

# **SEMESTER WISE COURSE STRUCTURE**

**&**

## **EVALUATION SCHEME**

For

### **B. TECH. MINOR DEGREE**

IN

**CHEMICAL TECHNOLOGY**

**PLASTIC TECHNOLOGY**

**(Effective from the session 2022-23)**



**DEPARTMENT OF PLASTIC TECHNOLOGY**

**SCHOOL OF CHEMICAL TECHNOLOGY**

**HARCOURT BUTLER TECHNICAL UNIVERSITY**

**KANPUR-208002**

**UTTAR PRADESH**

## **Department of Chemical Technology-Plastic Technology**

### **Vision:**

**“The department of chemical technology-plastic technology aspires to achieve excellence in technical knowledge and skill, research and innovation in Plastics and Allied areas”**

### **Mission:**

The mission of the Department of Chemical Technology- Plastic Technology are:

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

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

**M3 :** To develop state-of-the-art 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.

### **Program Educational Objectives (PEOs)**

The Program Educational Objectives (PEOs) of B.Tech. Chemical Technology-Plastic Technology program are:

**PEO1 :** Graduates will be technically competent in the field of polymers, resins, processing and allied areas to cater the need of country.

**PEO2 :** Graduates will be able to innovate in designs, production of materials and processes for sustainable development of society.

**PEO3 :** Graduates will serve the industry to meet the challenges in terms of quality assurance and standardization to with stand the global competitiveness.

**PEO4 :** Graduates will discharge duties with professional attitudes and ethics.

### **Program Specific Outcomes:**

**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.

## Consistency of PEOs with Mission of the Department

PEO Statements		M1	M2	M3	M4
<b>PEO1:</b>	Graduates will be technically competent in the field of polymers, resins, processing and allied areas to cater the need of country.	3	1	2	2
<b>PEO2:</b>	Graduates will be able to innovate in designs, production of materials and processes for sustainable development of society.	3	2	2	1
<b>PEO3:</b>	Graduates will serve the industry to meet the challenges in terms of quality assurance and standardization to with stand the global competitiveness.	3	2	2	2
<b>PEO4:</b>	Graduates will discharge duties with professional attitudes and ethics.	3	2	2	3

PEO	M1 (State-of-the art technology)	M2 ( Research and Innovation)	M3 (Training and consultancy)	M4 (Ethical Values)
<b>PEO1</b>	Good facilities are required to train graduates with high level of skills and technical knowledge	Graduates should have inclination towards research and innovation for growth of industry or organization	Graduates should have expertise in testing and characterization of polymers and related materials for developments in industry or organization	Graduates should have good professional attitude along with technical knowledge
<b>PEO2</b>	Graduates should have good technical knowledge for innovative designs of new products and processes	Graduates should have innovative approach for finding solutions to problems in society	Graduates should have skills for working on modern tools required for development	Graduates should be able to analyze impact of development on society
<b>PEO3</b>	Graduates should have good technical knowledge for meeting challenges in professional carrier with confidence	Graduates should have innovative approach for continuous growth of industry or organization	Graduates should have good knowledge for handling real time problems	Graduates should have knowledge of laws and legislations for sustainable progress
<b>PEO4</b>	Graduates should have good knowledge regulations followed in industry	Graduates should be aware of impact of research and development on environment	Graduates should be able to focus on analyzing professional ethics required in future	Graduates should focus on overall development of stakeholders of industry and society

## **Program Outcomes (POs) of B. Tech. Chemical Technology - Plastic Technology**

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

- PO1: Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.
- PO2: Problem Analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)
- PO3: Design/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified with consideration for the public health and safety, whole-life cost, net zero needs carbon, culture, society and environment as required. (WK5)
- PO4: Conduct Investigations of Complex Problems: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).
- PO5: Engineering Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)
- PO6: The Engineer and The World: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).
- PO7: Ethics: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
- PO8: Individual and Collaborative Team work: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
- PO9: Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences
- PO10: Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
- PO11: Life-Long Learning: Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

## **Knowledge and Attitude Profile (WK)**

- WK1: A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.
- WK2: Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.
- WK3: A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
- WK4: Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.
- WK5: Knowledge, including efficient resource use, environmental impacts, whole-life cost, reuse of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.
- WK6: Knowledge of engineering practice (technology) in the practice areas in the Engineering discipline.
- WK7: Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.
- WK8: Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.
- WK9: Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

**HARCOURT BUTLER TECHNICAL UNIVERSITY**  
**KANPUR**  
**SCHOOL OF CHEMICAL TECHNOLOGY**  
**B.TECH. PLASTIC TECHNOLOGY**  
Semester wise course structure  
(Applicable from Session 2022-23 for new entrants)

**For Minor Degree in Chemical Technology (Plastic Technology) students can choose 20 credits from the list of following courses**

