresses and viscous heat generation and it's importance for polymer deformation and flow.

Course Outcome 3 (CO3)

1. Concept of time-temperature sensitivity of viscoelastic solids and liquids.
2. Viscometers and Rheometers to measure polymer viscosity.

Course Outcome 4 (CO4)

1. Concept of polymer testing, different standard test methods.
2. Method, instrumentation and limitations of various thermal and mechanical test methods.
3. Methods, instrumentation and limitations of various electrical and optical test methods.

Course Outcome 5 (CO5)

1. Structural elucidation by Fourier-transform infra-red and nuclear magnetic resonance (NMR) spectrophotometers.
2. Thermal characterization by thermogravimetric analyzer (TGA) and Differential scanning calorimeter (DSC).

Course Outcome 6 (CO6)

1. Determination of various thermal and mechanical properties by standard test machines and it's correlation with actual performance.
2. Determination of viscosity.
3. Determination of polymer yield by microwave synthesizer.

Syllabus

Module -I:Fundamentals of Polymer Rheology

Introduction to polymer rheology, importance of rheology on polymer processing techniques such as extrusion, injection molding, etc., Newtonian and non-Newtonian fluids, time independent and time-dependent fluids, visco-elastic behavior, constitutive equations.

Module-II: Mechanical Models and Polymer Rheology

Mechanical models, discussion of models for flow and deformation in polymers and treatment of measurable rheological properties

Module – III: Measurement of viscosity and Rheometers

Measurement of viscosity and normal stresses. Viscous heat generation. Interpretation of time-temperature sensitivity of viscoelastic solids and liquids. Rheometers.

Module-IV: Testing of Polymer Properties
Testing of polymer properties viz. thermal, optical, electrical, and mechanical properties as per standard specifications, viz. ASTM, ISO, etc. and its importance, correlation of these tests with actual performance.

Module-V: Characterization of Polymers
Introduction to polymer characterization by instrumental techniques such as IR, NMR, DSC, TGA, etc.

Module-VI: Laboratory Experiments
Determination of Tensile Strength and Percent Elongation of polymer film/sheet/molded plastic specimen, Determination of the Izod/Charpy Impact Strength of given specimen, Determination of the Vicat Softening point/Melt Flow Index of given plastic sample, Determination of the Shore A Hardness of Rubber Sheet, Determination of the Percent Water Absorption in 24 hours of Molding Plastic samples, Determination of the Falling Dart Impact Strength of polyethylene film, Determination of viscosity of polymer by Brookefield viscometer, Determination of polymer yield by microwave synthesizer.

Reference Books and Suggested Readings :

1. J. D. Ferry, " Visco-elastic properties of polymers ", Wiley, 1980.
2. J. Ferguson and Z. Kemblowski, " Applied fluid rheology ", Springer Netherlands, 1991.
3. R.B. Brown, " Handbook of Plastics Test Method ", CRC Press, 1999.
4. Brown and Vishnu Shah, " Handbook of Plastic Testing Technology ", Wiley-Blackwell, 1998.
5. John M. Dealy, Kurt F. Wissburn, " Melt Rheology & its Role in Plastics processing theory & applications ", Springer Netherlands, 1998.
6. Brydson, JA, " Flow Properties of Polymer Melts ", CBLS, 1970.
7. Christopher W. Macosko, " Rheology, Principles, measurements and applications ", Wiley-VCH, 1994.

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Basics of polymer rheology**	
1.1	Introduction to polymer rheology, concept of stress, strain, shear rate and viscosity, concept of elastic and viscose responses	02
1.2	Importance of rheology on polymer processing techniques such as extrusion, injection moulding, etc., Quality control	02
1.3	Newtonian and non-Newtonian Fluids, Flow behavior of polymer melts and solutions, Shear-rate dependence, temperature dependence, molecular-weight dependence, etc on viscosity	02
1.4	Time-independent and time-dependent fluids	02

1.5	Viscoelastic behavior, constitutive equations	02
2.	**Mechanical Models and Polymer Rheology**	
2.1	Role of mechanical models in polymer rheology, mechanical analogies	02
2.1	Discussion on flow and deformation in polymers by different mechanical models	02
2.2	Concept of relaxation, creep and oscillatory experiments	02
2.3	Treatment of measurable rheological properties	02
3.	**Measurement of Viscosity and Rheometers**	
3.1	Discussion on measurement of viscosity and normal stresses	01
3.2	Viscous heat generation – concept and application in polymers	02
3.3	Interpretation of time-temperature sensitivity of viscoelastic solids and liquids	02
3.4	Different types of viscometers and rheometers for the measurement of polymer viscosity	02
4.	**Testing of Polymer Properties**	
4.1	Testing and its importance	01
4.2	Testing of various mechanical properties, viz. tensile strength, elongation-at-break, modulus, izod/charpy impact strength, falling dart impact strength	02
4.3	Testing of various thermal properties, viz. MFI, Vicat softening point heat distortion temperature, etc	02
4.4	Testing of various optical properties, viz. haze, transparency, etc.	02
4.5	Testing of various electrical properties, viz. dielectric constant, power factor, etc.	02
5.	**Characterization of Polymers**	
5.1	Structural elucidation by Fourier-transform infra-red and nuclear magnetic resonance (NMR) spectrophotometers	02
5.2	Thermal characterization by thermogravimetric analyzer (TGA) and Differential scanning calorimeter (DSC)	02
5.3	Other characterization techniques	02
	Total:	**40**
6.	**Laboratory Experiments**	
6.1	Determination of Tensile Strength and Percent Elongation of polymer film/sheet	06
6.2	Determination of the Vicat Softening point of given plastic sample on Vicat Softening Point apparatus	06
6.3	Determination of Tensile strength, Modulus and Percent Elongation of moulded plastic test specimen on Microprocessor Controlled Universal Testing Machine (U.T.M)	06
6.4	Determination of the Izod/Charpy Impact Strength of given specimen	06
6.5	Determination of the Melt Flow Index of polymer raw material by MFI tester	06
6.6	Determination of the Shore A Hardness of Rubber Sheet	06
6.7	Determination of the Percent Water Absorption in 24 hours of	06

	Moulding Plastic samples	
6.8	Determination of the Falling Dart Impact Strength of polyethylene film using Falling Dart Impact Tester	06
6.9	Determination of viscosity of polymer by Brookefield viscometer	06
6.10	Determination of polymer yield by microwave synthesizer	06
	Total hours	**60**
	G. Total:	**100**

TPL–302 : STRUCTURE AND PROPERTY OF POLYMERS

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to enable the students

- To understand about different structure of polymers and study the effect of structure on the mechanical, thermal, optical, electrical and chemical properties of polymers.
- To learn about the prediction of various physical, thermal, electrical, optical and chemical properties of polymers by using additive principle.

Course Outcome

On the successful completion of the course, students will be able to

CO1	understand correlation between polymers structure and property.	Understand
CO2	Apply mathematical equations to interpret the concept of molecular weight averages and MWD on polymer properties.	Apply
CO3	understand the concept of polymer crystallinity and its role to analyze polymer properties.	Analyze
CO4	apply mathematical equations to analyze polymer solution properties.	Apply
CO5	understand the concept of flexibility to interpret the glass transition temperature.	Understand

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3					3	3					3	3	3
CO2	3			2		3						3	3	3
CO3	3	3		2		3			2			3	3	3
CO4	3	3	3	2	2	3			2			3	3	3
CO5	3	3	3	2	2	3			2			3	3	3
Total	**3**	**3**	**3**	**2**	**2**	**3**	**3**		**2**			**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Concept of polymer and classification of polymers.
2. Salient features of basic structure of polymers.
3. Various parameters to establish a relation between the structure of polymer and its physical properties.
4. Role of chain extending bond, intermolecular forces and chemical stability to establish a structure-property relationship in polymers.

Course Outcome 2 (CO2)

1. Concept of average molecular weight (MW) in polymers, various types of molecular weight averages and establishment of mathematical equations for these averages.
2. Importance of molecular weight averages in polymer processing.
3. Determination of different types of molecular weights of polymers by different instrumental techniques and importance of each.
4. Concept of molecular weight distribution (MWD) and MWD curve.
5. Correlation of MW and MWD with the properties of polymers.

Course Outcome 3 (CO3)

1. Concept of crystallinity and crystallisability, requirements of crystallinity in polymers.
2. Structure of polymer on the basis of given models.
3. Difference between melting of low and high molecular weight substances.
4. Concept of polymer melting and thermodynamics of melting.
5. Effect of crystallinity on mechanical properties and molecular weight of polymers.

Course Outcome 4 (CO4)

1. Fractionation in polymers and fractionation techniques.
2. Flory-Huggin's theory.
3. Solution viscosity and empirical relationship between viscosity-average molecular weight and viscosity.
4. Concept of solubility of polymer, solubility parameter, different polymer-solvent systems and their solubility.

Course Outcome 5 (CO5)

1. Concept of flexibility and glass transition temperature (Tg) of polymers.
2. Significance of Tg on the basis of states of aggregation and phases.
3. Factors affecting glass transition temperature.
4. Effect of copolymerization on properties.
5. Concept of degradation behaviour of polymers.

Syllabus

Module-I:General Structural Features of Polymers

Basic structures in polymers, structure-property relationship. Effect of chemical composition and types of bonds in structure of polymer, intermolecular forces.

Module-II: Molecular weight averages and Molecular mass heterogeneity

Molecular weight averages and distributions. Determination of molecular weight averages. Polydispersity and MWD.

Module -III: Polymer Crystallinity and its measurement

Orientation of crystalline and amorphous zones and study of its effects on polymer properties. Polymer single crystal, dimensions of polymer chain, degree of crystallinity and its measurement.

Module-IV: Polymer-in-solution
Polymer-solvent interaction, good and poor solvents, intrinsic viscosity and Mark-Houwink equation, concept of fractionation processes.

Module-V:Flexibility and movement of macromolecules
Concept of flexibility, various factors deciding flexibility of polymers, polymer properties affected by flexibility, glass transition temperature (Tg), factors affecting glass transition temperature. Effect of copolymerization on properties. Degradation behaviour of polymers.

Reference Books and Suggested Readings :

1. Text Book of Polymer Science, F. W. Billmeyer, John Wiley & Sons, 2009.
2. Properties and structure of polymers, A. T. Tobolsky, Wiley, New York, 1960.
3. Polymer Chemistry, C. E. Carrshar, Marcel Dakker Inc., 2003.
4. Polymer Solutions – Introduction to Physical Properties, Teraoka, Iwao, John Wiley and Sons, Inc., 2002.
5. Polymer Chemistry – An Introduction, M. P. Stevens, Oxford University Press, 1990.
6. Encyclopedia of Polymer science and Technology, H.F.Mark, N.G. Gaylord, and N. M. Bikales, Eds., Interscience Publishers, New York, 1971.
7. Advanced Polymeric Materials: Structure property relationship, by G.O.Shonaike and S.G.Advani, Ed. CRC Press, 2000.

