SY B. Tech (Plastics and Polymer Engineering)

Course Category	Course Code	Course Name	Teaching Scheme (Hours/ Week)			Examination Scheme and Marks							Credits			
			Theory	Practical	Contact Hr/Week	ISE- I	ISE - II	TA	ESE	TW	PR/OR	TOTAL	TH	TW/PR	TOTAL	In Line WithUML
Semester - IV																
BSC	BSC401	Probability, Statistics, and Optimization	3	-	3	15	15	20	50	-	-	100	3	-	3	√
PCC	PPE431	Polymeric Materials - II	3	-	3	15	15	20	50	-	-	100	3	-	3	√
PCC	PPE432	Polymer Testing	2	-	2	15	15	20	50	-	-	100	2	-	2	√
PCC	PPE433	Thermodynamics and Heat Transfer	3	-	3	15	15	20	50	-	-	100	3	-	3	√
PCC	PPE434	Plastics Recycling and Sustainability	3	-	3	15	15	20	50	-	-	100	3	-	3	√
HMSC	HMSC421	Introduction to Economics	2	-	2	15	15	20	50	-	-	100	2	-	2	√
PCC	PPE491	Lab: Thermodynamics and Heat Transfer	-	2	2	-	-	-	-	-	25	25	-	1	1	√
PCC	PPE492	Lab: Plastics Process Engineering - I	-	2	2	-	-	-	-	25	-	25	-	1	1	√
PSI	PSI461	Minor Project - I	-	4	4	-	-	-	-	25	25	25	-	2	2	
Audit Course	HSSM421	Technical and Scientific Writing	2	-	2	Non-Credit Mandatory Course										
		Total	**18**	**8**	**26**	**90**	**90**	**120**	**300**	**50**	**50**	**675**	**16**	**4**	**20**	

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">S.Y. B. Tech in Plastics and Polymer Engineering, Semester-IV</td></tr>
<tr><td>Course Code</td><td colspan="7">BSC401</td></tr>
<tr><td>Course Category</td><td colspan="7">BSC (Basic Sciences Course)</td></tr>
<tr><td>Course title</td><td colspan="7">Probability, Statistics, and Optimization</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td colspan="2">L</td><td>P</td><td colspan="1">Total Contact Hours / Week</td><td colspan="3">Total Credits</td></tr>
<tr><td colspan="2">03</td><td>-</td><td>03</td><td colspan="3">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td>ISE-I</td><td>ISE-II</td><td>ESE</td><td>TA</td><td>TW</td><td>PR/OR</td><td>Total</td></tr>
<tr><td>15</td><td>15</td><td>50</td><td>20</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="7">• Calculus – I, II, and III</td></tr>
<tr><td>Course Objectives</td><td colspan="7">After the completion of the course, the student will be able to:
• Build foundational logical understanding of uncertainty and data summarization.
• Translate real-world events into mathematical functions and standard statistical models.
• Apply inferential statistical concepts for data-based decision-making.
• Perform deterministic optimization of linear objectives using Linear Programming techniques.
• Differentiate between Linear Programming Problems and regression-based models.
• Model relationships among variables to support prediction and analysis.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Distinguish between probability, statistics, and optimization concepts (Understand)
• CO2: Illustrate the transformation of real-world events into mathematical representations (Understand)
• CO3: Employ appropriate statistical techniques for effective decision-making (Apply)
• CO4: Utilize Linear Programming techniques to address real-world</td></tr>
</table>

	optimization problems (Apply) • CO5: Examine problem situations and formulate them into Linear Programming Problems (Analyze) • CO6: Interpret relationships among variables to forecast outcomes and trends (Analyze)

Unit No.	Course Content	Hours
I	**Introduction to Probability & Data Analysis** Measures of Central Tendency (Mean, Median, Mode) and Dispersion (Variance, Standard Deviation, Skewness, Kurtosis). Sample space and events, axioms of probability, addition and multiplication theorems, conditional probability. Law of Total Probability, Bayes' theorem, and its applications in real-world scenarios.	6
II	**Random Variables and Distribution Functions** Concept of Random variables: Discrete and Continuous. Probability Mass Function (PMF), Probability Density Function (PDF), and Cumulative Distribution Function (CDF), Mathematical Expectation, Variance, and Moment Generating Function (MGF).	6
III	**Hypothesis Testing** Introduction to sampling, Null and Alternate Hypotheses, Type I and Type II errors, Power of the test, and use of p-values, Parametric test, non-parametric test, ANOVA.	6
IV	**Linear Programming Problem (LPP)** Fundamentals and components of LPP (Decision variables, Objective function, Constraints). Mathematical formulation of linear models, Solving LPP by Graphical method, Simplex Method (Slack and Surplus variables), Big-M method (Method of Penalties) for artificial variables, Concepts of degeneracy and unbounded solutions (Special case in LPP).	6
V	**Transportation and Assignment Problems** Transportation Problem: Balanced and Unbalanced problems, finding Initial Basic Feasible Solution (NW Corner Rule, Least Cost Method, Vogel's Approximation Method), and testing for Optimality (MODI Method).	6

	Assignment Problem: Hungarian Method for solving assignment models, maximization cases, and restricted routes. Introduction to the Traveling Salesman Problem (TSP).	
VI	**Regression Analysis** Correlation analysis (Pearson's and Spearman's coefficients), partial correlation. Simple Linear Regression: Estimating model parameters using the method of least squares, inferences about slope parameters, coefficient of determination (R^2), predicting Y values, and prediction intervals, Introduction to Multiple Regression and its assumptions. Concepts of Non-linear Regression and Logistic Regression (Binary classification).	6

Text Books

1	Gupta, S.C. & Kapoor, V.K. (2020). Fundamentals of Mathematical Statistics. Sultan Chand & Sons.
2	Swarup, K., Gupta, P.K., & Man Mohan. (2019). Operations Research. Sultan Chand & Sons.
3	Walpole, R.E., Myers, R.H., Myers, S.L., & Ye, K. (2016). Probability and Statistics for Engineers and Scientists (9th Ed.). Pearson Education.

Reference Books

1	Taha, H.A. (2017). Operations Research: An Introduction (10th Ed.). Pearson.
2	Montgomery, D.C. & Runger, G.C. (2018). Applied Statistics and Probability for Engineers (7th Ed.). Wiley.
3	Ross, S.M. (2014). Introduction to Probability Models (11th Ed.). Academic Press.
4	Sharma, J.K. (2017). Operations Research: Theory and Applications. Macmillan.

Web Links and Video Lectures (E-Resources)

- NPTEL Course: Introduction to Probability and Statistics by Prof. G. Srinivasan (IIT Madras).
- NPTEL Course: Operations Research by Prof. Kusum Deep (IIT Roorkee).

Activity Based Learning (Suggested Activities in Class)

1. Chalk-Board
2. 3. Collaborative and Individual Problem based learning
4. Quizzes/Assignments/Activities

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Mapping of Course Outcomes with Program Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	-	-	-	-	-	-	-	-	-	2
CO2	2	2	-	-	-	-	-	-	-	-	-	2
CO3	3	2	-	-	-	-	-	-	-	-	-	2
CO4	3	3	-	-	-	-	-	-	-	-	-	2
CO5	3	3	-	-	-	-	-	-	-	-	-	2
CO 6	3	3	-	-	-	-	-	-	-	-	-	2
Avg	**2.5**	**2.3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**

Mapping of Course Outcomes with Program Specific Outcomes

CO \ PSO	PSO1	PSO2	PSO3
CO 1	2	-	-
CO 2	2	-	-
CO 3	2	-	-
CO 4	3	-	-
CO 5	3	-	-
CO 6	3	-	-
Average	**2.5**	**-**	**-**

Correlation Level

- Slightly Low: 1
- Moderately (Medium): 2
- Substantially (Strong): 3

CO-PO-PSO Mapping Justification

- CO1: Strongly relates to PO1, slightly to PO2, and moderately to PO12. It moderately supports PSO1.
- CO2: Moderately maps to PO1, PO2 and PO12 due to understanding how events can transform into mathematical models, which moderately aligns with PSO1 as it builds foundational understanding.
- CO3: Strongly maps to PO1 due to basic concepts, moderately to PO2 and PO12 due to understanding methods to apply, which moderately aligns with PSO1 as it builds understanding about various statistical methods.
- CO4: It strongly maps with PO1 and PO2 due to it involves the solution of LPP problems, which is strongly connected with PSO1.