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1	PCC	Introduction to Polymer Chemistry (ITPC)	NMPL 201	4	3	1	0	30	20	-	50	50	100
2	PCC	Polymerization Engineering-I (PE-I)	NMPL 203	4	3	0	2	15	20	15	50	50	100
3	PCC	Processing of Polymers -I (PP-I)	NMPL 202	4	3	0	2	15	20	15	50	50	100
4	PCC	Polymerization Engineering-II (PE-II)	NMPL 204	3	3	0	0	30	20	-	50	50	100
5	PCC	Polymerization Engineering Lab (PE LAB)	NMPL 206	2	0	0	4	-	20	30	50	50	100
6	PCC	Processing of Polymers -II (PP-II)	NMPL 301	4	3	0	2	15	20	15	50	50	100
7	PCC	Polymer Testing Lab (PT LAB)	NMPL 307	3	0	0	6	-	20	30	50	50	100
8	PCC	Polymer Composite (PC)	NMPL 306	3	3	0	0	30	20	-	50	50	100

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**For Minor Degree in Chemical Technology (Plastic Technology)**

**Odd Semester**

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1	PCC	Introduction to Polymer Chemistry (ITPC)	NMPL 201	4	3	1	0	30	20	-	50	50	100
2	PCC	Polymerization Engineering-I (PE-I)	NMPL 203	4	3	0	2	15	20	15	50	50	100
3	PCC	Processing of Polymers -II (PP-II)	NMPL 301	4	3	0	2	15	20	15	50	50	100
4	PCC	Polymer Testing Lab (PT LAB)	NMPL 307	3	0	0	6	-	20	30	50	50	100

**Even Semester**

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1	PCC	Processing of Polymers -I (PP-I)	NMPL 202	4	3	0	2	15	20	15	50	50	100
2	PCC	Polymerization on Engineering-II (PE-II)	NMPL 204	3	3	0	0	30	20	-	50	50	100
3	PCC	Polymerization Engineering Lab (PE LAB)	NMPL 206	2	0	0	4	-	20	30	50	50	100
4	PCC	Polymer Composite (PC)	NMPL 306	3	3	0	0	30	20	-	50	50	100

# NMPL 201 INTRODUCTION TO POLYMER CHEMISTRY (ITPC)

L-T-P-C: 3-1-0-4

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

- To understand polymers & plastics
- To understand the types & Classifications
- To understand various mechanism of polymerization.
- To understand the characterization of polymers by molecular weight.
- To understand the copolymerization reactions and its significance.

## 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 and apply the chain growth polymerization and its kinetics.	Apply
CO3	Understand and apply the step growth polymerization, its kinetics, mechanism and crosslinking.	Apply
CO4	Analyze molecular weight and molecular weight distribution of polymers, copolymers, etc.	Analyze
CO5	Understand and analyze co-polymerization usefulness and its types	Analyze

## Course Articulation Matrix (CO-PO Matrix)

CO	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO1	PSO2
CO1	3					2		1	1		3	3	3
CO2	3					2			1		3	3	3
CO3	3	2						1			3	3	3
CO4	3	2			1		1				3	3	3
CO5	3	2	2	2			1				3	3	3
<b>Total</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>1</b>		<b>3</b>	<b>3</b>	<b>3</b>

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

## Detailed Syllabus

### Module-I: Basics of Polymer formation

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

### Module-II: Introduction to 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, auto-acceleration.

### **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, polydispersity. 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. Significance & Global Impact of copolymerization on Plastic Industry

### **Text books:**

1. F. W. Billmeyer, "Text Book of Polymer Science ", John. Wiley & Sons, 1990.
2. V. R. Gowariker, "Polymer Science", New Age International, 1986.
3. P. Ghosh, "Polymer Science and Technology ", Tata McGraw-Hill Education, 1990.
4. G. Odian, "Principles of Polymerization ", Wiley, 1981.
5. P. J. Flory, "Principles of Polymer Chemistry ", Cornell University Press, 1953.
6. R. W. Lenz, "Organic Chemistry of Synthetic High Polymers ", John Wiley & Sons Inc, 1967.
7. D. Margerison, "An Introduction to Polymer Chemistry ", Pergamon, 1967.
8. A. Ravve, "Principles of Polymer Chemistry", Springer New York, 2012.
9. J. A. Brydson, "Plastics Material", 7<sup>th</sup> edition, Butterworth-Heinemann, 1999.
10. J. R. Fried, "Polymer Science & Technology", 3rd edition, Prentice Hall, 2014.

### **Reference Books:**

1. R. J. Young & P.A. Livell Ch. & Hall, "Introduction to Polymers", London, 1981
2. Seymour & Caraher, M. Decker, "Polymer Chemistry", 2003.
3. "Principles of Polymers-An Advanced Book", Nova Science Publishers, NY, 2013.