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**General Structural Features of Polymers**	
1.1	Concept of polymer, classification of polymer, salient features of basic structure of polymers	02
1.2	Various parameters to establish a relation between the structure of polymer and it's physical properties	02
1.3	Role of chain extending bond and intermolecular forces to establish a structure-property relationship in polymers	02
1.4	Role of chemical stability to establish a structure-property relationship in polymers	01
2.	**Molecular weight averages and Molecular mass heterogeneity**	
2.1	Concept of molecular weight average in polymer, comparison with low molecular weight compounds, polydispersity	02
2.2	Various types of molecular weight averages and establishment of mathematical equations for these averages	02
2.3	Importance of molecular weight averages in polymer processing	01
2.4	Determination of different types of molecular weights of polymers by different instrumental techniques and importance of each	04
2.5	Correlation of MW and MWD with the properties of polymers	02
3.	**Polymer Crystallinity and it's measurement**	
3.1	Concept of crstallinity, degree of crstallinity, and crystallisability in polymers, requirements for crystallinity	02

3.2	Proposed models for partially crystalline polymers, spherulites, unit cell, polymer single crystal	02
3.3	Theory of polymer crystallization	02
3.4	Determination of crystallinity	02
3.5	Effect of crystallinity on polymer properties	02
4.	**Polymer-in-solution**	
4.1	Polymer-solvent interaction, good and poor solvents, solubility parameter, calculation of solubility parameter for different polymers	02
4.2	Concept of intrinsic viscosity and determination of viscosity average molecular weight by Mark-Houwink's equation	02
4.3	Concept of fractionation and various fractionation processes	02
5.	**Flexibility and movement of macromolecules**	
5.1	Concept of flexibility, various factors deciding flexibility of polymers, polymer properties affected by flexibility	03
5.2	Glass transition temperature (Tg) and factors affecting glass transition temperature	02
5.3	Effect of copolymerization on properties	02
5.4	Degradation behaviour of polymers, types of degradation, role of degradation in polymer properties	03
	Total hours	**45**

	L	T	P	C
TPL–304 : POLYMER PROCESSING – II	**3**	**0**	**6**	**5**

OBJECTIVE: The objective of this course is to enable the students

- To understand the injection molding process and components of injection molding machine.
- To understand the processing techniques like thermoforming, calendaring, rotational moulding, blow molding etc.
- To process plastics on different types of moulding machines and prepare simple articles.

Course Outcome

On the successful completion of the course, students will be able to

CO1	understand the fundamentals of injection molding process for conversion of thermoplastic and analyze processing parameters and variables for modification and improvement of quality of products.	Understand and Analyze
CO2	understand the processing techniques for conversion of thermoset materials like compression, transfer molding and casting.	Understand and Analyze
CO3	Understand formation of low cost plastic products by thermoforming process and analyze utility of process for different applications.	Understand and Analyze
CO4	understand formation of hollow plastic products and analyze utility of various techniques.	Understand and Analyze
CO5	Understand reactive processes for formation of plastic products like RIM.	Understand
CO6	Use of different processing machines for formation of plastic products.	Apply

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3		1	1		3						3	3	3
CO2	3		1	1		3						3	3	3
CO3	3	3	1	1		3						3	3	3
CO4	3	3				3						3	3	3
CO5	3	3				3						3	3	3
CO6	3	3	3	3	1	3			3			3	3	3
Total	**3**	**3**	**1.5**	**1.5**	**1**	**3**			**3**			**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Types of Injection units and their construction viz. injection unit, clamping unit, nozzle, etc.

2. Specifications of injection molding machines and process variables and determination of clamping force, etc.
3. Different elements of plasticization process of plastic in screw
4. Faults and remedies in injection molding operation
5. Gas assist injection molding

Course Outcome 2 (CO2)

1. Description of compression and transfer molding operation
2. Description of thermoset injection molding operation
3. Comparisons of different types of processes for thermoset polymers

Course Outcome 3 (CO3)

1. Material characteristics important for thermoforming process
2. Utility of thermoforming process for plastic products
3. Process parameters for thermoforming process
4. Defects and faults for thermoforming process

Course Outcome 4 (CO4)

1. Process description of Injection Blow Molding and Extrusion Blow Molding processes
2. Co-relation between process parameters and molding faults
3. Process description of Rotational Molding Process

Course Outcome 5 (CO5)

1. Process description for Reaction Injection Molding for polyurethane products
2. Description of casting process for epoxy resin, nylon, acrylics, etc.

Course Outcome 6 (CO6)

1. Using Laboratory scale processing machines for forming different plastic products
2. Analyze variation in process parameters for preparation of specimens and product

Syllabus

Module-I:Injection Molding of Thermoplastics

Basic concepts of injection molding of thermoplastics Principle and theory of standard injection molding operation, molding cycle, Process variables, temperature, pressure, injection rate, etc. and their importance for machine cycle and quality of product. Faults and remedies in injection molding operation. Advances in injection molding.

Module-II: Molding Processes for Thermoset polymers

Concept of Injection molding of thermoset polymers and process details. General concept of compression and transfer molding process, the description of various types of compression and transfer molding processes and their utility in processing of thermosetting materials.

Module-III: Thermoforming Process

Concepts of thermoforming process and various means of forming. Description of various thermoforming methods. Thermoforming process variables affecting the product quality. Thermoforming faults and remedies. Thermoforming machines.

Module-IV: Molding Process for hollow products
General description of blow molding processes, type of blow molding machines, die shaping, parison control, process variables, blow molding faults and their remedies,
Rotational molding process description and features of rotational molding machines. Process variables in rotational molding process
Stretch blow molding process. Concepts of stretching temperature, transparency, etc. various types of stretch blow molding operation.

Module-V: In-situ Reaction Molding process
Reaction injection molding (RIM) Process, its basic principles, process description and utility. Concept of Casting of polymers, description of process for polymers like epoxy resins, nylons, polyurethanes, etc.

Module VI: Laboratory Experiments
Preparation of simple plastic products and test specimen on Injection Molding Machine; Preparation of simple article on Blow Molding Machine, Preparation of Fiber reinforced plastic sheet by using glass fiber mat and unsaturated polyester resin; Preparation of sheet by Hydraulic press/Two Roll Mill; Preparation of PET Bottle on Stretch Blow Moulding Machine, Preparation of an article by Rotational Molding Machine.

Reference Books and Suggested Readings :

1. Plastic Engg. HandBook, by Frados.
2. Injection and Compression Moulding Fundamentals, by Isayev.
3. Encyclopedia of Polymer Science and Technology Vol. 1-23, by Mark &Overberger.
4. HandBook of Injection Moulding, by Rosato& Rosato.
5. Practical Thermoforming Principles & Applications, by J. Florian.

Course contents and lecture schedule

Module	Topic	No. of Lectures
1.	**Injection Molding of Thermoplastics**	
11.	Concept of Injection Molding process, discussion of utility of this process for production of plastic products, advantages and disadvantages, plastic materials processed by injection molding	01
1.2	Elements of injection molding machine, types of injection unit, clamping unit, screws, molds and machine controls	03
1.3	Specifications for injection molding machines, determination of clamping force, torque and screw output. Discussion on screw plasticization process for efficient molding	03
1.4	Injection Molding Faults, the analysis of causes and suggestions and remedies	02

2.	**Molding Processes for Thermoset Polymers**	
2.1	Concept of Thermoset molding, Injection Molding Processes for Thermoset polymers, advantages, disadvantages, utility in various fields	01
2.2	Introduction of Compression molding process, material characteristics, important steps, variations in compression molding process, utility of this process for variety of products, molding faults and their solutions.	03
2.3	Introduction of Transfer molding process, types of Transfer molding process, advantages and disadvantages of transfer molding process, utility of this process for variety of products, molding faults and their solutions	03
3.	**Thermoforming process**	
3.1	Concept of thermoforming process, various means of forming, advantages, disadvantages and utility of process for variety of products formed by this process, material characteristics for thermoforming, types of thermoforming processes, concept of plug assist forming	03
3.2	Thermoforming machines, thermoforming variables	03
3.3	Thermoforming faults, their probable causes and remedies, solutions	02
4.	**Molding Processes for hollow products**	
4.1	Concept of blow molding process, concept of neck to bottom diameter of hollow products, blown ratio, advantages and disadvantages of process, Blow molding faults, their probable causes and remedies	02
4.2	Concept and types of Extrusion and injection blow molding process, various arrangements of molds for efficient molding, neck molding, die shaping and parison programming, mold cooling, air entrance, etc.	04
4.3	Concept of Rotational blow molding process, various arrangements of molds and types of machines for efficient molding, material characteristics for rotational molding process, advantages, disadvantages and molding parameters	02
4.4	Concept of Stretch blow molding process, Conditions for stretching, types of processes and machines	02
5.	**In-situ Reaction Molding Process**	
5.1	Concept of Reaction Injection molding (RIM) process, material characteristics for RIM, process details and utility	03
5.2	Casting process for variety of polymers like epoxy, Nylon, Acrylics, polyurethanes	03
	Total Hours:	**40**
6.	**Laboratory Experiments**	
6.1	Preparation of simple plastic products using Vacuum forming machine	06
6.2	Preparation of simple plastic products using Injection Molding	06

	Machine	
6.3	Preparation of simple plastic products using Compression Molding Machine	06
6.4	Preparation of film/sheet by extrusion process	06
6.5	Preparation of simple article on Blow Molding Machine	06
6.6	Preparation of Fiber reinforced plastic sheet by using glass fiber mat and unsaturated polyester resin	06
6.7	Mixing of plasticizer in PVC on Two Roll Mill	06
6.8	Preparation of sheet by Hydraulic press	
6.9	Preparation of PET Bottle on Stretch Blow Molding Machine;	06
6.10	Preparation of an article by Rotational Molding Machine	06
	Total Hours :	**60**
	G. Total Hours :	**100**

TPL –306 : POLYMERIZATION ENGINEERING - II

L	T	P	C
3	0	6	5

OBJECTIVE: The objective of this course is to enable the students

- To understand synthesis, , manufacturing process, properties and applications of engineering plastics.
- To learn the manufacturing of thermoset properties and applications of polymers.
- To understand the synthesis and manufacturing of flexible and rigid polyurethanes and analyze then formations and projects.