- CO5: Strongly aligns with PO1 and PO2 as it involves multiple observations to analyze real-world problems, and moderately with PO12 for personal growth, which strongly maps with PSO1.
- CO6: It strongly maps with PO1 and PO2 because it involves the understanding of relation between variables, analyze it and predict it, which strongly maps with PSO1.

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">S.Y. B. Tech in Plastics and Polymer Engineering, Semester-IV</td></tr>
<tr><td>Course Code</td><td colspan="7">PPE431</td></tr>
<tr><td>Course Category</td><td colspan="7">Professional Core Course (PCC)</td></tr>
<tr><td>Course title</td><td colspan="7">Polymeric Materials - II</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td colspan="1">L</td><td colspan="2">P</td><td>Total Contact Hours/ Week</td><td colspan="3">Total Credits</td></tr>
<tr><td>03</td><td colspan="2">-</td><td>03</td><td colspan="3">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td>ISE-I</td><td>ISE-II</td><td>ESE</td><td>TA</td><td>TW</td><td>PR/OR</td><td>Total</td></tr>
<tr><td>15</td><td>15</td><td>50</td><td>20</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="7">• Introduction to Organic and Polymer Chemistry
• Introduction to Polymer Engineering
• Polymeric Materials I
• Polymer Additives and Compounding</td></tr>
<tr><td>Course Objectives</td><td colspan="7">After the completion of the course, students will be able to:
• Show an understanding of engineering thermoplastics and thermosetting resins.
• Explain the chemistry, structure, and properties of major engineering thermoplastics and thermosetting polymeric systems.
• Provides an in-depth review of the major families of thermosetting resins and their processing methodology.
• Explain the difference between high-performance and specialty polymers</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Identify major engineering thermoplastics, their general synthesis routes, key properties, and typical applications in industrial, automotive, and consumer sectors. (Remember)
• CO2: Describe the processing methods, properties, and applications of polyesters and styrene-based copolymers for practical engineering use. (Understand)
• CO3: Utilize knowledge of thermosetting polymers, their chemistry,</td></tr>
</table>

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	curing mechanisms, and property–performance relationships to select suitable processing methods. (Apply) • CO4: Examine high-performance, specialty, and functionalized polymers to establish correlations among functionalization, properties, and potential applications. (Analyze)

Unit No.	Course Content	Hours
I	**Engineering Thermoplastics – I** Overview of engineering plastics and their commercial importance, definition, characteristics, and advantages of engineering thermoplastics, Nylons (PA 6, PA 6,6, PA 12) – general synthesis routes, types, typical thermal, mechanical, and chemical properties, processing methods: injection molding, extrusion, fiber formation, applications in automotive, electrical, industrial, and consumer goods, market sectors served by engineering thermoplastics	6
II	**Engineering Thermoplastics – II** Polyesters: Polyethylene Terephthalate (PET), Polybutylene Terephthalate (PBT), Styrene copolymers: ABS, SAN, general synthesis and polymerization techniques, typical thermal, mechanical, and chemical properties, processing overview: molding, extrusion, fiber or sheet formation, applications in textiles, packaging, medical, and household products, comparative discussion of properties and applications	6
III	**Major Engineering Thermosetting Polymers** Unsaturated polyester resins, chemistry, curing mechanisms, properties, and applications in reinforced plastics; Epoxy resins, synthesis, curing agents, structure property relationships, and applications; Silicone resins, chemistry, thermal stability, and specialty applications.; Polyurethanes, chemistry, classification, flexible, rigid, and elastomeric systems.	6
IV	**Processing of Thermosetting Polymers** Pre-polymer preparation, mixing with fillers, additives, and hardeners, compression molding – procedure, advantages, limitations, transfer molding method and its applications, injection molding technique for thermosets, its considerations, and applications, hand lay-up and spray-up methods for thermosetting composites, pultrusion and filament winding processes, thermal	6

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	and chemical property control during processing, common defects and troubleshooting.	
V	**Speciality Polymers** Overview of high-performance polymers, chemistry, properties and applications of high-performance polymers such as polyetheretherketone (PEEK), Polytetrafluoroethylene (PTFE), poly(phenylene sulfide) (PPS), Liquid crystal polymers, polyimides, etc,	6
VI	**Functionalized Polymers** Introduction to specialty and functionalized polymers, chemical and physical types of functionalization, impact of functional groups on polymer properties and performance, methods to introduce functionality – copolymerization, grafting, surface modification, and blending, correlation of functionalization with thermal, mechanical, chemical, and barrier properties, applications in adhesives, coatings, biomedical devices, electronics, packaging, sensors, and responsive materials	6

Text Books

1	Brydson, J. A., *Plastics Materials*, Butterworth-Heinemann.
2	Fried, J. R., *Polymer Science and Technology*, Pearson Education.
3	V.R. Gowarikar, N.V. Vishwanathan, Jayadev Sreedhar, Polymer Science,

Reference Books

1	P. Gosh, Polymer Science and Technology: Plastics, Rubbers, Blends and Composites, McGraw-Hill
2	Young, R. J., and Lovell, P. A., Introduction to Polymers, CRC Press.

Web Links and Video Lectures (E-Resources)

- Lec. 24: Processing of polymer: Thermosets by Prof. Swarup Bag, Department of Mechanical Engineering, Indian Institute of Technology Guwahati.
- Mod-16 Lec-39 Engineering and Specialty Polymers by Prof. B. Adhikari, Department of Metallurgy and Material Science, Indian Institute of Technology Kharagpur.

Activity Based Learning (Suggested Activities in Class)

1. Flipped Classroom and Online Tools
3. Collaborative and Individual Problem based learning
4. Quizzes/Assignments/Activities

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Mapping of Course Outcomes with Program Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	-	-	-	-	-	-	-	-	-
CO2	3	3	2	1	-	-	-	-	-	-	-	-
CO3	3	3	3	2	1	-	-	-	-	-	-	-
CO4	3	3	3	2	2	-	-	-	-	-	-	-
Average	3	2.75	2.25	1.67	1.5	-	-	-	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes

CO \ PSO	PSO1	PSO2	PSO3
CO1	3	1	2
CO2	3	2	2
CO3	3	1	3
CO4	3	1	3
Average	3	1.25	2.5

Correlation Level

- Slightly Low: 1
- Moderately (Medium): 2
- Substantially (Strong): 3

CO-PO-PSO Mapping Justification

- CO1: Builds foundational knowledge of engineering thermoplastics and nylons, supporting core polymer understanding (PO1, PO2) and application-oriented problem-solving.
- CO2: Strengthens understanding of polyesters and styrene copolymers, linking thermal, mechanical, and chemical properties to processing (PO1, PO2, PO3) and practical applications in polymer engineering (PSO1, PSO3).
- CO3: Provides insight into thermosetting polymers, curing mechanisms, and structure–property relationships, enhancing analytical skills (PO1–PO3) and applied problem-solving abilities (PSO1, PSO3).
- CO4: Focuses on processing methods, specialty and functionalized polymers, and high-performance polymers, promoting application of knowledge in design, processing, and industrial usage (PO1–PO3, PO4–PO5) while linking theory to practical engineering solutions (PSO1, PSO3).

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<tr><td>Year, Program, Semester</td><td colspan="7">S.Y. B. Tech in Plastics and Polymer Engineering, Semester-IV</td></tr>
<tr><td>Course Code</td><td colspan="7">PPE432</td></tr>
<tr><td>Course Category</td><td colspan="7">PCC (Professional Core Course)</td></tr>
<tr><td>Course title</td><td colspan="7">Polymer Testing</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td colspan="2">L</td><td>P</td><td>Total Contact Hours/ Week</td><td colspan="3">Total Credits</td></tr>
<tr><td colspan="2">02</td><td>-</td><td>02</td><td colspan="3">02</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td>ISE-I</td><td>ISE-II</td><td>ESE</td><td>TA</td><td>TW</td><td>PR/OR</td><td>Total</td></tr>
<tr><td>15</td><td>15</td><td>50</td><td>20</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="7">• Introduction to Polymer Engineering
• Polymeric Materials I</td></tr>
<tr><td>Course Objectives</td><td colspan="7">After the completion of the course, the student will be able to:
• Understand the fundamentals of polymer testing, standards, and specifications used for quality assurance and material evaluation in the polymer industry.
• Comprehend the principles of mechanical, thermal, permeation, electrical, chemical, optical, and flammability testing of polymeric materials.
• Relate polymer testing concepts to material structure, processing behavior, and end-use performance.
• Recognize appropriate polymer testing methods for evaluating polymer materials, plastic products, and sustainability aspects.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Enlist polymer testing standards, specifications, and the purpose of testing in polymer industries. (Remember)
• CO2: Explain the principles of mechanical, thermal, permeation, electrical, chemical, optical, and flammability testing of polymers. (Understand)
• CO3: Interpret polymer testing data to understand material behavior with respect to structure, processing, and end-use performance. (Understand)</td></tr>
</table>