### **Web Links:**

1. <https://archive.nptel.ac.in/courses/104/105/104105124/>
2. [https://nitsri.ac.in/Department/Chemical%20Engineering/M3\\_\\_Polymer\\_Technology.pdf](https://nitsri.ac.in/Department/Chemical%20Engineering/M3__Polymer_Technology.pdf)

# NMPL 203 POLYMERIZATION ENGINEERING – I (PE-I)

L-T-P-C: 3-0-2-4

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

- To understand Industrial polymerization techniques used to produce addition polymers.
- To understand the stereospecific polymerizations and its importance.
- To learn the manufacturing of thermoplastic resins
- To understand the manufacturing of thermosetting resins, molding powders.
- Apply techniques of polymerization for synthesis of polymers at lab scale

## 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.	Understand
CO2	Understand stereo specific catalyst and polymerizations.	Understand
CO3	Understand and apply the production process for commodity thermoplastics.	Apply
CO4	Understand and apply the production process for common thermoset polymers.	Apply
CO5	Understand and analyze production technology, properties and applications of polymers and their copolymers.	Analyze
CO6	Apply techniques of polymerization for synthesis of polymers at lab scale.	Apply

## Course Articulation Matrix (CO-PO Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3					2					3	3	3
CO2	3					2					3	3	3
CO3	3	3				2	1				3	3	3
CO4	3	3				2	1				3	3	3
CO5	3	3	3	2	1	2			1	1	3	3	3
CO6	3	3	2	2		2		2			3	3	3
<b>Total</b>	<b>3</b>	<b>3</b>	<b>2.5</b>	<b>2</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>3</b>	<b>3</b>	<b>3</b>

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

## Detailed Syllabus

### Module-I: Industrial Polymerization

Industrial methods of polymerization such as bulk, solution, suspension, emulsion. Layout and arrangement of polymer plant. Types of Commercial polymer production processes and reactors. Problems associated with Industrial polymerization & solutions.

## **Module-II: Stereospecific Polymerizations**

Concept of stereo-chemistry of polymers. Stereo-specific polymerization and types of Catalysts: Like Ziegler-Natta and Metallocene. Their utility in global polymer Industry, Recent advancement in catalyst.

## **Module-III: Production of Commodity Thermoplastics**

Commercial production processes of Commodity Thermoplastics eg. LDPE, HDPE & LLDPE. Their copolymer grades, properties and applications. Polypropylene production, and its copolymer grades.

## **Module-IV: Production of thermoset resins**

Manufacturing process, properties and applications of Formaldehyde based thermosetting resins such as phenol-formaldehyde, urea-formaldehyde and melamine-formaldehyde. Preparation of their molding powders- ingredients & processes.

## **Module-V: Production of polymers and copolymers of styrene & Vinyl chloride**

Production technology, properties and application of polystyrene, poly (vinyl chloride), 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.

### **List of Experiments:**

Sl. No.	List of Experiments
6.1	Polymerization of given Technique. monomer by Bulk Polymerization
6.2	Polymerization of given monomer by Solution Polymerization Technique
6.3	Polymerization of given monomer by Suspension Polymerization Technique.
6.4	Polymerization of given monomer by Emulsion Polymerization Technique
6.5	Preparation of Resol - type PF resin
6.6	Preparation of Novolac - type PF resin
6.7	Determination of molecular weight of polystyrene using Ostwald viscometer
6.8	Determination of K-value of PVC using Ostwald viscometer

### **Text books:**

1. J. A. Brydson, "Polymer Materials", Butterworth-Heinemann, 1990.
2. Mark & Overberger, "Encyclopedia of Polymer Science & Tech.", Wiley-Interscience, 1986.
3. V. R. Gowariker, "Polymer Science ", New Age International, 1986.
4. C. C. Ibeh, " Thermoplastic Materials: Properties, Manufacturing Methods, and Applications ", Taylor and Francis Group, 2011.
5. Brage, Golding & D. V. Nostrand, "Polymer and Resins; Their Chemistry and Chemical Engg.", 1959.
6. S. R. Sandler, Wolf Karo, Jo-Anne Bonesteel and Eli M. Pearce, "Polymer Synthesis and Characterization", 1<sup>st</sup> edition, 1998.

## NMPL 202 PROCESSING OF POLYMERS –I (PP-I)

**L-T-P-C: 3-0-2-4**

- OBJECTIVE: The objective of this course is to enable the students**
- To understand the fundamentals of polymer processing
  - To learn the fundamentals of extrusion processes of thermoplastics.
  - To learn the basic principle of compounding of thermoplastics
  - To learn the fundamentals of calendaring process.
  - To learn processing of plastics on different machines and prepare simple plastic articles.