Course Outcome

On the successful completion of the course, students will be able to

CO1	understand concept of engineering plastics, synthesis and manufacturing of common engineering plastics and analyze their properties for variety of applications.	Understand and Analyze
CO2	understand monomers and their properties, chemistry of synthesis and manufacturing of high performance thermoplastic materials and analyze their properties and applications.	Understand and Analyze
CO3	understand concept and characteristics of specialty plastics and their applications.	Understand
CO4	understand monomers, chemistry of synthesis, manufacturing, curing and properties of high temperature thermoset polymers like epoxy resin.	Understand
CO5	understand synthesis, manufacturing, properties and applications of specific polymers like polyurethane.	Understand
CO6	apply techniques for synthesis of modified polymer materials.	Apply

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2				3						3	3	3
CO2	3	2				3						3	3	3
CO3	3	2				3						3	3	3
CO4	3	2				3						3	3	3
CO5	3	2				3						3	3	3
CO6	3	2	2	3	1	3			3			3	3	3
Total	**3**	2	**2**	**3**	**1**	**3**			**3**			**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Criterion for engineering plastics

2. Manufacturing process and flow sheet for production of engineering plastics like ABS and PC.
3. Properties and applications of engineering plastics.

Course Outcome 2 (CO2)

1. Monomers for various engineering plastics like nylons and polyesters.
2. Manufacturing process, properties and applications of nylons, PET, PBT, etc.
3. Properties and applications of fluorine containing polymers.
4. Importance of glass filled polymers.

Course Outcome 3 (CO3)

1. Utility of high performance specialty plastics like PEEK.
2. Chemistry of synthesis and applications of polymers like PES, PPS, etc.

Course Outcome 4 (CO4)

1. Chemistry of synthesis of various grades of epoxy resin and their characteristics.
2. Manufacturing process for thermoset polymers like epoxy resin, polyimides.
3. Curing agents and curing mechanism for thermoset polymers.

Course Outcome 5 (CO5)

1. Monomers and synthesis of polyurethane.
2. Concept of flexible and rigid polyurethanes.
3. Production of variety of polyurethane.

Course Outcome 6 (CO6)

1. Apply techniques for the preparation of copolymers, ester gum resin, graft copolymer, polyester resin, moulding powder, etc.
2. Depolymerization of polystyrene.
3. Determination of epoxide equivalent and amine values.
4. Analysis of gel time of epoxy resin.
5. Modification of epoxide equivalent of resin.
6. Apply modification methods for improvement of polymers like epoxy, resin, styrene.

Syllabus

Module-I:Engineering Thermoplastics-I

General characteristics of commodity, engineering and high performance polymers. Monomers, chemistry of synthesis, manufacturing process, properties and applications of common engineering plastics such as ABS and polycarbonate.

Module-II: Engineering Thermoplastics-II

Monomers, chemistry of synthesis, manufacturing process, properties and applications of polyamides, polyesters, fluorine-containing polymers, etc.

Module-III: Specialty Thermoplastics

Monomers, chemistry of synthesis, manufacturing process, properties and applications of polyphenylene oxide, acetal resins, polysulphones and other specialty plastics.

Module-IV: Thermoset polymers-I
Monomers, chemistry and manufacturing process of thermosetting resins such as epoxy resins, unsaturated polyesters resins, polyimides, etc. their curing mechanism and effect of curing parameters on properties and applications of these polymers.

Module-V:Thermoset polymers-II
Synthesis and manufacturing of flexible and rigid polyurethanes and polyacrylatyes, and their properties and applications.

Module-VI: Laboratory Experiments
Preparations copolymers, ester gum resin, polyester resin, graft copolymer, molding powder Depolymerization of polystyrene; Determination of epoxide equivalent and amine values. Analysis of gel time of epoxy resin. Modification of epoxide equivalent of resin. Apply modification methods for improvement of polymers like epoxy, resin, styrene.

Reference Books and Suggested Readings :

1. Polymer production, by Mayo & Smith
2. Polymer Materials, by J. A. Brydson
3. Encyclopedia of Polymer Science & Tech., Vol 1-23, by Mark &Overberger
4. Handbook of Plastic Technology, Vol 1, by Allen W. S.
5. Handbook of Plastic Technology, Vol 2, by Allen W. S. and G. M. Swallowe
6. Vinyl acetate emulsion polymerization and copolymerization with acrylic monomers, by H.Yildilin Erbil
7. Handbook Of Thermoplastics, by Olagoke Olabisi
8. Engineering polymers, R.W. Dyson Chapman Hall NY 1990

Course contents and lecture schedule

Module	Topic	No. of Lectures
1.	**Engineering Plastics-I**	
1.1	Criterion for Classification of Thermoplastics, Definition and concept of Engineering Plastics	01
1.2	Monomers, Chemistry of synthesis of Polycarbonate, Manufacturing Processes, properties, and applications of polycarbonate. Utility of Polycarbonate in various of areas	O3
1.3	Monomers, Routs for synthesis, manufacturing process with flow sheet, properties and applications of ABS plastics. Utility of ABS plastics in various fields	03
2.	**Engineering Plastics-II**	
2.1	Introduction to Polyamides, Routs for synthesis of Nylons, Monomers, Flow sheets for manufacturing Nylon6 and Nylon66by batch and continuous polymerization reactors and discussion of various steps involved. Properties, relation of structure of polyamide with properties	04

	and applications of various nylons. Fillers for Nylons , properties and applications of Glass filled Nylons	
2.2	Monomers, Chemistry of synthesis of Polyesters: PET and PBT, Manufacturing Processes, flow sheets, properties, and applications of Polyesters. Utility of Polycarbonate in various of areas. Glass filled Polyesters and their properties and applications	03
2.3	Introduction of Flourine containing Polymers. Monomers, Chemistry of synthesis of Poly tetra fluoro ethylene (PTFE), properties, and applications of PTFE	01
3.	**Specialty Plastics**	
3.1	Monomers, Chemistry of synthesis of Polyphenylene ether (PPE), Manufacturing Processes, properties, and applications of PPE. Properties and applications of PPE blends, their characteristics and applications	02
3.2	Introduction to Acetal resins. Monomers, Chemistry of synthesis of Acetal Homopolymer resins Acetal Copolymer resin, their properties and applications and comparison of these Polymers for various fields of applications	02
3.3	Monomers, Chemistry of synthesis, different routes, manufacturing Processes, properties, and applicationsof Polysuphones. Various Commercial grades available	02
3.4	Monomers, Chemistry of synthesis of Polyesters: PET and PBT, Manufacturing Processes, flow sheets, properties, and applications of Polyesters. Utility of Polycarbonate in various of areas. Glass filled Polyesters and their properties and applications	02
3.5	Monomers, Chemistry of synthesis, properties, and applications of other specialty plastics like Polysulphide (PPS), Poly ether ether ketone (PEEK), and Polyarylates	02
4.	**Thermoset Polymers-I**	
4.1	Introduction to Epoxy resin, monomers, chemistry of synthesis of DGEBA and BPA based epoxy resin effect of reaction conditions on molecular weight of resin, monomers, manufacturing processes with flow sheet for low and high molecular weight resins, characterization, properties and applications of resins. Curing agents and curing mechanism of epoxy resins. Fillers, diluents and flexiblizers for epoxy resins	04
4.2	Other glycidyl ether based and Non glycidyl ether based epoxy resins	01
4.3	Introduction to polyimides, Monomers, Chemistry of synthesis, different grades, manufacturing Processes, properties, and applications of Polyimides and various modified polyimides viz. Poly ether imide, Poly (bis malenimide) and poly(amideimide)	03
5.	**Thermoset Polymers-II**	
5.1	Introduction to unsaturated polyesters, Routs for synthesis of polyesters, Monomers, Flow sheets for manufacturing polyesters and discussion of various steps involved. Properties, and applications of various types of commercial polyesters. Curing mechanism, fillers and additives for polyesters.	04
5.2	Introduction to Poly urethanes. Concept of flexible and rigid PU. Monomers, Various Poly urethane reactions, manufacturing processes for flexible and rigid PU and discussion of various steps involved. Properties and applications of various Polyurethanes	03
	Total Hours :	**40**

6.	**Laboratory Experiments**	
6.1	Synthesis of copolymer of styrene and maleic anhydride	06
6.2	Synthesis of ester gum resin	06
6.3	Synthesis of polyester resin	06
6.4	Determination of epoxide equivalent weight of epoxy resin	06
6.5	Determination of amine content of curing agent	06
6.6	Determination of gel time of epoxy resin	06
6.7	Depolymerization of polystyrene	06
6.8	Modification of epoxide equivalent of resin	06
6.9	Preparation of Molding powder	06
6.10	Synthesis of graft copolymer	06
	Total Hours :	**60**
	G. Total Hours :	**100**

TPL – 401 : ADVANCED POLYMER MATERIALS

L	T	P	C
3	0	3	4

OBJECTIVE: The objective of this course is to enable the students

- To understand the basics syntheses and applications of high performance polymers.
- To understand the determination of various properties using analytical instruments.

Course Outcome

On the successful completion of the course, students will be able to

CO1	understand chemistry of synthesis of polymers for high tech applications and analyze the properties of high performance polymers for specific application like aerospace, telecomm, biomedical, defense etc.	Understand and Analyze
CO2	Understand chemistry, preparation, properties and applications of high temperature resistant polymers.	Understand
CO3	Understand the preparation, properties and applications of liquid crystalline polymers, silicone polymer, and any newly developed material. Nanofillers and nanocomposites, their processing and economics.	Understand
CO4	Understand and analyze self reinforced polymer composite, high energy absorbing polymer, super absorbent polymers, and polymers for biomedical applications.	Understand and Analyze
CO5	understand modification techniques for preparation of specific polymers like polymer blends & alloys.	Understand
CO6	characterize polymers using analytical instruments like DSC,TGA,UV spectrophotometer.	Analyze

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3					3							3	3
CO2	3	2				3						3	3	3
CO3	3	2				3						3	3	3
CO4	3	2				3						3	3	3
CO5	3	3				3						3	3	3
CO6	3	3	3	3	3	3	1		3			3	3	3
Total	**3**	**2.5**	**3**	**3**	**3**	**3**	**1**		**3**			**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Course Level Assessment Questions

Course Outcome 1(CO1)

1. Understand the chemistry of synthesis of polymers for high tech applications such as aerospace, telecommunication, defense, medical, etc.

2. Analyze the properties of high performance polymers for specific applications like aerospace, telecomm, biomedical, defense etc.

Course Outcome 2(CO2)

1. Chemistry, preparation, properties and applications of high temperature resistant polymers like polyether imide, etc.
2. Concept of high temperature resistant specialty polymers.
3. Properties and applications of high temperature resistant polymers.

Course Outcome 3 (CO3)

1. Preparation, properties and applications of liquid crystalline polymers.
2. Preparation, properties and applications of silicone polymer.
3. Preparation, properties and applications of any newly developed material.
4. Concept of nanofillers and nanocomposites, carbon nanotube (CNT).

Course Outcome 4 (CO4)

1. Processing and economics of advanced polymers like self-reinforced polymer composite, high energy absorbing polymer, super absorbent polymer, etc.
2. Processing and economics of polymer for biomedical applications.
3.