	• CO4: Utilize polymer testing principles to select appropriate tests for polymer materials and plastic products in engineering applications. (Apply)

Unit No.	Course Content	Hours
I	**Introduction and Mechanical Testing of Polymers** Standards and specifications in polymer testing, need and role of polymer testing in industry, introduction to mechanical properties of polymers, tensile testing, flexural testing, compressive testing, impact strength testing, hardness testing, abrasion resistance, fatigue, creep and stress relaxation	4
II	**Thermal and Permeation Properties of Polymers** Thermal conductivity testing, coefficient of thermal expansion, heat deflection temperature, Vicat softening temperature, water vapor transmission rate testing, and gas transmission rate testing	4
III	**Electrical and Chemical Properties of Polymers** Dielectric strength testing, dielectric constant measurement, dissipation factor, surface resistivity, volume resistivity, arc resistance testing, immersion tests, stain resistance testing, environmental and solvent stress cracking resistance	4
IV	**Optical and Flammability Characteristics of Polymers** Refractive index measurement, luminous transmittance, haze measurement, gloss measurement, ignition properties and ignition temperature, limiting oxygen index testing, and UL 94 flammability classification	4
V	**Flow Behavior and Physicochemical Analysis of Polymers** Melt flow index testing, dilute solution viscosity methods for thermoplastics, cup viscometry for thermosetting polymers, rheological measurements using capillary, rotational and torque rheometers, density and specific gravity measurement, water absorption testing, moisture analysis, sieve analysis, melting point determination, and contact angle measurement	4
VI	**Product Testing and Biodegradation of Polymers** Introduction to plastic product testing, testing and evaluation of injection molded products, rotational molded products, blow molded products and extruded products, introduction to biodegradation of polymers, mechanisms of	4

	biodegradation, compostable polymers, biodegradable polymers, thermo-oxo- and photo-oxo-degradable polymers, standards and testing methods for biodegradability assessment	

Text Books	
1	Plastics Fundamentals, Properties, and Testing, Manas Chanda and Salil K. Roy, CRC Press, 1st Edition, 2008.
2	Practical Testing and Evaluation of Plastics, Achim Frick, Claudia Stern, Vibunanthan Muralidharan, Wiley-VCH, 1st Edition, 2019.
3	Handbook of Plastics Testing and Failure Analysis, Vishu Shah, John Wiley & Sons, 4th Edition, 2020.
Reference Books	
1	Polymer Testing, Wolfgang Grellmann and Sabine Seidler, Elsevier, 3rd Edition, 2022.
2	Handbook of Polymer Testing: Physical Methods, Roger Brown (Ed.), CRC Press, 1st Edition, 1999.
3	Plastic Materials and Processes: A Concise Guide, Vijay K. Stokes, William Andrew, 1st Edition, 2012.

Web Links and Video Lectures (E-Resources)

1. Polymer Testing (https://www.youtube.com/watch?v=vQMGfR__7M0)

Activity Based Learning (Suggested Activities in Class)

1. Flipped Classroom
2. Online Tools
3. Collaborative and Individual Problem based learning
4. Quizzes/Assignments/Activities

Mapping of Course Outcomes with Program Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	3	2	-	-	-	-	-	-	-	-	-	-
CO3	-	3	-	-	-	-	-	-	-	-	-	-
CO4	-	3	3	-	-	-	-	-	-	-	-	-
Average	**3**	**2.66**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

Mapping of Course Outcomes with Program Specific Outcomes

CO \ PSO	PSO1	PSO2	PSO3
CO1	3	-	-
CO2	3	-	-
CO3	2	-	-
CO4	2	-	-
Average	**2.5**	-	-

Correlation Level

- Slightly Low: 1
- Moderately (Medium): 2
- Substantially (Strong): 3

CO-PO-PSO Mapping Justification

- CO1 supports PO1 and PSO1 by enabling students to recall polymer testing standards, specifications, and industrial relevance, strengthening foundational knowledge in polymer science and testing practices.
- CO2 maps to PO1, PO2 and PSO1 as it builds conceptual understanding of testing principles across mechanical, thermal, electrical, and chemical domains, essential for material evaluation in polymer engineering.
- CO3 aligns with PO2 and PSO1 by developing the ability to interpret polymer testing data and relate it to structure–property–performance relationships in engineering applications.
- CO4 addresses PO2, PO3 and PSO1 by enabling students to apply polymer testing principles for selecting appropriate tests for materials and products in practical engineering scenarios.

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<tr><td>Course Code</td><td colspan="7">PPE433</td></tr>
<tr><td>Course Category</td><td colspan="7">PCC (Professional Core Course)</td></tr>
<tr><td>Course title</td><td colspan="7">Thermodynamics and Heat Transfer</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td colspan="2">L</td><td colspan="1">P</td><td>Total Contact Hours/ Week</td><td colspan="3">Total Credits</td></tr>
<tr><td colspan="2">03</td><td>-</td><td>03</td><td colspan="3">03</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td>ISE-I</td><td>ISE-II</td><td>ESE</td><td>TA</td><td>TW</td><td>PR/OR</td><td>Total</td></tr>
<tr><td>15</td><td>15</td><td>50</td><td>20</td><td>-</td><td>-</td><td>100</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="7">• Engineering Physics, Calculus-II, Calculus-III, Differential Equations</td></tr>
<tr><td>Course Objectives</td><td colspan="7">After completing this course, the students will be able to:
• Define and analyse thermodynamic systems relevant to polymer and plastics engineering.
• Apply laws of thermodynamics to evaluate energy interactions in polymer processing equipment.
• Understand phase behaviour and properties of pure substances and polymers.
• Analyse heat transfer mechanisms in plastics processing.
• Design and evaluate heat exchangers and thermal systems used in polymer industries.
• Introduce polymer thermodynamics concepts such as mixing, solution behaviour, and entropy.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Define thermodynamic systems, their laws, and their applications. (Remember)
• CO2: Interpret the properties of pure substances and their phase behavior. (Understand)
• CO3: Solve problems related to laws of thermodynamics systems, pure substances and their phase behaviour (Apply)
• CO4: Solve problems related to conductive, convective, and radiative</td></tr>
</table>

	heat transfer. (Apply) • CO5: Examine the role of heat exchangers and computational models in heat transfer operations. (Analyze)

Unit No.	Course Content	Hours
I	**Basic Thermodynamics and System Definition** Scope and importance of thermodynamics in plastics and polymer engineering, thermodynamic system, control mass, control volume, types of systems including closed, open and isolated systems, thermodynamic properties such as intensive, extensive and specific properties, state, path, process and cycle, thermal, mechanical and chemical equilibrium, Zeroth Law of Thermodynamics and temperature measurement, energy forms including kinetic, potential, internal and flow energy, engineering units and dimensional analysis.	6
II	**First and Second Laws of Thermodynamics** Energy balance for closed systems, Energy balance for steady-flow systems, Kelvin–Planck and Clausius statements, Heat engines, refrigerators, and heat pumps, Carnot cycle and efficiency, Entropy concept, Entropy balance for closed and open systems	6
III	**Properties of Pure Substances and Phase Behaviour** Pure substances and phase concept, Phase diagrams: P–T and T–V diagrams, Property relations and tables, Quality, saturation, superheated states, Equation of state (ideal and real fluids)	5
IV	**Heat Conduction** Modes of heat transfer, Fourier's law of heat conduction, One-dimensional steady-state conduction, Composite walls and thermal contact resistance, Cylindrical and spherical systems, Transient conduction concepts, Lumped system analysis, Introduction to numerical methods in heat conduction	5
V	**Convective and Radiation Heat Transfer** Newton's law of cooling, boundary layer concept, Forced and natural convection, dimensionless numbers: Reynolds, Prandtl, Nusselt, Grashoff, convective heat transfer in polymer melt flow and cooling channels, fundamentals of thermal radiation, black body, gray body, and real surfaces,	8