### Course Outcome

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

<b>CO1</b>	Understand the concepts of Extrusion process of plastic materials.	Understand
<b>CO2</b>	Understand and apply the utility of the single screw and multiple screw extruder systems.	Apply
<b>CO3</b>	Apply knowledge of extrusion process for manufacturing of different extruded plastic products.	Apply
<b>CO4</b>	Understand and apply compounding ingredients and methods for modification of polymer properties.	Apply
<b>CO5</b>	Understand the concept and utility of calendaring process for polymer/plastics.	Understand
<b>CO6</b>	Apply different parameters related to processing machines for formation of plastic products.	Apply

### Course Articulation Matrix (CO-PO Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
<b>CO1</b>	3					2					3	<b>3</b>	<b>3</b>
<b>CO2</b>	3					2			1		3	3	3
<b>CO3</b>	3	3	2			2		1	1		3	3	3
<b>CO4</b>	3	2	2	2		2	1			1	3	3	3
<b>CO5</b>	3	1	2			2					3	3	3
<b>CO6</b>	3	3	2	2	1	3	1	3	2	1	3	3	3
<b>Total</b>	<b>3</b>	<b>2.5</b>	<b>2</b>	<b>2</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>2</b>	<b>1</b>		<b>3</b>	3	3

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

### Detailed Syllabus

#### Module-I: Introduction to Polymer Processing

Principles and concept of Processing of polymers; introduction to different plastic processing techniques Criteria for selection of process for plastics; Factors determining efficiency of plastic processing: molecular weight, viscosity and rheology, Difference in approach for thermoplastic and thermoset processing. Sustainability of these processes

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

Concepts of Extrusion process for plastics- basic operation and analysis, solids conveying, drag induced conveying, melting mechanism, power consumption in metering zone. Fundamentals of single and twin screw extrusion; Features of Barrel and screw; type of screws, drive mechanism, specifications, heating and cooling systems, Design of screw for commodity, heat sensitive and engineering plastics. Overall extruder performance, die and screw characteristics curves, factors determining efficiency of an extruder. Local and global technological development in extrusion

## **Module-III: Extrusion Processes for plastic products**

Plastic Product formed by extrusion process, Basic principle, equipment used, and process details for plastic extrusion lines for production of Blown film, pipe, tubing, sheet, wire and cable coating, etc.; Utility of these products in urban développement. Extrusion Casting process for films and lamination; Process variables, die design and defects observed in each of the extrusion product. 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, lubricants, processing aids, etc. sustainability and effects on environment of variety of additives for plastics Mixing, blending and compounding techniques and equipments. Pelletization, Reactive compounding, Global technical development in compounding additives and compounding technology for plastics. Finishing of Plastics

## **Module-V: Calendaring of plastics**

Calendaring- description and features of calendaring process, calendar roll arrangements, application of calendaring. Production of synthetic leather and coated fabric sheets, Process variables, calendar design and defects observed.

## **Module VI: Laboratory Experiments**

1. Preparation of plastic film on Blown Film Extrusion;
2. Preparation of HDPE plastic pipe on Extrusion;
3. Compounding of PVC on Two Roll Mill;
4. Preparation of sheet by Hydraulic press;
5. Preparation of Fiber reinforced plastic sheet by using glass fiber mat and unsaturated polyester resin

### **Text Books:**

1. Plastics Extrusion Technology, by Grief, Allen L; published by Hassell Street Press, 2021, Hawthorne, U.S.A.
2. Extrusion of Polymers Theory & Practice, Chan I. Chung; Hanser Publishers, Munich Hanser Publications, Cincinnati, 2019.
3. Screw extrusion of Plastics, by H

4. R. Jacobi; London, GB ILIFFE Books Ltd. 1963.
5. Polymer Mixing and Extrusion Technology, by Nicholas Cheremisinoff; First Published 1987; eBook Published 25 October 2017; CRC Press, Available on Taylor and Francis eBooks.
6. Additives for Plastics; J. Stepek and H Daoust; Springer New York; 1983.

**Reference books:**

1. Plastic Engg. Hand Book of SPI, by Joel Frados, Published July 1st 1976 by Wiley, John & Sons, Incorporated.
2. Plastic Materials and Processes: a concise encyclopedia, by Charles A. Harper and Edward M. Petrie; John Wiley & Sons, 10-Oct-2003
3. Polymer Extrusion 5E; Chris Rauwendaal, Hanser Publishers, Munich Hanser Publications, Cincinnati; 2014.
4. Plastics Additives: An A-Z reference; Editors: Geoffrey Pritchard; Springer Dordrecht; 1998.
5. Plastics Technology Handbook Fifth Edition; Manas Chanda; CRC Press Taylor & Francis Group NY, 2018

**Web links:**

1. <https://www.twi-global.com/technical-knowledge/faqs/plastic-extrusion>
2. <https://www.extrusion-info.com>  
<https://www.iqsdirectory.com/articles/plastic-extrusion.html>