Course Outcome 5 (CO5)

1. Concept of polymer blends and alloys, polymer miscibility, methods of blending.
2. Various commercial polymer blends and their applications.

Course Outcome 6 (CO6)

1. Determination of glass transition temperature/crystallinty/heat of reaction by using Differential Scanning Calorimeter (DSC).
2. Determination of Initial Degradation Temperature (IDT), Final Degradation Temperature and char yield (FDT) of polymers by using Thermo Gravimetric Analyzer (TGA).
3. Dispersion of two liquid or solid-liquid sample using Ultrasonicator.
4. Rheological properties of given polymer blends or mixtures.

Syllabus

Module-I:Role of Polymers for High-tech areas

Role of polymers for high-tech areas such as aerospace, telecommunication, defence, medical, etc.

Module-II: High performance polymers – I

Chemistry, preparation, properties and applications of high temperature resistant polymers like polyetherether ketone (PEEK), etc. Specialty polymers.

Module-III: High performance polymers – II
Preparation, properties and applications of liquid crystalline polymers, silicone polymer, and any newly developed material. Nanofillers and nanocomposites, their processing and economics.

Module-IV: High performance polymers – III
Self reinforced polymer composite. High energy absorbing polymer. Super absorbent polymers. Polymers for biomedical applications.

Module-V: Modification of Polymers
Polymer blends and alloys, theories of polymer miscibility, various commercial blends and their applications, methods of blending.

Module-VI: Laboratory Experiments
Determination of glass transition temperature/crystallinty/heat of reaction by using Differential Scanning Calorimeter (DSC), determination of Initial Degradation Temperature (IDT), Final Degradation Temperature and char yield (FDT) of polymers by using Thermo Gravimetric Analyzer (TGA), experiments based on UV-VIS spectrophotometer, wear and friction monitor, and ultrasonicator, measurements of rheological properties of given polymer blends or mixtures.

Reference Books and Suggested Readings :

1. Encyclopedia of polymer science and technology, Vol. 14, H. F. Mark, N. G. Gaylord and N. M. Bikales, Eds., Interscience Publishers, 1971.
2. Plastic Materials, J. A. Brydson, Butterworth-Heinemann, 1999.
3. Polymer Science, by Gowarikar, Viswanathan & Jayadev
4. Macromolecular Synthesis, by J.R. Fllyott
5. Hand Book of Fibre glass and Advanced Plastic Composites, by G. Lubin
6. Polymer modification by John J. Merister
7. Polymer gels and Network by Yoshihido osada
1. Polymer Blends Hand Book – Vol. I & II, by L.A.Utracki

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Role of Polymers for High-tech areas**	
1.1	Role of polymers for high-tech areas such as aerospace, telecommunication, defense, medical, etc.	03
1.2	Development of newer polymers	02
2.	**High performance polymers – I**	
2.1	Chemistry, synthesis, processing and applications of high temperature resistant polymers like polyetherether ketone (PEEK), etc.	04
2.2	Processing and applications of specialty polymers	03
3.	**High performance polymers – II**	

2.1	Chemistry, classification, synthesis, processing and applications liquid crystalline polymers	03
2.2	Chemistry, classification, synthesis, processing and applications of silicone polymers	03
2.3	Concept of nanofillers, processing and economics of polymer nanocomposites	03
3.	**High performance polymers – III**	
3.1	Processing and economics of self reinforced polymer composite	02
3.2	Processing and economics of high energy absorbing polymer	02
3.3	Processing and economics of super absorbent polymers	03
3.4	Processing and economics of polymers for biomedical applications	02
3.5	Nanofillers and nanocomposites	03
4.	**Modification of Polymers**	
4.1	Concept of Polymer blends and alloys	02
4.2	Methods of blending and theories of polymer miscibility	03
4.3	Various commercial blends and their applications	03
	Total Hours :	**41**
5.	**Laboratory Work**	
5.1	Determination of glass transition temperature/ crystallinty/ heat of reaction by using Differential Scanning Calorimeter (DSC)	06
5.2	Determination of Initial Degradation Temperature (IDT), Final Degradation Temperature and char yield (FDT) of polymers by using Thermo Gravimetric Analyzer (TGA)	06
5.3	Determination of the presence of U.V. Stabilizer in polycarbonate sample by UV-VIS Spectrophotometer	03
5.4	Determination of the percentage transmittance of given film or sheet sample by UV-VIS Spectrophotometer	03
5.5	Recording of spectra for given chemical in U.V. band visible range using UV-VIS Spectrophotometer	03
5.6	Study of wear and friction of the given plastic/composite materials sample using wear and friction monitor	03
5.7	Dispersion of two liquid or solid-liquid sample using Ultrasonicator	03
5.8	To determine the rheological behaviour of given polymer blends or mixtures	03
	Total hours :	**30**
	G. Total Hours :	**71**

PROGRAMME ELECTIVE COURSE I

TPL-403 : PLASTIC PRODUCT AND MOULD DESIGN

L	T	P	C
3	0	0	3

OBJECTIVE: The objective of this course is to enable the students

- To understand the concepts of product design and composite product design and important design features.
- To understand various parts of injection mold and their types.
- To learn the problems related to multicavity injection molds and their solution.
- To understand the design concept for different types of extrusion dies.

Course Outcome

On the successful completion of the course, students will be able to

CO1	understand need for designing for plastic products. Design of polymeric products, design criteria based upon product functions and geometry.	Understand
CO2	understand design features for mold designs for plastic product and apply.	Understand
CO3	understand concepts and structure of injection molds with materials.	Understand
CO4	understand concepts and structure of compacts of compressive & transfer molds.	Understand
CO5	understand concepts and structure of extrusion dies.	Understand

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3		1									2	3	3
CO2	3	2	1									2	3	3
CO3	3	2	1									2	3	3
CO4	3	2	1	1	2	1						2	3	3
CO5	3	2										2	3	3
Total	**3**	**2**	**1**	**1**	**2**	**1**						**2**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Differences in plastic product design features.
2. Constraints related to molding.
3. Choice of plastic material.

Course Outcome 2 (CO2)

1. Design checklist and important information.

2. Basic structural design parameters.
3. Specific design features.

Course Outcome 3 (CO3)

1. Basic functions of Injection mold.
2. Types of injection molds.
3. Standard structural design features and materials for mold base.

Course Outcome 4 (CO4)

1. Difference between compression and Injection Molds.
2. Compression mold structure and types.
3. Transfer molds.

Course Outcome 5 (CO5)

1. Basic Die Characteristics.
2. Types of Extrusion Dies.
3. Die design for simple films, sheet etc.

Syllabus

Module-I:Plastic product design criteria
Design of polymeric products, design criteria based upon product functions and geometry, material selection by property assessment, selection of appropriate forming processes.

Module-II: Product Design Features
Moulding consideration : Draft, Radii, dimensional tolerances, wall thickness, ribs and bosses, inserts, sink marks, undercuts, feeding system, gate location, flow pattern, shrinkage and post moulding shrinkage.

Module-III: Injection Mold Design
Injection mould design: single, multi cavity, semi automatic and automatic moulds, Types of injection moulds, their applications, detailed structure and working. Materials for mould making & Mould making processes.

Module-IV: Design Concept of other Mold types
Design concepts for compression molds and transfer molds. Extradites dies basics, types and general structure.

Module-V:Computer Aided Design
Concept of CAD/CAM in product design moulding and plastic. Modeling and Simulation applications for mold designing, such as mould flow etc.

Reference Books and Suggested Readings :

1. Plastic Product Design, by R. D. Beck.
2. Injection mould Design, by R.G.W. Pye.
3. Plastic Mould Engg, Hand Book, by J. H. Dubois & W. I. Pribble.

4. Dies for Plastic Extrusion, by M. V. Joshi.
5. Injection Moulding Hand Book, by Rosato & Rosato.

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Plastic product design criteria**	
1.1	Need to study plastic product design	01
1.2	Product Checklist	01
1.3	Design criteria based upon product functions	02
1.4	Material selection process	02
1.5	Selection of forming process	01
2.	**Product Design Features**	
2.1	Introduction to moulding consideration	01
2.2	Basic structural design features wall thickness, draft, radii etc	03
2.3	Flow of melt in mould	01
2.4	Special design features	02
2.5	Feeding system, gate location	02
3.	**Injection Mold Design**	
3.1	Basic functions of injection mold, cycle time	01
3.2	Main structural parts of injection mold	01
3.3	Types of Injection mold	02
3.4	Automatic and semiautomatic molds	01
3.5	Multicavity molds with design criterias	01
3.6	Materials and mold making	01
4.	**Design Concept of other Mold types**	
4.1	Differences between Injection and compression molds	01
4.2	Basic design of compression mold	01
4.3	Types of compression mold	02
4.4	Transfer molds	01
4.5	Basics of extrusion dies	02
4.6	Types of Extrusion dies	03
5.	**Computer Aided Design**	
5.1	Concept of CAD in plastic product design	02
5.2	Application of CAD/ CAM in making molds	01
5.3	Advantages and applicability of CAM	01
5.4	Use of modeling and simulation in product & mold design	01
5.5	Advantages and cost reduction using CAD /CAM	02
	Total Hours	**40**

PROGRAMME ELECTIVE COURSE II

TPL –405 : TECHNOLOGY OF ELASTOMERS

L	T	P	C
2	0	0	2

OBJECTIVE: The objective of this course is to enable the students

- To provide the knowledge of some synthesis & manufactory process knowledge of natural rubber and various synthetic rubbers.
- To enable the students to understand the need of various additives and compounding of rubbers and vulcanization.

Course Outcome

On the successful completion of the course, students will be able to

CO1	understand characteristic properties of elastomers, utility of compounding ingredients for variety of applications.	Understand and Apply
CO2	Understand source, procurement process, properties, vulcanization and applications natural rubber.	Understand
CO3	understand chemistry of synthesis, manufacturing process, properties and applications synthetic rubbers.	Understand
CO4	understand processing methods and vulcanization of elastomers.	Understand
CO5	analyze quality and testing of properties of various rubbers.	Analyze

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3											3	3	3
CO2	2	2	2			2						3	3	3
CO3	3											3	3	3
CO4	3					2						3	3	3
CO5	3	2				2						3	3	3
Total	**3**	**2**	**2**			**2**						**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Characteristic properties of elastomers and relation between structure and elastic properties.
2. Concept of vulcanization of rubbers.
3. Concept of thermoplastic elastomers.
4. Utility of compounding ingredients for variety of applications.
5. Compounding equipments.

Course Outcome 2 (CO2)

1. Source of natural rubber.

2. Methods for obtaining dry rubber.
3. Vulcanization, Properties & Applications of NR.
4. Derivatives of NR, Modified rubbers & technically opened rubber.