	Stefan–Boltzmann law, view factors and radiation exchange, radiation effects in polymer processing and heating ovens,	
VI	**Heat Exchangers & Computational Methods** Types of heat exchangers, LMTD and effectiveness–NTU methods, Heat exchanger applications in plastics processing, Introduction to numerical methods in heat transfer, overview of the use of computational tools for thermal analysis	6
	Text Books	
1	Y. A. Çengel & M. A. Boles, Thermodynamics: An Engineering *Approach*,9th Edition, McGraw-Hill Publication, New York, 2019	
2	P.K. Nag, Engineering Thermodynamics, 5th Edition, McGraw-Hill, New Delhi, 2013	
3	J.P. Holman, Heat Transfer, McGraw-Hill, New York, 10th Edition, 2009	
4	J H Lienhard, A Heat Transfer Textbook, Phlogiston Press, 2024	
	Reference Books	
1	Van Wylen, Sonntag & Borgnakke, Fundamentals of Classical Thermodynamics, 4th Edition, Wiley,2013	
2	Smith, J.M., Van Ness, H.C., and Abbott, M.M., Introduction to Chemical Engineering Thermodynamics, 5th Edition, McGraw-Hill, 2018	
3	Incropera, Dewitt, Fundamentals of Heat and Mass Transfer, 8th Edition, John Wiley & Sons (Asia) Pvt. Ltd., 2017	
4	Kreith, F., Manglik, R.M., and Bohn, M.S., Principles of Heat Transfer, 7th Edition, Cengage, 2011	

Web Links and Video Lectures (E-Resources)

NPTEL Lectures Videos:

- Engineering Thermodynamics, IIT Kanpur, Prof. D.P. Mishra https://nptel.ac.in/courses/101104063
- Thermodynamics, IIT Delhi, Prof. S.R. Kale, https://nptel.ac.in/courses/112102255
- Heat Transfer, IIT Guwahati, Prof. A.K. Ghoshal, https://nptel.ac.in/courses/103103031
- Heat Transfer, IIT Bombay, Prof. Ganesh Viswanathan, https://nptel.ac.in/courses/103101137

- Thermodynamics Concepts & Problems,
  https://www.youtube.com/playlist?list=PLD8E646BAB3366BC8

Introduction to Heat Transfer, https://www.youtube.com/watch?v=7Bj3N1E7vZk

Activity Based Learning (Suggested Activities in Class)

1. Chalk & Board + PPT
2. Numerical problem solving
3. Industrial application videos (extrusion, molding, cooling)
4. Flipped Classroom
5. Collaborative and Individual Problem

Mapping of Course Outcomes with Program Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	3	2	-	-	-	-	-	-	-	-
CO3	-	3	-	-	-	-	-	-	-	-	-	-
CO4	-	-	2	3	2	-	-	-	-	-	-	-
Average	3	3	2.5	2.5	2	-	-	-	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes

CO \ PSO	PSO1	PSO2	PSO3
CO1	3	-	-
CO2	-	3	-
CO3	3	-	-
CO4	2	2	2
Average	2.66	2.5	2

Correlation Level

- Slightly Low: 1
- Moderately (Medium): 2
- Substantially (Strong): 3

CO-PO-PSO Mapping Justification

- CO1 maps to PO1 and PSO1 by developing foundational understanding of thermodynamic principles relevant to polymer materials and systems.

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- CO2 aligns with PO3, PO4 and PSO2 through application of heat transfer principles to solve practical thermal problems in polymer processing equipment.
- CO3 supports PO2 and PSO1 by examining energy balances and entropy effects to analyze efficiency and performance of polymer processing systems.
- CO4 addresses PO3, PO4, PO5 and PSO1–PSO3 by assessing heat exchanger performance and thermal management strategies using analytical and basic computational approaches.

Year, Program, Semester	S.Y. B. Tech in Plastics and Polymer Engineering, Semester-IV						
Course Code	PPE434						
Course Category	PCC (Professional Core Course)						
Course title	**Plastics Recycling and Sustainability**						
Teaching Scheme and Credits	**L**	**P**	**Total Contact Hours/ Week**	**Total Credits**			
	03	-	03	03			
Evaluation Scheme	**ISE-I**	**ISE-II**	**ESE**	**TA**	**TW**	**PR/OR**	**Total**
	15	15	50	20	-	-	100
Pre-requisites (if any)	• Introduction to Organic and Polymer Chemistry • Introduction to Polymer Engineering • Polymeric Materials I						
Course Objectives	After completing this course, the students will be able to: • Understand the sources, composition, and environmental impact of plastic waste generation. • Learn the fundamentals of plastic recycling routes and waste management practices. Including recycling equipment and the processing behavior of recycled polymers. • Develop the ability to assess recycling applications and waste management tools for different plastic streams. • Understand sustainability frameworks, life cycle thinking, and circular economy concepts in polymers. • Appreciate environmental health aspects, degradation behavior, and standards related to sustainable plastics.						
Course Outcomes	• CO1: Identify sources, types, classification, and disposal routes of plastic waste along with fundamental recycling concepts. (Remember) • CO2: Explain plastic recycling processes, equipment, and the processing behavior of recycled polymers. (Understand) • CO3: Demonstrate the selection of suitable recycling techniques and waste management tools for different plastic products and waste streams. (Apply) • CO4: Examine the environmental impact of plastics using sustainability						

	frameworks, life cycle thinking, and material flow concepts. (Analyze) • CO5: Appraise circular economy strategies, extended producer responsibility models, and sustainable material options in the plastics sector. (Evaluate)

Unit No.	Course Content	Hours
I	**Plastic Waste Generation and Recycling Fundamentals** Global plastics production and composition, plastic waste generation and disposal routes, environmental impact and need for recycling, identification and classification of plastics for recycling, collection of plastic waste, sorting and segregation techniques, primary recycling, secondary recycling, tertiary recycling, quaternary recycling, landfilling	6
II	**Plastic Recycling Equipment and Processing Behaviour** Shredder, granulator, pulverizer, extruder, cutter, reactors for chemical recycling, mechanical and rheological behaviour of recycled plastics, processing of mixed plastic waste, additives for recycling of polymers	6
III	**Plastic Recycling Applications and Waste Management Tools** Recycling of PE/PP packaging films and woven sacks, recycling of PET bottles and films, recycling of multilayer packaging, recycling of PVC products, municipal solid waste collection and storage, transportation and disposal of MSW, sorting of MSW, primary and secondary collection vehicles and equipment, product stewardship, shared producer responsibility, extended producer responsibility, oxo-degradable plastics	6
IV	**Environmental Sustainability Framework for Plastics** Principles of environmental sustainability, environmental impact of polymers and plastics, role of plastics in sustainable development, environmental ethics in engineering practice, responsibility of polymer engineers towards environment, UN Sustainable Development Goals and relevance to plastics and polymer industry	6
V	**Life Cycle Thinking and Circular Design in Polymers** Life cycle thinking concepts, life cycle assessment stages and methodology, cradle-to-grave and cradle-to-cradle approaches, tools and indicators for environmental performance evaluation, material flow analysis in polymer systems.	6

	identification of environmental hotspots in polymer value chains, circular economy principles in plastics, closed-loop material systems, design for sustainability and recyclability, case examples of circular polymer products	
VI	**Sustainable Polymer Materials and Environmental Health Aspects** Polymer degradation and environmental persistence, toxicity of plastics and microplastics, additives and leachables in polymers, human and ecological health risks, bio-based and biodegradable plastics concepts, PLA, PHA and starch-based polymers, standards and certifications such as ASTM D6400 and EN 13432, applications and end-of-life scenarios of sustainable plastics, degradation pathways and composting conditions	6

Text Books	
1	Plastics Fabrication and Recycling, Manas Chanda and Salil K. Roy, CRC Press, 4th Edition, 2007.
2	Plastic Recycling & Waste Management by Er Alok Gupta, Dr Anupam Jain, Prof. Praveen Goswami, Dr. Vinod Kumar Jain, JSR Publishers; 1st Edition. 2023.
3	Recycling of Plastic Materials, Francesco Paolo La Mantia Chemtec Publishing, 2nd Edition, 1993
4	Management of municipal solid waste, T. V. Ramchandra, TERI Press, 1st, 2009.
5	Andrady, Anthony. Plastics and Environmental Sustainability. Wiley, Hoboken (2014). ISBN: 978-1-118-31260-5.
6	Introduction to Plastics Engineering, Vijay K. Stokes, Wiley, Hoboken, 2020
Reference Books	
1	Plastics and Sustainability: Towards a Peaceful Coexistence between Bio-based and Fossil Fuel-based Plastics, Michael Tolinski, Wiley-Scrivener, Hoboken, 2021
2	Feedstock Recycling and pyrolysis of waste plastics John Schiers & W. Kaminsky, John Wiley and Sons, 1st Edition, 2006
3	Recycling of Polymers, Raju Francis Wiley-VCH, 1st Edition, 2016
4	Introduction to Plastics Recycling, Vannessa Goodship, Smithers Rapra, 2nd Edition, 2006
Web Links and Video Lectures (E-Resources)	
1. Plastic Waste Management (https://onlinecourses.nptel.ac.in/noc20_ce13/preview)	