## NMPL 204 POLYMERIZATION ENGINEERING–II (PE-II)

**L-T-P-C: 3-0-0-3**

<p><b>OBJECTIVE:</b> The objective of this course is to enable the students</p> <ul style="list-style-type: none"> <li>• To understand synthesis, manufacturing process, properties and applications of engineering plastics.</li> <li>• To learn the manufacturing of high performance thermoset resins and their applications.</li> <li>• To understand synthesis, manufacturing process, properties and applications of specialty plastics.</li> <li>• To understand the synthesis and manufacturing of flexible and rigid polyurethanes and analyze their properties and applications.</li> </ul>
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### Course Outcome

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

<b>CO1</b>	Understand concept of engineering plastics, synthesis and manufacturing of common engineering plastics and their properties for variety of applications.	Understand
<b>CO2</b>	Understand monomers and their properties, chemistry of synthesis and manufacturing of high performance thermoplastic materials and analyze their properties and utility for variety of application.	Analyze
<b>CO3</b>	Understand concept and characteristics of specialty plastics and their applications.	Understand
<b>CO4</b>	Understand monomers, chemistry of synthesis, manufacturing, curing and properties of high temperature thermoset polymers like epoxy resin, and analyze their properties and utility for variety of applications.	Analyze
<b>CO5</b>	Understand synthesis, manufacturing, properties and applications of specific polymers and analyze their utility to meet desired end use properties.	Understand

### Course Articulation Matrix (CO-PO Matrix)

	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>	<b>PO6</b>	<b>PO7</b>	<b>PO8</b>	<b>PO9</b>	<b>PO10</b>	<b>PO11</b>	<b>PSO1</b>	<b>PSO2</b>
<b>CO1</b>	3	2	1			3	1		1		3	3	3
<b>CO2</b>	3	2	1			3	1		1		3	3	3
<b>CO3</b>	3	2	1			3	1	1	1		3	3	3
<b>CO4</b>	3	2	1	1		3	1		1		3	3	3
<b>CO5</b>	3	2	1	1	1	3	1	1	1	1	3	3	3
<b>Total</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>3</b>	<b>1</b>	<b>3</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>3</b>	<b>3</b>	<b>3</b>

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

## **Detailed Syllabus**

### **Module-I: Engineering Thermoplastics-I**

Definition of engineering plastics and high performance polymers. Monomers, chemistry of synthesis, manufacturing process, properties and applications of common engineering plastics viz, ABS; polycarbonate; Acrylic polymers and copolymers like PMMA, Polyacrylonitrile; Polyacrylamide, etc. effect of these polymers on environment sustainability, global and local manufacturers of these polymers

### **Module-II: Engineering Thermoplastics-II**

Monomers, chemistry of synthesis, manufacturing process, properties and applications of polyamides: Nylon6, Nylon 66, Nylon 11 and aromatic polyamide, polyesters: PET, PBT, fluorine-containing polymers Polytetrafluoroethylene, Polyvinylidene fluoride, Polychlorofluoroethylene, etc. effect of these polymers on environment sustainability. Global and local manufacturers of these polymers

### **Module-III: Specialty Thermoplastics**

Monomers, chemistry of synthesis, manufacturing process, properties and applications of polyphenylene oxide, acetal resins, polysulphones, polysulphides, polyamideimide and other specialty plastics. Effect of these polymers on environment sustainability, global and local manufacturers of these polymers

### **Module-IV: Thermoset polymers-I**

Monomers, chemistry and manufacturing process of thermosetting resins such as epoxy resins, alkyd resins, unsaturated polyesters resins, polyimides: polybismalenimides, polyetherimides, etc. Their curing mechanism; effect of curing parameters on properties and applications of these polymers. Effect of these polymers on environment sustainability, global and local manufacturers of these polymers

### **Module-V: Thermoset polymers-II**

Synthesis and manufacturing of flexible and rigid polyurethanes and their properties and applications. Monomers, chemistry of synthesis, manufacturing process, properties and applications of Silicone polymers. Effect of these polymers on environment sustainability, global and local manufacturers of these polymers

### **Text Books:**

1. Polymer Materials, by J. A. Brydson Butterworth-Heinemann Oxford,1999
2. Handbook of Plastic Technology, Vol 1, by Allen W. S. CBS Publishers & Distributors, 1988
3. Handbook of Thermoplastics, by OlagokeOlabisi; CRC Press; 2016.
4. Engineering polymers, R.W. Dyson; Chapman Hall NY; 1990
5. Polymer Manufacturing: Technology and Health Effects Hardcover– Import, 1 December 1986; Radian Corporation; Noyes Publications; 1986
6. Industrial Polymers, Specialty Polymers, and Their Applications by Salil K Roy, Manas Chanda, Salil K. Roy, CRC Press,2019.