Course Outcome 3 (CO3)

1. Chemistry of synthesis and manufacturing process for variety of synthetic rubbers like SBR, Nitrile rubber, etc.
2. Vulcanization of synthetic rubbers, their properties and applications.

Course Outcome 4 (CO4)

1. Vulcanization techniques for curing of rubbers.
2. Processing methods like compression, transfer molding, extrusion, injection molding.

Course Outcome 5 (CO5)

1. Testing methods for rubber properties.
2. Concepts of cure characteristics and assessment of level of curing & optimum curing.

Syllabus

Module-I:Introduction to elastomers and compounding

Definition and characteristics of rubber and elastomer, significance of structure and important features of elastomers. Compounding ingredients and method of compounding, various compounding equipments. Types of fillers, their characteristics and affect on rubber properties. Mechanism of reinforcement of elastomers. Carbon black its characteristics and methods of production. Mastication of rubbers.

Module-II: Natural rubber

History of natural and synthetic elastomers Production of different grades of natural rubber from latex, modified natural rubber and its derivatives. Application of latex, technically specified rubber, chemistry of vulcanization and various vulcanization techniques.

Module-III: Synthetic Rubber -I

Manufacturing processes, properties and application of synthetic elastomers viz. styrene-butadiene rubbers, acrylonitrile- butadiene rubber, butyl rubber, polychloroprene rubber.

Module-IV: Synthetic Rubber -II

Manufacturing processes, properties and application of ethylene-propylene rubber, polyurethane elastomers, chlorosulphonated polyethylene, polysulphide and silicon rubber, Concept of various types of thermoplastic elastomers and their applications.

Module-V:Industrial fabrication of Rubber Products

Industrial fabrication of rubber article such as transmission belts, hoses, tyres, dipped goods. Processing techniques of rubbers, applications and manufacturing of articles from latex. Testing methods for determination of properties and curing of rubbers.

Reference Books and Suggested Readings :

1. Rubber Technology & Manufacture, by C.M.Blow
2. Encyclopedia of Polymer Science and Technology Vol. 1-23, by Mark &Overberger
3. Rubber Technology, by Maurice Morton
4. Synthetic Rubbers, by D.C. Blacklay
5. Anil .K. Bhowmic, Howard L. Stephens (Edt), Handbook of Elastomers – New Developments & Technology, Marcel Decker Inc. New York 1988.

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Introduction to elastomers and compounding**	
1.1	Introduction to elastomers characteristic features of polymer chains to behave like an elastomers, sources of natural and synthetic rubber. History and brief discussion of structure and behavior of natural and various synthetic rubber available	01
1.2	Introduction of compounding and compounding ingredients, their importance and utility for rubbers. Importance of compounding recipe for rubber goods manufacturing. Mastication of rubbers	01
1.3	Vulcanization process, Vulcanization agents, various types of Vulcanization agents, Vulcanization conditions. Accelerators, their classification with examples, accelerator activators. Age resistors-antioxidants, antioxidants, their mechanism softeners or plasticizers, miscellaneous ingredients	01
1.4	Utility of filers in rubbers, types of fillers used in rubbers, reinforcement concepts, introduction of carbon blacks. Various methods for manufacturing C-black and size obtained from each, typical filler characteristics and their influence on Vulcanizate properties, filler characteristics and mixing process, bound rubber, reinforcement and cross linking	01
2.	**Natural rubber**	
2.1	Brief history of natural rubber, plantation, agriculture involved in growing NR plants, latex tapping	01
2.2	Preparation of different types of dry rubber, properties of natural rubber	01
2.3	Importance, synthesis and characteristics of various rubber derivatives. various types of modified rubbers, their importance and method of synthesis. Technically specified rubbers, methods for manufacturing these rubbers	01
2.4	Various methods for processing of rubbers- compression, transfer molding, injection molding, extrusion. various Vulcanization methods e.g. open cures, continuous Vulcanization, radiation cures	01
2.5	Chemistry and mechanism of sulphur Vulcanization rate of cure state of cure, optimum cure time, overawe, scorch. Chemistry and	01

	mechanism of non-sulphur Vulcanize and peroxide curing	
3.	**Synthetic Rubber -I**	
3.1	Introduction to styrene butadiene rubber, various methods of synthesis, composition of SBR & percent cis-trans contents. Description of manufacturing process with flow diagram for production of SBR, typical formulation. Physical properties, compounding and processing of SBR, uses of SBR, introduction and importance of polybutadiene mechanization properties and uses	02
3.2	Introduction to nitrite rubber, various grades, property trends influenced by composition i.e. percent Acrylonitrile content. Manufacturing process description of Nitrite rubber with diagram, oil resistance of these rubber, effect of polymer structure and compounding ingredients on it. Specific compounding ingredients used with Nitrite rubbers, various uses of nitrite rubber0	02
3.3	Introduction to butyl rubber, description of manufacturing process with flow sheet. Molecular characteristics, mole percent unstauration, cis- and trams- structures, properties and applications of butyl rubber, Vulcanization of butyl rubber. Introduction to chlorobutyl rubber, advantage of chlorination manufacturing process, stabilization and Vulcanization, applications	02
3.4	Introduction to Neoprene rubbers, classification of grades on basis of basis of applications compounding of neoprene's, processing, vulcanization and applications of neoprenes.	01
4.	**Synthetic Rubber -II**	
4.1	Introduction to Ethylene/propylene rubbers, their, structure compositional distribution , variables in molecular structure, polymer, properties. Polymer unstauration in EPR and various denies introduced for unstauration, structure, property relationship, EPDM varieties. Manufacturing process description of EPDM with flow sheet, application of EPDM.	01
4.2	Chlorosulphonated polyethylene introduction, synthesis, types of Hypalon available, compounding, curing and applications. Introduction to polysulfide rubbers, type A and B polysulfide, and FA and ST types polysulfide plasticization and curing, solvent resistance and other properties, application of polysulfide rubber	01
4.3	Introduction to silicon rubbers, synthesis of silicon rubbers. Vulcanization, compounding and processing of silicon rubbers, various applications of silicon rubbers, room temperature vulcanizing rubbers	01
4.4	Introduction to Urethane elastomers, chemistry and structure, casting system thermoplastic PU rubbers.	01
4.5	Thermoplastic elastomers- introduction, concept of rigid and electrometric block i.e. A-B-A type polymers, example like S-B-S block copolymers, advantages over vulcanizing type rubbers, chemical nature of TPR's processing of TPR	01
5.	**Industrial fabrication of Rubber Products**	

5.1	Various types of compounding machines:- mills, internal mixers. Various continuous mixers, extruders etc.	01
5.2	Calendaring process for producing rubber sheets. Coating of textile fabric by rubber direct manufacturing articles from latex. Moulding of rubber articles like footwears, bonding of rubber to metals	01
5.3	Manufacturing process for pneumatic tyres, fabrication of tyre, tyre construction, tyre components, flow sheet for manufacturing plant, brief description of various steps involved	01
5.4	Manufacturing process for transmission belt	01
5.5	Dip coating process	01
	Total hours	**26**

PROGRAMME ELECTIVE COURSE III

TPL –407 : POLYMER COMPOSITES

L	T	P	C
2	0	0	2

OBJECTIVE: The objective of this course is to enable the students

- To understand concept of polymer composite and basic construction.
- To understand the properties and manufacturing of various polymer matrix materials used for Plastic composites.
- To know the manufacturing and properties of various in forcemeats used in Plastic composites.
- To learn various processing techniques , testing and applications of fibers in forced plastics.

Course Outcome

On the successful completion of the course, students will be able to

CO1	understand the concept of composite materials and reinforcement.	Understand
CO2	understand the types and forms of reinforcement materials used in composites.	Understand
CO3	understand various thermoset and thermoplastic materials used in composites.	Understand
CO4	understand different production techniques for composite structures like hand-layup, bag molding etc.	Understand
CO5	apply knowledge of production technique for making different structure like hybrid structure and sandwich structure.	Apply

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3											3	3	3
CO2	3		2			2						3	3	3
CO3	3		2			2						3	3	3
CO4	3	2	2			2						3	3	3
CO5	3	2	2	1		2						3	3	3
Total	**3**	**2**	**2**	**1**		**2**						**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Course Level Assessment Questions

Course Outcome 1(CO1)

1. Definition & components of polymer composites
2. Principle of reinforcement
3. Effect of fibers on strength of composites
4. Concepts of interface
5. Advantages & disadvantages of polymer composites

Course Outcome 2(CO2)

1. Types of reinforcement used in polymer composites
2. Types and forms of glass fibers, their production process
3. Production process for carbon fibers
4. Production process for boron and aramid fibers
5. Surface treatment for enhancement of bond strength

Course Outcome 3(CO3)

1. Utility of thermoset types of matrix materials like epoxy resin, vinyl ester resin, etc for polymer composites and their characteristics properties
2. Utility and characteristics properties of thermoplastic materials for polymer composites.

Course Outcome 4(CO4)

1. Description of Hand layup, spray molding and bag molding
2. Description of filament winding process and pultrusion.
3. Description of sheet and dough molding compounds and their processing preform and resin transfer molding

Course Outcome 5(CO5)

1. Production of hybrid structures based on polymer composites
2. Production of sandwiched polymer composites.

Syllabus

Module-I:Introduction to polymer composites

Introduction to composite materials, comparison of different materials with composites-advantages and disadvantages. Principles of composite reinforcement. Effect of fibrous reinforcement on composite strength.

Module-II: Reinforcements for Polymer composites

Types of reinforcement such as natural, glasses, carbon/graphite, aramid fibers boron fibers and then utility in polymer composites various forms of reinforcement and surface treatment of fibers

Module-III: Matrices for Polymer composites

Thermosetting and thermoplastic material used for the composites and their selection for a particular application

Module-IV: Production Techniques -I

Processing and production techniques like hand-layup, bag moulding, filament winding and pultrusion

Module-V:Production Techniques -II

Prepegs, their manufacture and characterization. Sheet moulding and dough moulding compounds and their processing. Perform and resin transfer moldings.
Hybrid and sandwich type composites.