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2. Polymers: concepts, properties, uses and sustainability (https://www.youtube.com/playlist?list=PLyqSpQzTE6M_KQ5MqUkoOqAxxOrdvFOMB)

Activity Based Learning (Suggested Activities in Class)

1. Flipped Classroom
2. Online Tools
3. Collaborative and Individual Problem based learning
4. Quizzes/Assignments/Activities

Mapping of Course Outcomes with Program Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	-	2	-	-	-	-	-
CO2	2	2	-	-	2	-	-	-	-	-	-	-
CO3	2	3	-	2	3	-	-	-	-	-	-	-
CO4	-	2	-	3	-	-	3	-	-	-	-	-
CO5	-	2	-			-	3	-	-	-	-	2
Average	**2**	**2.25**	**-**	**2.5**	**2.5**	**-**	**2.67**	**-**	**-**	**-**	**-**	**2**

Mapping of Course Outcomes with Program Specific Outcomes

CO \ PSO	PSO1	PSO2	PSO3
CO1	3	-	-
CO2	3	2	1
CO3	2	3	2
CO4	3	-	1
CO5	3	-	2
Average	**2.8**	**2.5**	**1.5**

Correlation Level

- Slightly Low: 1
- Moderately (Medium): 2
- Substantially (Strong): 3

CO-PO-PSO Mapping Justification

- CO1: Mapped to PO1, PO7, PSO1 as it builds foundational knowledge of plastic waste, recycling concepts, and environmental sustainability in polymer engineering.
- CO2: Mapped to PO1, PO2, PO5, PSO1, PSO2 since it covers recycling processes, equipment, processing behavior, and use of modern polymer processing tools.

- CO3: Mapped to PO1, PO2, PO4, PO5, PSO1, PSO2, PSO3 through analysis and evaluation of recycling applications, waste management tools, and process-related challenges.
- CO4: Mapped to PO2, PO4, PO7, PSO1, PSO3 as it emphasizes life cycle assessment, sustainability frameworks, and environmental impact analysis of polymer systems.
- CO5: Mapped to PO2, PO7, PO12, PSO1, PSO3 by evaluating circular economy approaches, sustainable polymer materials, and emerging environmental standards.

Year, Program, Semester	S.Y. B. Tech in Plastics and Polymer Engineering, Semester-IV						
Course Code	HSMC421						
Course Category	PCC (Professional Core Course)						
Course title	**Introduction to Economics**						
Teaching Scheme and Credits	**L**		**P**	**Total Contact Hours/ Week**	**Total Credits**		
	02		-	02	02		
Evaluation Scheme	**ISE-I**	**ISE-II**	**ESE**	**TA**	**TW**	**PR/OR**	**Total**
	15	15	50	20	-	-	100
Pre-requisites (if any)	• Basic knowledge of mathematics, including arithmetic, graphs, and elementary algebra • Familiarity with fundamental concepts of plastics and polymer materials and their common applications • General awareness of manufacturing and industrial processes in engineering.						
Course Objectives	After completing this course, the students will be able to: • Understand fundamental economic principles relevant to engineering and industrial decision-making. • Analyse market behaviour, cost structures, and pricing mechanisms in manufacturing industries. • Apply microeconomic and macroeconomic concepts to polymers, plastics processing, and allied sectors. • Develop awareness of national and global economic systems, sustainability, and industrial policy. • Support managerial, entrepreneurial, and techno-economic decisions in engineering practice.						
Course Outcomes	• CO1: Describe fundamental economic concepts, economic systems, and the relevance of economics to engineering decision-making with specific reference to plastics and polymer industries. (Remember)						

	• CO2: Examine demand, supply, elasticity, and market equilibrium to understand market behavior of industrial and consumer polymer products. (Understand) • CO3: Evaluate production functions, cost behavior, and break-even conditions associated with polymer processing operations such as extrusion and injection molding. (Apply) • CO4: Differentiate market structures and pricing mechanisms to assess competitive behavior and pricing strategies of polymer raw material suppliers and plastic product manufacturers. (Analyze) • CO5: Relate macroeconomic indicators, government policies, time-resource allocation, and sustainability concepts to industrial growth, circular economy practices, and long-term development of the plastics and polymer sector. (Evaluate)

Unit No.	Course Content	Hours
I	**Introduction to Economics and Economic Systems** Meaning and scope of economics, Microeconomics vs. macroeconomics, Engineering economics vs. general economics, Scarcity, opportunity cost, Economic systems: Capitalist economy, Socialist economy, Mixed economy (Indian context), Role of economics in engineering, manufacturing, and industrial planning, Relevance of economics to plastics and polymer engineering	4
II	**Demand, Supply, and Elasticity** Concept of demand and law of demand, Factors affecting demand for industrial and consumer polymer products, Demand forecasting (qualitative overview), Supply and law of supply, Market equilibrium, Elasticity of demand: Price elasticity, Income elasticity	4
III	**Production and Cost Analysis** Concept of production function, Short-run and long-run production, Laws of returns, Cost concepts: Fixed, variable, and total cost, Average and marginal cost, Break-even analysis (introductory), Cost behaviour in plastics processing industries (extrusion, injection molding, etc.)	4

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IV	**Market Structures and Pricing** Perfect competition, Monopoly, Monopolistic competition, Oligopoly, Price determination under different market structures, Price discrimination (overview), Case illustrations from polymer raw material suppliers and plastic product manufacturers	4
V	**Introduction to Macroeconomics and Indian Economy** National income concepts (GDP, GNP, NDP – basic understanding), Inflation: causes and impact on manufacturing industries, Unemployment and industrial growth, Role of government in economic development, Industrial policy and economic reforms in India (overview), Impact of globalization on plastics and polymer industries, Introduction to sustainable development and circular economy	4
VI	**Time Management and Sustainability in Economics** Time as a scarce economic resource, Opportunity cost of time, Trade-off between leisure and work, Productivity and efficient time allocation, Time preference and economic decision-making, Sustainable development, Efficient use of natural resources, Role of government in promoting sustainability.	4
	Text Books	
1	K. K. Dewett & Navalur, Modern Economic Theory, S. Chand & Company.	
2	H. L. Ahuja, Principles of Microeconomics, S. Chand & Company.	
	Reference Books	
1	Principles of Economics, N. Gregory Mankiw, Cengage Learning, 8th Edition, 2018.	
2	Economics, Paul A. Samuelson and William D. Nordhaus, McGraw-Hill Education, 19th Edition, 2010.	
3	Microeconomics, Robert S. Pindyck and Daniel L. Rubinfeld, Pearson Education, 9th Edition, 2018.	
4	Indian Economy, Ruddar Datt and K. P. M. Sundharam, S. Chand Publishing, 66th Edition, 2019.	
5	Economic Survey of India, Government of India, Ministry of Finance, Latest Edition (2024–25).	
	Web Links and Video Lectures (E-Resources)	

- Youtube
- Every Major Economic Theory Explained in 20 minutes
- Economics for Engineers
- How do we create a better economy?
- The Future of Work: High Paying Careers that AI won't Replace

Activity Based Learning (Suggested Activities in Class)

- Chalk & talk with real-life industrial examples
- Case studies from plastics and polymer industries
- Short numerical illustrations
- Group discussion on current economic issues
- Use of charts, economic data, and policy documents

Mapping of Course Outcomes with Program Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	2	3	-	-	-	-	-	-	-	-	-	-
CO3	2	3	-	-	-	-	-	-	-	-	-	-
CO4	2	3	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	2	3	-	-	-	-	2
Average	**2.25**	**3**	**-**	**-**	**-**	**2**	**3**	**-**	**-**	**-**	**-**	**2**

Mapping of Course Outcomes with Program Specific Outcomes

CO \ PSO	PSO1	PSO2	PSO3
CO1	3	-	-
CO2	3	-	-
CO3	2	2	3
CO4	2	-	2
CO5	3	-	2
Average	**2.6**	**2**	**2.33**

Correlation Level

- Slightly Low: 1
- Moderately (Medium): 2
- Substantially (Strong): 3

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CO-PO-PSO Mapping Justification

- CO1: Builds foundational economic understanding required for engineering decision-making in polymer industries, supporting PO1, PO2 and PSO1 through core knowledge application.
- CO2: Enables analysis of market behavior and demand–supply dynamics for polymer products, strengthening PO1, PO2 and PSO1 by applying problem analysis skills relevant to polymer engineering.
- CO3: Connects economic cost and production analysis with polymer processing operations, supporting PO1, PO2 and PSO1, PSO2, PSO3 by interpreting economic and operational data for informed decisions.
- CO4: Assists in evaluating market structures and pricing strategies in polymer industries, linking PO1, PO2 and PSO1, PSO3 to economic reasoning and industrial competitiveness.
- CO5: Addresses sustainability, policy, and resource allocation aspects, aligning PO6, PO7, PO12 and PSO1, PSO3 with societal responsibility, environmental sustainability, and circular economy concepts.