**Reference books:**

1. Polymer production, by Mayo & Smith, 1975
2. Encyclopedia of Polymer Science & Tech., Vol 1-23, by HF Mark, NM Bikales and CG Over-berger Wiley-Interscience, New York; 1985
3. Handbook of Plastic Technology, Vol 2, by Allen W. S. and G. M. Swallowe, CBS Publishers & Distributors, 2004.
4. Plastics Fabrication and Recycling by Salil K Roy, Manas Chanda, Salil K. Roy, CRC Press,2019.

**Web links:**

1. <https://nptel.ac.in/courses/112107221>

## NMPL 206 POLYMERIZATION ENGINEERING LAB (PE LAB)

L-T-P-C: 0-0-4-2

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

- To understand and apply polymerization techniques for synthesis of various polymers.
- To understand the concept of analytical characterization of different polymers such as PVC, copolymer of styrene and maleic anhydride, epoxy resins, etc.
- To understand the concept of curing mechanism and content of curing agent selection for epoxy resin.

### Course Outcome

<b>CO1</b>	To understand the method of synthesis of some common polymers and resins such as copolymer of styrene and maleic anhydride, polyester resin, phenol formaldehyde resin, etc.	Understand and Apply
<b>CO2</b>	Determination of molecular weight of epoxy resins	Understand and Apply
<b>CO3</b>	Understand and apply the concept of curing mechanism and epoxy equivalent of epoxy resin.	Understand and Apply

### Course Articulation Matrix (CO-PO Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
<b>CO1</b>	3	3				1			1	1	3	3	3
<b>CO2</b>	3	3				1			1	1	3	3	3
<b>CO3</b>	3	3				1	1		1	1	3	3	3
<b>Total</b>	<b>3</b>	<b>3</b>				<b>1</b>	<b>1</b>		<b>1</b>	<b>1</b>	<b>3</b>	<b>3</b>	<b>3</b>

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

### List of Experiments

Sl. No.	Details of Experiments
1	Synthesis of copolymer of styrene and maleic anhydride
2	Synthesis of ester gum from rosin
3	Synthesis of unsaturated polyester resin
4	Determination of epoxide equivalent weight of epoxy resin
5	Determination of amine content of curing agent
6	Preparation of phenol formaldehyde based molding powder
7	Preparations of laminates from epoxy resin and filter papers
8	Determination of molecular weight of epoxy resin.

## NMPL 301 PROCESSING OF POLYMERS- II (PP-II)

**L-T-P-C: 3-0-2-4**

**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, rotational moulding, blow molding, stretch blow molding.
- To understand the reaction injection molding technique
- 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

<b>CO1</b>	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
<b>CO2</b>	Understand the processing techniques for conversion of thermoset materials like compression, transfer molding and casting.	Understand
<b>CO3</b>	Understand formation of low cost plastic products by thermoforming process and analyze utility of process for different applications.	Analyze
<b>CO4</b>	Understand formation of hollow plastic products and analyze utility of various techniques for production of hollow products.	Analyze
<b>CO5</b>	Understand reactive processes for formation of plastic products like RIM and casting	Understand
<b>CO6</b>	Apply different parameters related to processing machines for formation of plastic products.	Apply

### Course Articulation Matrix (CO-PO Matrix)

CO	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO1	PSO2
<b>CO1</b>	3	3	1	1	1	3	1	1	1		2	3	3
<b>CO2</b>	3		1	1		3	1	1	1		2	3	3
<b>CO3</b>	3	3	1	1		3	1	1	1		2	3	3
<b>CO4</b>	3	3				3	1	1	1		2	3	3
<b>CO5</b>	3	3				3	1	1	2		3	3	3
<b>CO6</b>	3	3	3	3	1	3	1	3	2	1	3	3	3
<b>Total</b>	<b>3</b>	<b>3</b>	<b>1.5</b>	<b>1.5</b>	<b>1</b>	<b>3</b>	<b>1</b>	<b>1.3</b>	<b>1.3</b>	<b>1</b>	<b>2.3</b>	<b>3</b>	<b>3</b>

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

## **Detailed Syllabus**

### **Module-I: Injection Molding of Thermoplastics**

Basic concepts and principles of injection molding of thermoplastics. Principle of standard injection molding operation; types and specifications of injection unit, clamping units, screws, nozzle, etc.; Molding cycle of process; Process variables: temperature, pressure, injection rate, etc. and their importance for molding cycle and quality of product. Faults and remedies in injection molding operation. Injection molding of Amorphous and semi-crystalline plastics, Indian and Global manufacturers; Advances in injection molding process; Sustainability of process

### **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; hydraulic press and their capacity; process parameters; advantages and disadvantages of these processes; description of various types of transfer molding processes and their utility in processing of thermosetting materials. Advances in compression and transfer molding process: global and Indian scenario.