Reference Books and Suggested Readings :

1. Hand Book of Composites, by George Lubin
2. Hand Book of Fibre glass and Advanced Plastic Composites, by G. Lubin
3. Reinforced Thermoplastics, by W.V. Titov
4. Engineering Design for Plastics, by Eric Baer
5. Glass Engineering Hand Book, by E.S. Shend
6. Plastics and Composites welding Handbook by Grewell, Benatar& Park
7. Polymer and composite Rheology by R. K. Gupta
8. Reinforced Plastic Handbook by Rosato&Rosato

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Introduction to polymer composites**	
1.1	Concept polymer composites their advantages and disadvantages	01
1.2	Components and principle of composites reinforcement and effect of fibrous reinforcement on polymer	01
1.3	Determination of composites strength	01
1.4	Importance of interface between reinforcement and polymer matrix	01
2.	**Reinforcements for Polymer composites**	
2.1	Introduction to glass fiber, their types, production process and their characteristics properties	01
2.2	Different forms of glass fibers and their utility	01
2.3	Production of carbon fibers, their structures and methods for enhancement of strength of carbon fiber and their properties. Graphitization of carbon fibers	01
2.4	Production odd boron fibers and their properties. Production of aramid fibers and their characteristics properties	03
2.5	Types of natural fibers used in polymer composites and their source and characteristics	01
3.	**Matrices for Polymer composites**	
3.1	Characteristics properties of epoxy and vinyl ester resins, its utility for polymer composites	02
3.3	Properties and applications of glass filled thermoplastics like PC, PBT, Nylons etc.	01
4.	**Production Techniques -I**	
4.1	Process description of techniques for production of polymer composites like hand layup and spacey layup	01
4.2	Process description of Filament Winding technique for production of polymer composite pipes	01
4.3	Process description of Pultrusion technique for production of polymer composite rods, etc.	01

5.	**Production Techniques -II**	
5.1	Prepegs, their manufacture and characterization	01
5.2	Sheet and dough moulding compounds and their processing	04
5.3	Perform and resin transfer moldings.	01
5.4	Hybrid and sandwich type composites.	02
	Total Hours	**25**

OPEN ELECTIVE (PLASTIC TECHNOLOGY)

TPL- 409: INTRODUCTION TO POLYMER TECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVE: The objective of this course is to enable the students

- To understand basics concepts of polymer and their utility.
- To understand the mechanism of polymerization, various, techniques of polymerization, classification and kinetics of polymers.
- To understand manufacturing process of thermoplastic and thermoset polymers; Copolymerization.

Course Outcome

On the successful completion of the course, students will be able to

CO1	understand basics of polymer science and their classifications.	Understand
CO2	understand different types of polymerizations with mechanism and kinetics.	Understand
CO3	understand production processes of commodity plastics	Understand
CO4	understand chemistry and production of common formaldehyde based thermoset.	Understand
CO5	understand different plastic processing techniques and Indian markets of Plastics.	Understand

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3											2	3	3
CO2	3					2						2	3	3
CO3	3											2	3	3
CO4	3											2	3	3
CO5	3	2				2	2					2	3	3
Total	**3**	**2**				**2**	**2**					**2**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Introduction of Polymers.
2. Classification of Polymers.

Course Outcome 2 (CO2)

1. Mechanism and Kinetics of Polymerization.
2. Techniques of Polymerization.

3. Copolymerization

Course Outcome 3 (CO3)

1. Manufacturing process of common thermoplastics.
2. Their properties and applications.

Course Outcome 4(CO4)

1. Chemistry of different thermoset based on formaldehyde.
2. Their production and molding powder preparation.

Course Outcome 5(CO5)

1. Common processing techniques for thermoplastics and thermoset.
2. Plastic industries in India.

Syllabus

Module -I:Introduction to Polymers/ Plastics

Polymeric Materials and their macro molecular nature (e.g. Plastics, rubber, fibers), concept of polymer structure, classification of polymers.

Module -II: Chemistry of polymerizations

Principle of addition and condensation polymerization, different techniques of polymerization, chemistry and kinetics of polymerization, Copolymerization.

Module -III: Thermoplastic resins

Chemistry and manufacturing process of some important thermoplastic polymers such as polyethylene, polystyrene, polyvinylchloride etc., their properties and applications.

Module -IV: Thermoset resins

Chemistry and manufacturing process of some important thermoset polymers such as phenol-formaldehyde, urea-formaldehyde and Melamine formaldehyde resin.

Module -V: Processing of Plastics

Processing techniques for processing of Thermosets and Thermoplastics, Scope of polymeric materials industries in India.

Reference Books and Suggested Readings :

1. Polymer Science and Technology, by J.R.Fred
2. Introduction to polymer science, by F. W. Billmeyer
3. Properties and structure of polymers, by Tobolosky
4. Principles of Polymerization, by G. Odian
5. Plastics Materials, by J.A. Brydson
6. Plastic Engg. HandBook, by Frados

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Introduction to Polymers/ Plastics**	
1.1	Introduction to polymeric materials	02
1.2	Monomer and respective polymer structures	02
1.3	Classification of polymers with details	02
1.4	Important properties of polymers	02
2.	**Chemistry of polymerizations**	
2.1	Principle of addition polymerization with mechanism examples and kinetics	02
2.2	Principle of Condensation polymerization with mechanism examples and kinetics	02
2.3	Techniques of polymerization	02
2.4	Copolymerization	02
3.	**Thermoplastic resins**	
3.1	Manufacture of Low density polyethylene	02
3.2	Manufacture of High density polyethylene & using stereospecific catalysis	03
3.3	Manufacture of other commodity plastics	02
3.4	Properties and application of these plastics	01
4.	**Thermoset resins0**	
4.1	Chemistry of both types of phenol formaldehyde resin	02
4.2	Production and molding powder manufacture for Phenol formaldehyde resin	01
4.3	Chemistry and production of Urea formaldehyde resin	02
4.4	Chemistry and production of Melamine formaldehyde resin	01
4.5	Properties and applications of these resin	02
5.	**Processing of Plastics**	
5.1	Processing Techniques for Thermoplastics	04
5.2	Processing Techniques for Thermosets	03
5.3	Indian Plastics Industries current scenario and future growth	01
	Total Hours	**40**

TPL - 417 : INDUSTRIAL TRAINING

L	T	P	C
0	0	4	2

OBJECTIVE: The objective of this course is to enable the students

- make students observe and learn practical knowledge of processing or manufacturing of polymers
- understand professional ethics and discipline required in industry
- Understand and analyze product planning and implementation in industry.
- Communicate their experiences in the form of project report and power point presentation

Course Outcome

On the successful completion of the course, students will be able to

CO1	acquire practical skills in any plastic and allied industry.	Understand
CO2	understand professional ethics and discipline required in industry.	Understand & Ethics
CO3	analyze problems in products and process and resolves by working on short term project.	Analyze & Apply
CO4	Understand and analyze product planning and implementation in industry.	Understand and Analyze
CO5	Communicate their experiences in the form of project report and power point presentation.	Apply & Analyze

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3	2		3	1				1		3	1
CO2						3		3	3			2	1	3
CO3		3	3	2			1				1			
CO4		3		2					3		1	2		
CO5	3									3				
Total	**3**	**3**	**3**	**2**		**3**	**1**	**3**	**3**	**3**	**1**	**2**	**2**	**2**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

TPL - 471 : SEMINAR

L	T	P	C
0	0	4	2

OBJECTIVE: The objective of this course is to enable the students

- to study a topic of latest developments/innovative technology on their own and to prepare a dissertation report on this topic.
- to present a lecture on the topic on power point format.
- to improve the communication skill of the students.

Course Outcome

On the successful completion of the course, students will be able to

CO1	understand a topic of latest developments/innovative technology.	Understand
CO2	apply the knowledge to prepare a dissertation report on this topic.	Apply
CO3	deliver a lecture on the topic on power point format.	Apply
CO4	improve the communication skill of the students.	Communication
CO5	Analyze environment and sustainability of related technology	Analyze Environment & Sustainabilitity

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3			1		2	3					3	3	3
CO2	3	2	2	1	1	2	3			3	2	3	3	3
CO3	3									3		3	3	3
CO4	3									3		3	3	3
CO5	3	2				2	3					3	3	3
Total	**3**	**2**	**2**	**1**	**1**	**2**	**3**			**3**	**2**	**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

TPL – 497: PROJECT

L	T	P	C
0	0	8	4

OBJECTIVE: The objective of this course is to enable the students

- to identify a plastic product that can be manufactured in India or a research problem and conduct experiment.
- to prepare a feasibility report for a project based on manufacturing of product.
- to present a lecture on the topic on power point format.
- to improve the communication skill of the students.

Course Outcome

On the successful completion of the course, students will be able to

CO1	understand a topic of latest developments/innovative technology.	Understand Individual & Team Work
CO2	apply the knowledge to prepare a feasibility/dissertation report on this topic.	Apply Project Management and Finance
CO3	deliver a lecture on the topic on power point format.	Apply
CO4	improve the communication skill of the students.	Communication
CO5	Analyze environment and sustainability of related technology	Analyze Environment & Sustainability

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3			1		3	3		3			3	3	3
CO2	3	2	2	1	1	3	3		3	3	3	3	3	3
CO3										3		3	3	3
CO4							3			3		3	3	3
CO5						3	3		3			3	3	3
Total	**3**	**2**	**2**	**1**	**1**	**3**	**3**		**3**	**3**	**3**	**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

TPL – 417 : EDUCATIONAL TOUR

L	T	P	C
0	0	0	0

Students will be taken to the visit of industries/research organization, in their field of specialization, during the vacation period

OBJECTIVE: The objective of this course is to enable the students

- to visit industries/research organization in their field of polymer/plastic technology during the vacation period.
- to demonstrate a variety of product formation and manufacturing processes in industries specialization.
- to learn professional ethics.

Course Outcome

On the successful completion of the course, students will be able to

CO1	visit industries/research organization in their field of polymer / plastic technology.	Engineer and Society Life long Learner
CO2	to demonstrate a variety of product formation and manufacturing processes in industries specialization.	Engineer and Society Individual & Team Work
CO3	To learn professional ethics.	Ethics
CO4	improve the communication skill of the students.	Communication
CO5	Analyze environment and sustainability of related technology.	Analyze Environment & Sustainability

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3					3			1			3	3	3
CO2	3	2				2	2		1			3	3	3
CO3	3							3				3	3	3
CO4	3									3		3	3	3
CO5	3					2	3		1			3	3	3
Total	**3**	**2**				**3.5**	**2.5**	**3**	**1**	**3**		**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

PROGRAMME ELECTIVE COURSE V

	L	T	P	C
TPL- 402 : POLYMER PACKAGING AND WASTE MANAGEMENT	**3**	**1**	**0**	**4**

OBJECTIVE: The objective of this course is to enable the students

- To understand concept of packaging and utility of plastics in packaging.
- To analyze properties of polymers for their utility in packaging of vanity of products.
- To know various sources of plastics waste generation and the and its managements.
- To understand the recycling techniques used for various plastics.