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<table>
<tr><td>Year, Program, Semester</td><td colspan="7">S.Y. B. Tech in Plastics and Polymer Engineering, Semester-IV</td></tr>
<tr><td>Course Code</td><td colspan="7">PPE433</td></tr>
<tr><td>Course Category</td><td colspan="7">PCC (Professional Core Course)</td></tr>
<tr><td>Course title</td><td colspan="7">Thermodynamics and Heat Transfer (Laboratory)</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Total Contact Hours</td><td colspan="3">Total Credits</td></tr>
<tr><td>-</td><td>-</td><td>2</td><td>2</td><td colspan="3">1</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td>ISE-I</td><td>ISE-II</td><td>ESE</td><td>TA</td><td>TW</td><td>PR/OR</td><td>Total</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>25</td><td>25</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="7">• Engineering Physics, Calculus-III</td></tr>
<tr><td>Course Objectives</td><td colspan="7">After completing this course, the students will be able to:
• Define and analyse thermodynamic systems relevant to polymer and plastics engineering.
• Apply laws of thermodynamics to evaluate energy interactions in polymer processing equipment.
• Understand phase behaviour and properties of pure substances and polymers.
• Analyse heat transfer mechanisms in plastics processing.
• Design and evaluate heat exchangers and thermal systems used in polymer industries.
• Introduce polymer thermodynamics concepts such as mixing, solution behaviour, and entropy.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Perform experiments to determine thermal properties such as conductivity, heat transfer coefficient, and emissivity for solids, fluids, and composite systems using standard laboratory equipment. (Apply)
• CO2: Analyze convective, conductive, and radiative heat transfer phenomena in different polymer processing and experimental setups to understand heat transfer mechanisms. (Analyze)
• CO3: Evaluate energy and entropy changes in polymer processing systems such as extruders and molds to correlate theoretical</td></tr>
</table>

	predictions with practical measurements. (Analyze) • CO4: Demonstrate proper laboratory practices including equipment handling, data acquisition, safety, and systematic documentation of experiments, including journal writing and viva-voce. (Evaluate)

Sr. No.	Name of Experiment	Hours
I	Determination of Thermal Conductivity of given bar at various temperatures	2
II	Measurement of emissivity of non-black surface over a range of temperatures	2
III	Determination of Thermal Conductivity of Insulating Powder	2
IV	Determine the rate of heat transfer through different layers of composite wall	2
V	Determination of Stefan - Boltzmann Constant	2
VI	Determination of heat transfer coefficient for inner and outer surface of tubes. Study of variation of heat transfer coefficient with the type of flow	2
VII	To study of temperature distribution along the length of fin in both natural & forced convections	2
VIII	To find out heat transfer co-efficient of drop wise and film wise condensation at various flow rates of water	2
IX	To study the polymer processing line, identify the system boundaries, and analyze energy input and output.	2
X	To examine the extrusion process, measure temperatures and energy, and calculate energy changes and entropy.	2
XI	To measure temperature distribution across mold walls and calculate heat flux and thermal resistance.	2
XII	To study the cooling of a heated polymer sheet under convection and radiation, measure surface temperatures, and calculate heat transfer coefficients.	2

Reference Books	
1	Y. A. Çengel & M. A. Boles, Thermodynamics: An Engineering Approach,9th Edition, McGraw-Hill Publication, New York, 2019
2	P.K. Nag, Engineering Thermodynamics, 5th Edition, McGraw-Hill, New Delhi, 2013
3	J.P. Holman, Heat Transfer, McGraw-Hill, New York, 10th Edition, 2009

4	J H Lienhard, A Heat Transfer Textbook, Phlogiston Press, 2024
5	Van Wylen, Sonntag & Borgnakke, *Fundamentals of Classical Thermodynamics*, 4th Edition, Wiley,2013
6	Smith, J.M., Van Ness, H.C., and Abbott, M.M., Introduction to Chemical Engineering Thermodynamics, 5th Edition, McGraw-Hill, 2018
7	Incropera, Dewitt, Fundamentals of Heat and Mass Transfer, 8th Edition, John Wiley & Sons (Asia) Pvt. Ltd., 2017
8	Kreith, F., Manglik, R.M., and Bohn, M.S., Principles of Heat Transfer, 7th Edition, Cengage, 2011

Mapping of Course Outcomes with Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	2	-	-	-	-	1	-	-	1	-	2
CO 2	3	3	2	2	-	-	2	-	-	2	-	2
CO 3	3	3	2	2	2	-	2	1	-	2	-	2
CO 4	2	-	-	-	-	-	-	3	3	2	-	3
Avg.	**2.75**	**2.33**	**2**	**2**	**2**	**-**	**1.66**	**2**	**3**	**1.75**	**-**	**2.25**

Mapping of Course Outcomes with Program Specific Outcomes

COs	PSO1	PSO2	PSO3
CO1	3	2	-
CO2	3	3	2
CO3	3	3	2
CO4	2	2	-
Avg.	**2.75**	**2.5**	**2**

Correlation Level

Slightly Low: 1

Moderately (Medium): 2

Substantially (Strong): 3

CO-PO-PSO Mapping Justification

- CO1: Builds practical competence in applying thermodynamic and heat transfer principles to polymer systems, supporting core engineering knowledge (PO1), problem analysis (PO2), use of modern tools (PO5), and effective communication/documentation (PO10), while reinforcing fundamental polymer science and laboratory skills (PSO1, PSO2).

- CO2: Enhances the ability to analyze conductive, convective, and radiative heat transfer phenomena, strengthening problem-solving and system analysis skills (PO2, PO3, PO4), promoting environmental awareness and thermal efficiency considerations (PO7), and linking experimental interpretation with polymer processing and process design (PSO1, PSO2, PSO3).
- CO3: Facilitates evaluation of energy, entropy, and thermal performance in polymer processing equipment, connecting theoretical thermodynamic principles with real-world system analysis (PO1, PO2, PO3, PO4), emphasizing sustainability and responsible engineering practice (PO7, PO8), and supporting polymer process design and development competencies (PSO1, PSO2, PSO3).
- CO4: Promotes professional laboratory practices, safety, equipment handling, and systematic documentation (PO8, PO9, PO10, PO12), fostering ethical and responsible conduct, teamwork, and lifelong learning habits in practical polymer engineering contexts (PSO1, PSO2).

<table>
<tr><td>Year, Program, Semester</td><td colspan="7">S.Y. B. Tech in Plastics and Polymer Engineering, Semester-IV</td></tr>
<tr><td>Course Code</td><td colspan="7">PPE492</td></tr>
<tr><td>Course Category</td><td colspan="7">PCC (Professional Core Course)</td></tr>
<tr><td>Course title</td><td colspan="7">Plastics Process Engineering – I (Laboratory)</td></tr>
<tr><td rowspan="2">Teaching Scheme and Credits</td><td>L</td><td>T</td><td>P</td><td>Total Contact Hours</td><td colspan="3">Total Credits</td></tr>
<tr><td>-</td><td>-</td><td>2</td><td>2</td><td colspan="3">1</td></tr>
<tr><td rowspan="2">Evaluation Scheme</td><td>ISE-I</td><td>ISE-II</td><td>ESE</td><td>TA</td><td>TW</td><td>PR/OR</td><td>Total</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>-</td><td>25</td><td>-</td><td>25</td></tr>
<tr><td>Pre-requisites (if any)</td><td colspan="7">• Materials Science and Engineering/IOPC
• Polymeric Materials I</td></tr>
<tr><td>Course Objectives</td><td colspan="7">Student should be able to:
• Perform standard mechanical, physical, thermal, and rheological tests on polymer samples using appropriate testing instruments and procedures.
• Record, analyze, and interpret experimental data obtained from polymer testing experiments through systematic laboratory documentation and viva-voce.
• Demonstrate safe laboratory practices, proper equipment handling, and professional conduct during experimental work and assessments.</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Carry out standard mechanical tests such as tensile, flexural, compressive, and impact testing on polymer samples in accordance with relevant ASTM/ISO standards. (Apply)
• CO2: Measure and report physical, thermal, and rheological properties of polymers including density, bulk density, moisture content, melt flow index, heat deflection temperature, and volatile content using appropriate laboratory equipment. (Apply)
• CO3: Interpret experimental results to correlate polymer structure and composition with observed mechanical, thermal, and processing behavior. (Analyze)</td></tr>
</table>