### **Module-III: Thermoforming Process**

Concepts of thermoforming process and various means of forming. Description of various thermoforming techniques. Thermoforming process variables affecting the product quality. Thermoforming faults and remedies. Thermoforming machines. Utility of this process for local needs, Advancements in thermoforming process; Sustainability of process

### **Module-IV: Molding Process for hollow products**

General description of blow molding process, Injection and extrusion blow molding processes, type of blow molding machines, die shaping, parison control, process variables, processing parameters for optimum product performance; blow molding faults and trouble shooting.

Rotational molding process description and features of rotational molding machines. Process variables in rotational molding process. Sustainability of process

Stretch blow molding process. Concepts of stretching temperature, transparency, etc. various types of stretch blow molding operation. Utility of these processes for local needs.

### **Module-V: In-situ Reaction Molding process**

Reaction injection molding (RIM) Process, its basic principles, process description and utility. Slush molding process

Concept of Casting of polymers, description of process for polymers like epoxy resins, nylons, polyurethanes, PMMA, polyesters, etc. Advantages and disadvantages of casting process, .Encapsulation, lamination, coatings of resins. Sustainability of process

### **Module VI: Laboratory Experiments**

1. Preparation of simple Dumble shape test specimen on Semi-Automatic Injection Molding Machine.
2. Preparation of simple Bar/Disc shape test specimen on Hand Injection Molding Machine.
3. Preparation of simple article on Blow Molding Machine.
4. Preparation of PET Bottle on Stretch Blow Moulding Machine.

5. Preparation of an article by Rotational Molding Machine.
6. Preparation of an article by Compression Molding Machine.

**Text books:**

1. Plastic Engg. HandBook of SPI, by Joel Frados, Wiley, John & Sons, 1st Edition, 1976.
2. Injection and Compression Moulding Fundamentals, Edited By Avraam I. Isayev, First Published: 1987; eBook Published 25 October 2017
3. Injection Moulding HandBook, by D V Rosato & Rosato; Springer, 2012
4. Practical Thermoforming: Principles and Applications; by Raymond J. Mikulak, Raymond J. McDermott, Michael Beaugard; 2nd Edition; Taylor & Francis Ltd., 1996.
5. Practical Thermoforming: Principles and Applications; Second Edition, By Florian; Marcel Dekker Inc., 1996
6. Blow Molding Handbook Technology, Performance, Markets, Economics. The Complete Blow Molding Operation. D. V. Rosato, Carl Hanser Verlag, GmbH & Co. Publication, 2003
7. Rosato, D.V., Rosato, D.V. Compression and Transfer Molding. In: Plastics Processing Data Handbook. Springer, Dordrecht. 1990

**Reference books:**

1. Encyclopedia of Polymer Science and Technology Vol. 1-15, 4<sup>th</sup> edition, Herman F. Mark (Editor), Wiley, 2014..
2. Advanced Polymer Processing Operations; Edited by: Nicholas P. Cheremisinoff, Noyes Publications, New Jersey, U.S.A., 1998
3. Plastics technology handbook (Plastics engineering) by Salil K. Roy and Manas Chanrda; CRC Press, 2006.
4. Encyclopedia of Polymer Science & Tech., Vol 1-23, by HF Mark, NM Bikales and CG Over-berger Wiley-Interscience, New York; 1985

**Web links:**

1. <https://elearn.nptel.ac.in/shop/nptel/processing-of-polymers-and-polymer-composites/>
2. [https://web.ics.purdue.edu/~kviswana/polymerProc\\_Dec29.pdf](https://web.ics.purdue.edu/~kviswana/polymerProc_Dec29.pdf)
3. <https://nptel.ac.in/courses/112107221>

## NNPL 307 POLYMER TESTING LAB (PT Lab)

L-T-P-C:0-0-6-3

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

- To determine various mechanical properties of plastic film/Sheet.
- To determine various mechanical properties of rubber sheet.
- To determine the rheological properties of polymers.
- To determine the thermal properties of polymers.

### Course Outcome

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

<b>CO1</b>	Testing of various mechanical properties of plastic and rubber materials	Apply
<b>CO2</b>	Testing of the rheological properties of polymers	Apply
<b>CO3</b>	Testing of the thermal properties of polymers	Apply
<b>CO4</b>	Analyze testing of plastic materials on different testing equipments.	Analyze

### Course Articulation Matrix (CO-PO Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
<b>CO1</b>	3	2	2	1		3		3	3		3	3	3
<b>CO2</b>	3	2	2	1		3		3	3		3	3	3
<b>CO3</b>	3	2	2	1		3		3	3		3	3	3
<b>CO4</b>	3	2	2	1	2	3	1	3	3		3	3	3
<b>Total</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>1</b>	<b>3</b>	<b>3</b>		<b>3</b>	<b>3</b>	<b>3</b>