Course Outcome

On the successful completion of the course, students will be able to

CO1	understand plastic packaging, scope, advantages and disadvantages of plastic packages, and application of polymer films for packaging.	Understand
CO2	understand and analyze selection criteria for various household and industrial polymeric packages, their testing and utility on various fields.	Understand and Analyze
CO3	understand various policies legislation related to plastic waste management and their effects on environment.	Understand and Apply
CO4	understand recycling technologies for variety of plastics.	Understand
CO5	understand biodegradable polymers and prospects for biodegradable plastics based on renewable resource polymers.	Apply

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3		2				3					3	3	3
CO2	3	2	2			3	3					3	3	3
CO3	3		2			3	3					3	3	3
CO4	3		2			3	3					3	3	3
CO5	3		2			3	3					3	3	3
Total	**3**	**2**	**2**			**3**	**3**					**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Concept of plastic packaging.
2. Scope and frictions of package.
3. Advantages and disadvantages of polymeric packages over conventional packaging materials.
4. Plastic packages and their applications.

Course Outcome 2 (CO2)

1. Selection criteria of suitable polymeric packages for household and industrial goods.
2. Testing and quality control in polymeric packaging.
3. Newer developments in plastic packaging.

Course Outcome 3 (CO3)

1. Global policies and regulations.
2. Plastic waste management.

Course Outcome 4 (CO4)

1. Recycling and recovery of various plastics items/materials.
2. Plastics and Environment.
3. Methods of recycling.

Course Outcome 5 (CO5)

1. Various modification techniques/latest development in polymers to improve waste management.
2. Biodegradable programs for various applications viz. food packaging, agriculture.
3. Waste treatment of various plastic plants, estimation of power requirement and efficiency of size reduction operation of plastics.

Syllabus

Module-I: Elements of packaging

Concept of plastic packaging, present state of packaging technology, scope of packaging, advantages and disadvantages of polymeric packages over conventional packaging materials. Polymer films for packaging.

Module-II: Polymer Packages and Quality Control

Selection criteria of various household and industrial polymeric packages. Printing on polymeric packages. Testing and quality control. Newer developments in polymer packaging.

Module-III: Plastic waste management

Global policies and regulations. Social and environmental challenges of plastic waste in India. Plastics and environment. Salient features of the plastic waste management (PWM) rules. Waste treatment of various plastic plants, estimation of power requirement and efficiency of size reduction operation of plastics.

Module-IV: Recycling Technology

Recycling and recovery of various plastics items/materials-their effect on environment. Waste collection and recycling methods. Comparative study of conversion of plastic waste into value added products.

Module-V: Biodegradable Polymers

Biodegradable polymers - prospects & utilization, prospects for biodegradable plastics based on renewable resource polymers. Biodegradable programs for various applications viz. food packaging, agriculture, etc.

Reference Books and Suggested Readings :

1. Hand Book of Polymer Science and Technology – V0l. 4, by N.P.Cheremisinoff
2. Comprehensive Polymer Science – Vol. 7, by Sir Geoffrey Allen
3. Plastics films and packaging, by C.R.Oswin
4. Science and Technology of Polymer films, by J.F.Hamlin
5. Protective Wrapping, by C.R.Oswin
6. Environmental effect on polymeric materials, by Dominick V. Rosato & Robert T. Schwartz
7. Plastic waste management and environment, by V.P.Malhotra
8. Synthetic Rubber Waste Disposal, by L.D.Dougan & J.C.Bell
9. Plastic waste and its recovery, by M.E.Bocqueye

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Elements of packaging**	
1.1	Concept of plastic packaging, present state of packaging technology, scope of a packaging	02
1.2	Polymeric packages over conventional packaging materials – advantages and disadvantages	02
1.3	Plastic packages and their applications	03
2.	**Polymer Packages and Quality Control**	
2.1	Selection criteria of various household polymeric packages	03
2.2	Selection criteria of various industrial polymeric packages	03
2.3	Printing on polymeric packages	02
2.4	Testing and quality control	03
2.5	Newer developments in polymer packaging	02
3.	**Plastic Waste Management**	
3.1	Global policies and regulations, plastics and environment.	02
3.2	Social and environmental challenges of plastic waste in India.	02
3.3	Salient features of the plastic waste management (PWM) rules.	02
3.4	Waste treatment of various plastic plants.	02
3.5	Estimation of power requirement and efficiency of size reduction operation of plastics.	01
4.	**Recycling Technology**	
4.1	Recycling and recovery of various plastics items/materials-their effect on environment.	03
4.2	Waste collection and recycling methods	02
4.3	Comparative study of conversion of plastic waste into value added products.	02

5.	**Biodegradable Polymers**	
5.1	Biodegradable polymers - prospects & utilization.	02
5.2	Prospects for biodegradable plastics based on renewable resource polymers	02
5.3	Biodegradable programs for various applications viz. food packaging, agriculture, etc.	03
	Total hours	**45**

TPL –404 : POLYMER COATING TECHNOLOGY

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to enable the students

- Understand concept of surface coatings and constitution of paints, varnishes etc, and concept of surface preparation and treatment.
- Understand roll and types of various pigments used in paints and pigment dispersion.
- Understand rheological behaviors of paints and methods of coatings applications.

At the End of the course, Students will be able to

CO1	understand the concept of surface coating, constituents of paint, varnish and lacqers, mechanism of film formation, and characteristics of natural and synthetic polymers used in coatings, varnishes and sealants.	Understand
CO2	understand pigment and pigmentation, dispersion techniques, and role of wetting agents, driers, solvent and plasticizers in coatings.	Understand
CO3	understand principles of coating formulation, machines/ball mills used in making coating formulations, and safety, health and hazards.	Understand and Apply
CO4	understand the surface preparation and pretreatments for coatings.	Understand and Apply
CO5	understand and analyze types of coatings for industrial and architectural application, rheological behavior and testing of coatings.	Understand and Analyze

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3					1						2	3	3
CO2	3					1						2	3	3
CO3	3					1						2	3	3
CO4	3		1			1						2	3	3
CO5	3	2	1			1						2	3	3
Total	**3**	**2**	**1**			**1**						**2**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Concept of surface coating, origin and developments in surface coating.
2. Constitution of surface coating.
3. Functions of coatings and mechanism of film formation.
4. Characteristics of natural and synthetic polymers used in coatings, varnishes and sealants.
5. Utility of surface coating.

Course Outcome 2 (CO2)

1. Principles of coating formulation.
2. Formulation of natural and synthetic polymers based coatings.
3. Formulation of varnishes and sealants.
4. Machines/Ball mills used in making coating formulations.

Course Outcome 3(CO3)

1. Pigment and pigmentation.
2. Dispersion techniques.
3. Role of wetting agents, driers, solvent and plasticizers in coatings.

Course Outcome 4(CO4)

1. Surface preparation.
2. Surface pretreatments.

Course Outcome 5(CO5)

1. Industrial coatings.
2. Specialty coatings like water based coating, powder coating and high solid based coating.
3. Application methods and curing techniques for coatings.

Course Outcome 6(CO6)

1. Rhelogical behaviour of coatings.
2. Testing of coatings.

Syllabus

Module-I: Elements of surface coatings

Origin and development of surface coating, constituents of paint, varnishes and lacquers. Functions of coatings and mechanism of film formation. Characteristics of natural and synthetic polymers used in coatings, varnishes and sealants.

Module-II: Pigments and Pigmentation

Pigment and pigmentation. Dispersion techniques, role of wetting agents, driers, solvent and plasticizers in coatings.

Module-III: Formulation and Manufacture of coatings

Principles of coating formulation. Coating manufacture. Machines/Ball mills used in making coating formulations. Safety, health and hazards.

Module-IV: Surface Preparation and Pre-treatments

Surface preparation and pretreatments. Rhelogical behaviour and testing of coatings. Application methods and curing techniques for coatings.

Module-V: Industrial and Specialty Coatings

Specialty coatings like water based coating, powder coating and high solid based coating etc. Industrial and architectural coatings and finishes.

Reference Books and Suggested Readings :

1. Organic Coating Technology Vol. I & II, by H.F.Pyne
2. Surface Coating, by OCCAA
3. Protective and Decorative coatings, by J.J.Mattiello
4. Paint and Varnishes Production Manual, by V.C.Bidlack & E.W.Fasig

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Elements of surface coatings**	
1.1	Origin and developments of surface coating.	02
1.2	Constituents of paint, varnishes and lacquers.	02
1.3	Functions of coatings and mechanism of film formation	02
1.4	Characteristics of natural and synthetic polymers used in coatings, varnishes and sealants	02
2.	**Pigments and Pigmentation**	
2.1	Concept of pigment and pigmentation.	02
2.2	Dispersion techniques used for making paints, varnishes and lacquers.	02
2.3	Role of wetting agents in coatings.	01
2.4	Role of driers in coatings.	01
2.5	Role of solvent and plasticizers in coatings.	02
3.	**Formulation and Manufacture of coatings**	
3.1	Principles of coating formulation.	02
3.2	Manufacture of coatings.	02
3.3	Machines used in making coating formulations.	02
3.4	Ball mills used in making coating formulations.	03
3.5	Safety, health and hazards in paint industries.	02
4.	**Surface Preparation and Pre-treatments**	
4.1	Preparation and pretreatments of surface for coatings.	02
4.2	Rhelogical behavior of coatings.	02
4.3	Testing of coatings.	02
4.4	Curing techniques for coatings.	02
4.5	Application methods for coatings.	02
5.	**Industrial and Specialty Coatings**	
5.1	Industrial coatings and finishes.	02
5.2	Architectural coatings and finishes.	02
5.3	Specialty coatings	02
5.4	Recent developments in industrial, architectural, and specialty coatings.	03
	Total hours	**46**

PROGRAMME ELECTIVE COURSE VI

TPL – 406 : POLYMERIC ADHESIVES AND FOAMS

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to enable the students

- To understand concepts of adhesion and adhesives.
- To understand the types of adhesives and their applications, surface treatments and preparation for adhesive bonding.
- To understand formulation and production techniques for variety of adhesives.
- To understand concept, production process, properties and applications of variety of polymeric foams.

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

CO1	understand the concept of adhesive, adhesive joints and mechanism of adhesives.	Understand
CO2	understand the surface preparation and surface treatments for various substrates.	Understand
CO3	understand the principle of adhesives formulation and production techniques.	Understand
CO4	apply properties of polymers for constitution of variety of adhesives.	Apply
CO5	understand concept of polymer foams and their utility in variety of application and anayze production, process and properties of Polyurethane, Polystyrene and Epoxy foams .	Understand and Analyze

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3					1	2					3	3	3
CO2	3					1	2					3	3	3
CO3	3					1	2					3	3	3
CO4	3	2	1			1	2					3	3	3
CO5	3					1	2					3	3	3
Total	**3**	**2**	**1**			**1**	**2**					**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Define adhesive and adhesive joints.
2. Classification of adhesives.
3. Mechanism of adhesive bond failure.
4. Theories of adhesion.

Course Outcome 2 (CO2)

1. Surface characteristics.
2. Surface preparation for various substrates.
3. Surface treatment of various substrates.
4. Techniques for the evaluation of bond strength.