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	CO4: Demonstrate proper laboratory practices, safety procedures, equipment handling, and systematic documentation through laboratory journals and viva-voce. (Evaluate)

Sr. No.	Name of Experiment	Hours
I	To determine the tensile strength of a given polymer sample	2
II	To determine the flexural strength of a given polymer sample	2
III	To determine the compressive strength of a given polymer sample/product.	2
IV	To determine the izod/charpy impact strength of a given polymer sample	2
V	To determine the dart impact strength of a given polymeric film sample	2
VI	To determine the melt flow index of given polymer sample	2
VII	To determine the density of given polymer sample	2
VIII	To determine the apparent density of given polymer sample	2
IX	To determine the moisture content of given polymer sample	2
X	To determine the heat deflection temperature and vicat softening temperature of given polymer sample	2

Reference Books	
1	Handbook of Polymer Testing: Physical Methods by Roger Brown, CRC Press, 1st Edition, 1999
2	Polymer Testing by Wolfgang Grellmann and Sabine Seidler, Hanser, 3rd Edition, 2022
3	Handbook of Plastics Testing and Failure Analysis, Vishu Shah, Wiley, 4th Edition, 2020.
4	Practical Testing and Evaluation of Plastics, Achim Frick, Claudia Stern, Vibunanthan Muralidharan, Wiley, 1st Edition, 2018

Mapping of Course Outcomes with Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	2	-	-	-	-	-	-	-	-	-	-
CO 2	2	3	-	-	-	-	-	-	-	-	-	-
CO 3	3	2	-	-	-	-	-	-	-	-	-	-
CO 4	-	-	3	-	-	-	-	-	-	-	-	-
Avg.	2.66	2.33	3	-	-	-	-	-	-	-	-	-

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Mapping of Course Outcomes with Program Specific Outcomes

COs	PSO1	PSO2	PSO3
CO1	3	2	-
CO2	2	3	-
CO3	3	2	-
CO4	2	1	-
Avg.	**2.5**	**2**	**-**

Correlation Level

Slightly Low: 1

Moderately (Medium): 2

Substantially (Strong): 3

CO-PO-PSO Mapping Justification

- CO1: Maps to PO1 and PO2 by applying fundamental polymer science knowledge and standard testing tools, and aligns with PSO1 and PSO2 through hands-on evaluation of mechanical performance.
- CO2: Supports PO1 and PO2 by applying laboratory techniques for property measurement and reporting, and contributes to PSO1 and PSO2 through use of polymer characterization equipment.
- CO3: Addresses PO1 and PO2 by analyzing experimental data to relate polymer structure with performance, supporting PSO1 and PSO2 via scientific interpretation of test results.
- CO4: Maps to PO4 by emphasizing safety, ethics, and professional conduct, and supports PSO1 and PSO2 through disciplined laboratory practices and systematic documentation.

Year, Program, Semester	S.Y. B. Tech in Plastics and Polymer Engineering, Semester-IV						
Course Code	PSI461						
Course Category	PSI (Project Seminar Internship)						
Course title	**Minor Project - I (Laboratory)**						
Teaching Scheme and Credits	**L**	**T**	**P**	**Total Contact Hours/Week**	**Total Credits**		
	-	-	4	4	02		
Evaluation Scheme	**ISE-I**	**ISE-II**	**ESE**	**TA**	**TW**	**PR/OR**	**Total**
	-	-	-	-	25	25	50
Pre-requisites (if any)	Seminar and Basics of Plastics and Polymer Engineering						
Course Objectives	After the completion of the course, the students should be able: • To convert literature-based understanding into practical project work • To identify and define a clear problem statement based on real-world or research challenges • To plan and initiate experimental or analytical work systematically • To develop teamwork, documentation, and technical communication skills						
Course Outcomes	• CO1: Identify a relevant engineering problem in the field of polymers, plastics, or allied domains based on prior literature review, seminar outcomes, and practical considerations. (Remember) • CO2: Formulate clear project objectives, scope, constraints, and a feasible project plan including methodology, resources, and timeline for addressing the identified problem. (Understand) • CO3: Implement the proposed methodology through preliminary experimental work, simulations, design iterations, or analytical studies using appropriate tools, equipment, or software. (Apply) • CO4: Analyze initial results, observations, and challenges by						

	applying fundamental engineering and scientific principles, and refine the approach based on findings. (Analyze) • CO5: Communicate project progress and preliminary outcomes effectively through technical reports, project logbooks, PowerPoint presentations, and poster presentations following standard professional and ethical practices. (Evaluate)

Guidelines and Rubrics

Minor Project I shall focus on exploratory, foundational-level work rather than full-scale product development or advanced research. The project should aim at understanding, applying, and documenting basic engineering principles through limited-scope implementation. Students are expected to demonstrate systematic methodology and technical reasoning, not complete industrial-scale validation.

The following categories are indicative and not exhaustive:

A. Experimental / Laboratory-Based Projects (Basic Level)

Students may undertake:

- Preparation of a polymer blend or composite with limited formulation variables
- Evaluation of one or two key properties (mechanical, thermal, electrical, or physical)
- Study of processing parameter influence on a molded product
- Basic material characterization and reporting

Examples:

- Preparation of a PP/LDPE blend and tensile property comparison
- Effect of plasticizer concentration on flexibility of PVC
- Study of curing temperature influence on rubber hardness
- Comparison of recycled vs virgin polymer properties

B. Computational / Simulation-Based Projects (Introductory Level)

Students may:

- Perform basic simulation studies using available software (e.g., flow simulation, CAD-based stress analysis)
- Conduct parameter variation studies
- Validate simulation trends using literature data

Examples:

- Mold flow analysis of a simple injection molded component
- Stress distribution analysis of a plastic bracket using softwares
- Cooling time estimation for different wall thicknesses

C. Analytical / Literature-Based Projects (Structured Review Level)

Projects may involve:

- Structured literature survey with analytical comparison
- Lifecycle assessment (basic LCA framework, not advanced modelling)
- Comparative sustainability analysis of two materials
- Standards comparison and interpretation

Examples:

- Basic Life Cycle Assessment of PET bottle vs glass bottle (using secondary data)
- Comparative study of biodegradable plastics
- Review and technical comparison of flame-retardant systems in polymers

D. Design-Oriented Projects (Conceptual Level)

Students may:

- Develop a concept-level product design
- Perform material selection using standard databases
- Prepare design drawings and justification

Examples:

- Material selection for automotive interior component
- Design of reusable polymer packaging concept
- Development of eco-friendly carry bag design concept

Clearly Defined Boundary for Minor Project I

To ensure appropriate scope:

- The project should not require advanced instrumentation beyond routine laboratory access
- No extensive statistical optimization is expected
- No mandatory publication-level novelty is required
- Work should be executable within one semester with the available in-house resources.
- Emphasis should be on methodology, understanding, documentation, and structured execution

Minor Project I focuses on:

- Learning how to plan and execute a project
- Applying engineering fundamentals
- Collecting and interpreting limited data
- Developing structured technical documentation

The outcomes of Minor Project I may serve as the foundation for Minor Project II, where advanced depth, optimization, or full-scale implementation can be pursued.

A group of 4–5 students will work under the guidance of a faculty mentor. Continuous evaluation will be carried out to assess progress, technical understanding, and teamwork.

The course content and its activities include, but is not limited to:

1. Problem Identification and Project Planning
   - Refinement of topic finalized during Seminar
   - Clear problem statement formulation
   - Definition of objectives, scope, and constraints
   - Work breakdown and timeline planning
2. Methodology Development
   - Selection of materials, tools, equipment, or software
   - Experimental design or analytical framework
   - Identification of variables, parameters, and evaluation criteria
   - Safety and feasibility considerations
3. Preliminary Implementation
   - Initial trials, experiments, simulations, or design iterations
   - Data collection and observation
   - Identification of practical challenges and limitations
   - Iterative refinement of approach
4. Progress Review and Documentation
   - Regular mentor meetings and progress reporting
   - Maintenance of project logbook
   - Interim documentation of results and learnings

The assessment for Minor Project I will be based on continuous evaluation during ISE I, ISE II, and ESE based on the mentioned rubrics.