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

### List of Experiments:

S. No.	Laboratory Experiments
1	Determination of Tensile Strength and Percent Elongation of polymerfilm/sheet
2	Determination of the Vicat Softening point of given plastic sample on Vicat Softening Point apparatus
3	Determination of Tensile strength, Modulus and Percent Elongation of moulded plastic specimen
4	Determination of the Izod/Charpy Impact Strength of given specimen
5	Determination of the Melt Flow Index of polymer raw material by MFI tester
6	Determination of the Shore A Hardness of Rubber Sheet
7	Determination of the Percent Water Absorption in 24 hours of Moulding Plastic samples
8	Determination of the Falling Dart Impact Strength of polyethylene film using Falling Dart Impact Tester
9	Determination of viscosity of polymer by Brookefield viscometer
10	Determination of Tensile strength, Modulus and Percent Elongation of rubber specimen

## NMPL 306 POLYMER COMPOSITE (PC)

**L-T-P-C: 3-0-0-3**

**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 polymer composites.
- To know the manufacturing and properties of various reinforcements used in polymer composites.
- To learn various processing techniques, testing and applications of fibers in reinforced plastics.

**Course Outcome:**

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

<b>CO1</b>	Understand the concept of composite, matrix and reinforcement.	Understand
<b>CO2</b>	Understand the classification and utility of reinforcement materials	Understand
<b>CO3</b>	Understand characteristics of various thermoset and thermoplastic materials used in polymer composites.	Understand
<b>CO4</b>	Present and apply different production techniques for composite structures like hand-layup, bag molding etc.	Apply
<b>CO5</b>	Perform design and fabrication of different composite structures like hybrid, sandwich, etc. and perform characterization of polymer composites	Apply

**Course Articulation Matrix (CO-PO Matrix)**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
<b>CO1</b>	3						1	-	-	-	3	3	3
<b>CO2</b>	3		2			2	1	-	-	-	3	3	3
<b>CO3</b>	3		2			2	1	-	-	-	3	3	3
<b>CO4</b>	3	2	2			2	1	1	-	-	3	3	3
<b>CO5</b>	3	2	2	1		2	1	1	-	-	3	3	3
<b>Total</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>1</b>		<b>2</b>	<b>1</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>3</b>	<b>3</b>	<b>3</b>

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

**Detailed Syllabus**

**Module-I: Introduction to polymer composites**

Introduction to basic components of a polymer composite, Concept of matrix and reinforcement, Principles of composite reinforcement, Concepts of interfacial bonding, Prediction of composite properties using rule of mixing.

**Module-II: Reinforcements for Polymer composites**

Types of reinforcement such as natural, glasses, carbon/graphite, aramid fibers boron fibers and their utility in polymer composites, various forms of reinforcement and surface treatment of fibers, effect of fibrous reinforcement on composite strength, concept of critical fibre length.

**Module-III: Matrices for Polymer composites**

General characteristics of thermoplastic and thermoset matrices in polymer composites and their global and local need in packaging, construction, transportation, aerospace, etc.

**Module-IV: Production Techniques -I**

Fabrication of polymer composites using hand-layup, vacuum bag moulding, filament winding and pultrusion

**Module-V: Production Techniques -II**

Concept of Prepregs, hybrid and sandwich type composites, fabrication of polymer composites using Sheet moulding and dough moulding and resin transfer moldings. Characterization of polymer composites.

**Text Books:**

1. P.G. Kelleher, Reinforced Thermoplastics - Composition, Processing and Applications, New Jersey Polymer Extension Center, 1993.
2. Prof. Dr. Sabu Thomas, Prof. Dr. Kuruvilla Joseph, Dr. Sant Kumar Malhotra, Prof. Dr. Koichi Goda, Dr. Meyyarappallil Sadasivan Sreekala "Polymer Composites", Wiley VCH Verlag GmbH & Co. KGaA, 2013.
3. R. K. Gupta "Polymer and composite & Rheology", CRC Press, 2014.
4. "Mechanics of Composite materials", Second Ed., by Robert Jones and Robert M. Jones.

**Reference Books:**

1. G. Lubin "HandBook of Composites", 2nd edition, Kluwer Academic Publishers Group, 1982
2. G. Lubin, V. N. Reinhold, "HandBook of Fibre glass and Advanced Plastic Composites", 1970
3. E.S.Shand, "Glass Engineering HandBook", McGraw-Hill, 1958.
4. Grewell, Benatar & Park, "Plastics and Composites welding Handbook", Hanser Publications, 2003.
5. Rosato & Rosato, "Reinforced Plastic Handbook", Elsevier, 2004

**Web link:**

1. [Processing of Polymers and Polymer Composites - Course \(nptel.ac.in\)](https://www.nptel.ac.in/)