Course Outcome 3 (CO3)

1. Principle of adhesives formulation.
2. Principle of adhesive production techniques.
3. Adhesives formulation for various industries such as packaging, textiles, automotive, consumer, etc.

Course Outcome 4 (CO4)

1. Properties of polymers for constitution of hot melt adhesives.
2. Properties of polymers for constitution of solvent-activated adhesives.
3. Properties of polymers for constitution of anaerobic and pressure sensitive adhesives, etc.

Course Outcome 5 (CO5)

1. Definition of polymer foam.
2. Chemistry and physical formation of polymer foam.
3. Foaming ingredients.
4. Concept, production process, properties and applications of variety of polymeric foams.

Syllabus

Module – I: Introduction and adhesion theories

Definition of adhesives and adhesive bonding, functions of adhesives, classification of adhesives, advantages and disadvantages of joining using adhesives, requirements of a good bond, theories of adhesion, definition of failure modes, mechanisms of bond failure.

Module – II: Surface preparation and surface treatments

Surface characterization. Surface preparation and surface treatments for various substrates. Techniques for evaluation of adhesives bond strength. Testing and quality control.

Module – III: Adhesives formulation and production techniques

Principle of adhesives formulation and production techniques. Adhesives formulation for various industries viz. construction, packaging, textiles, automotive, consumer, abrasives and friction materials, shoes, electrical, aerospace, etc.

Module – IV: Characteristics and applications of adhesives
Characterization and applications of hot melt adhesives, solvent-activated adhesives, anaerobic and pressure sensitive adhesives, etc. Bonding of polymeric materials to various substrates. Polymer sealants. Structural adhesives.

Module – V: Polymeric foams
Introduction to polymer foams, chemistry and physical formation, foaming ingredients, their effect on foam morphology and physical properties and applications of polymer foams. Polyurethane foam (rigid & flexible), Polystyrene foams, Epoxy foams. Recent developments in foam technology.

Reference Books and Suggested Readings :

1. Adhesives, by Skiest
2. Industrial Cold Adhesive, by Roga Dulac
3. Handbook of Adhesives Raw material, by Ernest W. Flick
4. Sealants & Adhesives, by H.A. Perry

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Introduction and adhesion theories**	
1.1	Definition of adhesives and adhesive bonding and functions of adhesives	02
1.2	Classification of adhesives	02
1.3	Advantages and disadvantages of joining using adhesives	01
1.4	Requirements of a good bond, theories of adhesion	02
1.5	Definition of failure modes	01
1.6	Mechanisms of bond failure	01
2.	**Surface preparation and surface treatments**	
2.1	Surface characterization	02
2.2	Surface preparation and surface treatments for various substrates	02
2.3	Techniques for evaluation of adhesives bond strength	02
2.4	Testing and quality control	02
3.	**Adhesives formulation and production techniques**	
3.1	Principle of adhesives formulation and production techniques	02
3.2	Adhesives formulation for construction and packaging industries	02
3.3	Adhesives formulation for textiles and automotive industries	02
3.4	Adhesives formulation for shoe, electrical and aerospace industries, etc.	02
3.5	Adhesives formulation for abrasives and friction materials	02
4.	**Characteristics and applications of adhesives**	
4.1	Characterization and applications of hot melt adhesives	02
4.2	Characterization and applications of solvent-activated adhesives	02

4.3	Characterization and applications of anaerobic adhesives	02
4.4	Characterization and applications of pressure sensitive adhesives, etc.	02
4.5	Structural adhesives	02
5.	**Polymeric foams**	
5.1	Introduction to polymer foams, chemistry and physical formation	02
5.2	Foaming ingredients, their effect on foam morphology and physical properties and applications of polymer foams	03
5.3	Polyurethane foam (rigid & flexible), polystyrene foams and epoxy foams	03
5.4	Recent developments in foam technology	02
	Total hours	**46**

TPL –408 : POLYMER NANOCOMPOSITES

L	T	P	C
3	1	0	4

OBJECTIVE: The objective of this course is to enable the students

- To understand concept of polymer nanocomposites and their applications.
- To understand clay and carbon nanotube based nanocomposites, their formation and applications.
- To understand metal containing polymer nanocomposites.
- To understand concept of nanopolymers.

Course Outcome

On the successful completion of the course, students will be able to

CO1	understand the concept of polymer nanocomposites and nano polymer	Understand
CO2	understand formation of inorganic nano clay based polymer nanocomposites and their application	Understand
CO3	Understand formation of carbon nanotube and carbon allotropes based polymer nanocomposites and their applications.	Understand
CO4	understand formation of metal based polymer nanocompsites and their applications	Understand
CO5	understand characterization of polymer nanocomposites	Understand

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3											3	3	3
CO2	3	2	1			1						3	3	3
CO3	3	2	1			1						3	3	3
CO4	3	2	1			1						3	3	3
CO5	3		1									3	3	3
Total	**3**	**2**	**1**			**1.25**						**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Concept of macro, micro and nano materials
2. Types of nano fillers and their availability
3. Construction polymer nanocomposites
4. Advantages and disadvantages and applications of polymer nano-composites

Course Outcome 2 (CO2)

1. Types of inorganic nano clay and their availability
2. Synthesis of nano clay and their structure
3. Methods for formation of clay based polymer nanocomposites

4. Concept of exfoliation, interfaces and ordered structures

Course Outcome 3 (CO3)

1. Concept of carbon nanotubes and their types
2. Synthesis and structure of various nano carbon tubes
3. Carbon allotropes, their types and utility
4. Characteristic properties and applications of carbon based polymer nanocomposites

Course Outcome 4 (CO4)

1. Types of nano metals available and their characteristic properties
2. Synthesis, structure and physicochemical properties of nano metal based polymer nanocomposites
3. Potential applications of nano metal based polymer nanocomposites

Course Outcome 5 (CO5)

1. Flow properties and processing of polymer nanocomposites
2. Morphological properties of polymer nanocomposites and characterization methods like SEM and TEM
3. Thermal and mechanical properties polymer nanocomposites

Syllabus

Module-I:Concept of Nano materials and nanocomposites

Introduction to nano materials, and nanocomposites. Construction of polymer nano-composites, importance of interface between nano fillers and polymer matrix, the advantages and disadvantages and applications of polymer nano-composites

Module-II:Polymer clay nanocomposties

Types of nano clay available, Synthesis of nano clay, their structure, properties and utility in polymer nanocomposites, formulation of Polymer clay nanocomposties, their properties and applications, concept of ordered structures, exfoliation, interfaces, surface induced patterns, etc.

Module-III:Carbon based polymer nanocomposites

Carbon nanotubes and carbon allotropes based polymer composites, types of nano tubes, their synthesis and structure. Methods for synthesis, structures, properties and potential applications of carbon based polymer nanocomposites

Module-IV:Metal based polymer nanocomposites

Types of nano metals available and their characteristic properties, Metal based polymer nanocomposites their synthesis, structure and physicochemical properties and potential applications

Module-V:Characterization of polymers nanocomposites

Rheology and processing of polymers nanocomposites; characterization, of polymer nanocomposites for morphological, thermal and mechanical properties

Reference Books and Suggested Readings:

1. Viswanathan V.R.,N.V. and JayaderSreedhar, "Polymer Science", New age International publications.
2. Yiu-Wing Mai and Zhong-Zhen yu"Polymernanocomposites", CRC press.
3. Alfred rudin , "The elements of polymer science and engineering", 2ndedition, Academic press publication.
4. Alan Kin-TakLau, Farzanahussain, Khalidlafdi, "Nano and Biocomposites",CRC press.
5. Abe, A.-C. Albertsson, R.Duncan "Advances in polymer science",Springer.
6. Low I. M. "Ceramic matrix composites:Microstructure, properties and Applications ", Woodhead Publishing Limited.
7. Luigi Nicolais Gianfranco Carotenuto"Metal – polymer Nanocomposites",WileyInterscience.

Course contents and lecture schedule

Module No.	Topic	No. of Lectures
1.	**Concept of Nano materials and nanocomposites**	
1.1	Concept of macro, micro and nano materials and examples	02
1.2	Types of nano fillers and their availability, polymers suitable for polymer nanocomposites, construction of polymer nanocomposites	04
1.4	Importance of interface between nano fillers and polymer matrix	02
1.5	Advantages and disadvantages of polymer nanocomposites	01
2.	**Polymer clay nanocomposties**	
2.1	Types of nano clay fillers and their availability	02
2.2	Synthesis of nano clay, their structure, properties and utility in polymer nanocomposites,	03
2.3	Formulation of Polymer clay nanocomposties, their properties and applications,	03
2.4	Concept of ordered structures, exfoliation, interfaces, surface induced patterns, etc.	03
3.	**Carbon based polymer nanocomposites**	
3.1	Introduction of carbon allotropes, nanotubes, their synthesis and structure	02
3.3	Methods for synthesis of carbon based polymer nanocomposites	02
3.4	Structures, properties and potential applications of CNT-PNC	03
4.	**Metal based polymer nanocomposites**	
4.1	Types of nano metals available and their characteristic properties	03
4.2	Metal based polymer nanocomposites and their synthesis	03
4.3	Structure and physicochemical properties of Metal based polymer nanocomposites	02
4.4	Potential applications of Metal based polymer nanocomposites	02
5.	**Characterization of polymers nanocomposites**	
5.1	Rheology and processing of polymers nanocomposites;	02

5.2	Polymer nanocomposites for morphological properties	03
5.3	Thermal and mechanical properties of polymer nanocomposites	03
	Total Hours	**45**

TPL – 498 : PROJECT

L	T	P	C
0	0	16	8

OBJECTIVE: The objective of this course is to enable the students

- to prepare a detailed project report on fabrication of a product/equipment/process of a plant for production of plastic product with complete lay-out or a research problem and conduct experiment.
- to assess the economic analysis and to prepare a feasibility report for a project based on manufacturing of product/equipment/process.
- to present a lecture on the topic on power point format.
- to improve the communication skill of the students.

Course Outcome

On the successful completion of the course, students will be able to

CO1	understand a topic of latest developments/innovative technology.	Understand Individual & Team Work
CO2	apply the knowledge to prepare a feasibility/dissertation report on this topic.	Apply Project Management and Finance
CO3	deliver a lecture on the topic on power point format.	Apply
CO4	improve the communication skill of the students.	Communication
CO5	Analyze environment and sustainability of related technology	Analyze Environment & Sustainabilitity

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3			1		3	3		3			3	3	3
CO2	3	2	2	1	2	3	3		3		3	3	3	3
CO3					2					3		3	3	3
CO4							3			3		3	3	3
CO5						3	3		3			3	3	3
Total	**3**	**2**	**2**	**1**	**2**	**3**	**3**		**3**	**3**	**3**	**3**	**3**	**3**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*