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Component	Marks	Assessment Method
Project Proposal and Planning	10%	Faculty evaluation of problem statement clarity, defined objectives and scope, methodology feasibility, and quality of project planning.
Implementation Progress	20%	Continuous assessment of work execution, use of tools and techniques, adherence to methodology, problem-solving ability, and individual and group contribution.
Technical Understanding	30%	Evaluation of conceptual understanding, justification of methods or design choices, application of engineering principles, and linkage between literature and practical work.
Presentation	20%	Rubric-based assessment of PowerPoint and poster presentations focusing on structure, clarity, visuals, communication, time management, and responses to questions.
Report	20%	Assessment of the project report based on content structure, methodology, results and discussion, conclusions, formatting, referencing, language quality, and originality within prescribed plagiarism limits.

Information Sources	
1	Scopus: A large abstract and citation database that covers a wide range of subjects, including chemistry, physics, engineering, and materials science.
2	Web of Science: Another significant bibliographic database with multidisciplinary coverage across sciences, social sciences, and arts & humanities.
3	ScienceDirect: A leading platform for millions of academic articles published by Elsevier, with a strong focus on scientific and technical content.
4	Google Scholar: A freely accessible web search engine that indexes a broad range of scholarly literature, including journal articles, theses, books, and abstracts from various publishers.

Mapping of Course Outcomes with Program Outcomes

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	2	1	-	-	-	-	-	-	-	2	-	-
CO 2	1	-	-	-	-	-	-	2	-	3	-	-
CO 3	-	2	-	2	-	-	-	-	-	3	-	-
CO 4	-	3	-	-	-	-	-	-	2	2	-	-
Avg.	1.5	2.33	-	2	2	-	-	2	2	2.5	-	-

Mapping of Course Outcomes with Program Specific Outcomes

CO/PSO	PSO 1	PSO 2	PSO 3
CO 1	-	2	2
CO 2	-	-	3
CO 3	-	2	3
CO 4	-	3	2
Avg.	-	2.33	2.5

Correlation Level

- Slightly Low: 1
- Moderately (Medium): 2
- Substantially (Strong): 3

CO-PO-PSO Mapping Justification

- CO1: PO2, PO10; PSO2, PSO3

  Introduces students to the structure and purpose of scientific seminars, enabling them to recognize credible literature sources and effectively present domain-specific knowledge.
- CO2: PO8, PO9, PO10; PSO3

  Builds understanding of research documentation, citation ethics, and plagiarism, fostering responsible scientific writing and communication in polymer-related work.
- CO3: PO2, PO4, PO9; PSO2, PSO3

  Develops the ability to independently gather, organize, and apply literature review techniques for relevant polymer engineering topics.
- CO4: PO2, PO4, PO10; PSO2, PSO3

  Trains students to critically analyze scientific papers to identify research gaps and methodologies, strengthening investigative and technical reporting skills in polymer science.

Year, Program, Semester	S.Y. B. Tech in Plastics and Polymer Engineering, Semester-IV						
Course Code	HSSM421						
Course Category	HSSM (Humanities and Social Sciences including Management Course)						
Course title	**Technical and Scientific Writing (Mandatory Non-Credit Course)**						
Teaching Scheme and Credits	**L**	**P**		**Total Contact Hours/ Week**	**Total Credits**		
	02	-		02	-		
Evaluation Scheme	**ISE-I**	**ISE-II**	**ESE**	**TA**	**TW**	**PR/OR**	**Total**
	-	-	-	-	-	-	-
Pre-requisites (if any)	• Professional Communication and basic knowledge of Polymers						
Course Objectives	• Encourage student to work on scientific writing from an early stage of their career • Adapt writing for different audiences and purposes • To develop the skills and intricacies of scientific and technical writing to the students, enabling them to create technical documents that are clear, concise, consistent, and effective, in accordance with internationally recognized standards. • The course will assist in analyzing the student's knowledge and skills in technical writing • Empower students to develop writing abilities for their lifelong learning process.						
Course Outcomes	• CO1: Identify the purpose, audience, and structure of technical and scientific documents, and recognize the stages of effective scientific writing (Remember) • CO2: Select relevant literature, research articles, and sources to support technical arguments and research objectives (Understand) • CO3: Draft clear, coherent, and well-structured technical and scientific documents including methodology, results, and discussion sections, using proper language and formatting conventions (Apply)						

	• CO4: Revise, edit, and improve technical manuscripts by applying peer review feedback, addressing logical and stylistic issues, and ensuring academic integrity (Analyze)

Unit No.	Course Content	Hours
I	**Introduction to Technical and Scientific Writing** Understanding the purpose and scope of technical and scientific writing, identifying the audience and the context of communication, overview of scientific communities and their communication norms, stages of writing: planning, drafting, revising, and editing, recognizing different types of scientific documents (reports, papers, proposals)	6
II	**Finding and Selecting Relevant Literature** Techniques for conducting literature surveys, finding and selecting high-quality research and review papers, assessing relevance and credibility of sources, understanding how existing literature informs research questions, organizing references and notes for easy retrieval	6
III	**Reading Technical and Scientific Papers** Differentiating between review papers, research papers, and technical reports, reading for detail versus reading for main ideas, extracting key points, interpreting figures and tables, identifying gaps in knowledge, creating an outline and organizing arguments, critical analysis for shaping your own research	6
IV	**Writing Methodology and Results** Selecting precise and appropriate language for scientific writing, drafting methodology and experimental procedures, reporting quantitative and qualitative data clearly, structuring results and discussion sections, using tables, graphs, and figures effectively, connecting results to research objectives and literature	6
V	**Citations, References, and Academic Ethics** Understanding plagiarism and maintaining academic integrity, correct citation and reference formatting styles (e.g., APA, IEEE, Harvard), acknowledging sources properly, revising mistakes and logical fallacies, ethical considerations	6

	in publishing, choosing a suitable journal for submission, and using citation management tools	
VI	**Revision, Editing, and Peer Review** Macro vs. micro revision strategies, addressing reviewer comments and feedback, improving clarity, coherence, and readability, proofreading for grammar, punctuation, and formatting, participating in peer review to refine writing quality, iterative improvement of drafts before final submission	6

Text Books

1	Michael Alley, The Craft of Scientific Writing, Springer-Verlag, New York, 3rd Ed., 2009.
2	University of Illinois at Chicago Library, Measuring Your Impact: Impact Factor, Citation Analysis, and Other Metrics, www.researchguides.uic.edu.
3	Gerald. J. Alred, Charles. T. Brusaw and Walter. E. Oliu, Handbook of Technical Writing, St. Martin's Press, New York, Ninth Ed., 2008

Reference Books

1	Riordan, D. G., Technical Communication, Cengage Learning India Pvt. Ltd., New Delhi., 2005
2	Leslie. C. Perelman, James. Paradis, and Edward. Barrett, The Mayfield Handbook of Technical and Scientific Writing, Mayfield Publishing (ed.), 1998

Web Links and Video Lectures (E-Resources)

Research Writing by Prof. Aradhna Malik, Indian Institute of Technology Kharagpur.
https://nptel.ac.in/courses/110105091

Activity Based Learning (Suggested Activities in Class)

1. Flipped Classroom
2. Online Tools
3. Collaborative and Individual Problem based learning
4. Quizzes/Assignments/Activities

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Mapping of Course Outcomes with Program Outcomes

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	-	-	-	-	-	-	-	-	-
CO2	3	3	2	1	-	-	-	-	-	-	-	-
CO3	3	3	3	2	1	-	-	-	-	-	-	-
CO4	3	3	3	2	2	-	-	-	-	-	-	-
Average	3	2.75	2.5	1.67	1	-	-	-	-	-	-	-

Mapping of Course Outcomes with Program Specific Outcomes

CO \ PSO	PSO1	PSO2	PSO3
CO1	3	2	-
CO2	3	2	-
CO3	3	3	-
CO4	3	3	-
Average	3	2.5	-

Correlation Level

- Slightly Low: 1
- Moderately (Medium): 2
- Substantially (Strong): 3

CO-PO-PSO Mapping Justification

- CO1: Builds foundational understanding of technical and scientific writing, identifying audience, structure, and process, supporting problem-solving, communication, and program fundamentals.
- CO2: Enables students to select relevant literature and sources, developing analytical skills and critical thinking required for engineering research and project-based applications.
- CO3: Strengthens ability to draft clear and structured scientific documents, linking technical communication skills with practical engineering and analytical tasks in polymer, plastics, or allied domains.
- CO4: Develops skills to revise, edit, and improve manuscripts by addressing feedback and ensuring integrity, aligning communication competency with professional and ethical responsibilities in engineering practice.

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