SEMESTER WISE COURSE STRUCTURE & EVALUATION SCHEME

for

M. TECH. DEGREE PROGRAMME
IN
CHEMICAL TECHNOLOGY PLASTIC TECHNOLOGY
(Effective from the session 2023-24)

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.

HARCOURT BULTER TECHNICAL UNIVERSITY KANPUR
SCHOOL OF CHEMICAL TECHNOLOGY
DEPARTMENT OF CHEMICAL TECHNOLOGY (PLASTIC TECHNOLOGY)
Semester wise Course Structure
M. Tech. Chemical Technology (Plastic Technology)

(Applicable from Session 2023-2024 for new entrants)
Year I, Semester I

(A Stream Only for students having B. Tech. in Plastic Technology background)
(B Stream Only for students having B. Tech. in other than Plastic Technology background)
(C Stream Only for students of M.Sc. (Chemistry/Applied Chemistry /Industrial Chemistry) background)

Stream A

Sr. No.	Course Type	Subject Code	Course Title	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PCC	NPL 501	Advanced Polymer Chemistry	4	3	0	2	15	20	15	50	50	100
2.	PCC	NCH 503	Advanced Chemical Reaction Engineering	4	3	1	0	30	20	-	50	50	100
3.	PCC	NPL 505	Advanced Polymer Processing	4	3	1	0	30	20	-	50	50	100
4.	PEC	NCH 507 NPL 509	Artificial Intelligence in Chemical Engineering Advanced Polymer Composites	4	3	1	0	30	20	-	50	50	100
		Total		**16**	**12**	**3**	**2**				**200**	**200**	**400**

OR

Stream B/C

Sr. No.	Course Type	Subject Code	Course Title	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PCC	NPL 513	Polymer Processing	4	3	1	0	30	20	-	50	50	100
2.	PCC	NPL 515	High Polymer Chemistry	4	3	0	2	15	20	15	50	50	100
3	PCC	NPL 517	Polymer Rheology	4	3	1	0	30	20	-	50	50	100
3.	PEC	NPL 519 NCH 513	Polymer Additives and Compounding Instrumental Methods of Analysis	4	3	1	0	30	20	-	50	50	100
		Total		**16**	**12**	**3**	**2**				**200**	**200**	**400**

*Only for students of Non-mathematics background at graduation level

HARCOURT BULTER TECHNICAL UNIVERSITY KANPUR
SCHOOL OF CHEMICAL TECHNOLOGY
DEPARTMENT OF CHEMICAL TECHNOLOGY (PLASTIC TECHNOLOGY)
Semester wise Course Structure
M. Tech. Chemical Technology (Plastic Technology)

(Applicable from Session 2023-2024 for new entrants)

Year I, Semester II

Sr. No.	Course Type	Subject Code	Course Title	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PCC	NPL 502	Advanced Polymerization Engineering	4	3	1	0	30	20	-	50	50	100
2.	PCC	NPL 504	Advanced Plastic Product and Mould Design	4	3	1	0	30	20	-	50	50	100
3.	PCC	NPL 506	Polymer Testing and Characterization	4	3	0	2	15	20	15	50	50	100
4.	PEC	NCH 508 NPL 510 NPL 512	Statistical Design of Experiments Advanced Rubber Technology Structure–property relationship in Polymers	4	3	1	0	30	20	-	50	50	100
		Total		**16**	**12**	**3**	**2**				**200**	**200**	**400**

Industrial Training / Minor Project (during vacation after completion of first year)

HARCOURT BULTER TECHNICAL UNIVERSITY KANPUR
SCHOOL OF CHEMICAL TECHNOLOGY
DEPARTMENT OF CHEMICAL TECHNOLOGY (PLASTIC TECHNOLOGY)
Semester wise Course Structure
M. Tech. Chemical Technology (Plastic Technology)

(Applicable from Session 2024-2025 for new entrants)

Year II, Semester III

Sl. No.	Course Type	Subject Code	Course Title	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PEC	NPL 601 NPL 603	Technology of Waste Management Technology of Polymer Blends & Alloys	4	3	1	0	30	20	-	50	50	100
2.	OEC	OPL 601	Advanced Polymer Materials	3	3	0	0	30	20	-	50	50	100
3.	Seminar	NPL 605	Seminar	1	0	0	2	-	50	-	50	50	100
4.	Dissertation/ Project	NPL 607	*Dissertation/ Project I	8	0	0	16	-	50	-	50	50	100
		Total		**16**	**6**	**1**	**18**	**-**			**200**	**200**	**400**

*Dissertation to be continued in fourth semester.

HARCOURT BULTER TECHNICAL UNIVERSITY KANPUR
SCHOOL OF CHEMICAL TECHNOLOGY
DEPARTMENT OF CHEMICAL TECHNOLOGY (PLASTIC TECHNOLOGY)
Semester wise Course Structure
M. Tech. Chemical Technology (Plastic Technology)

(Applicable from Session 2024-2025 for new entrants)

Year II, Semester IV

Sl. No.	Course Type	Subject Code	Course Title	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	Dissertation/ Project	NPL 602	Dissertation/ Project II	16	0	0	32	-	50	-	50	50	100
		Total		**16**	**0**	**0**	**32**	**-**			50	50	100
Total credits				**64**	**30**	**08**	**52**				650	650	1300

Year I, Semester II

(Applicable from session 2023-24 for new entrants)

NPL 501 ADVANCED POLYMER CHEMISTRY

L	T	P	C
3	1	2	5

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

- To understand Step polymerization and their kinetics
- To understand Ionic & Ring Opening Polymerizations
- To understand new complex and Catalytic polymerization.
- To analyze polymerization reaction kinetics.
- To understand the copolymerization and Polymer modifications.

Course Outcome

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

CO1	Understand the fundamentals of Step polymerization and their kinetics.	Understand
CO2	Understand Ionic & Ring Opening Polymerizations and it's 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)

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

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

Detailed Syllabus

Unit 1: Synthesis by step-growth polymerizations

Systematic study of polymers with emphasis on those synthesized by step-growth polymerization and their kinetics such as - polyesters, polycarbonates, polyamides, epoxy, etc.

Unit 2: Synthesis by Ionic & Ring opening polymerizations

Systematic study of ionic polymers; Cationic and Anionic polymerisation. Mechanism of ionic polymerisation , effect of reaction conditions. Polymerization by ring opening polymerization and their kinetics.

Unit 3: New and Complex catalytic polymerisations
Complex catalytic polymerisations, mechanism stereospecific polymerizations. Newer polymerization reactions such as ATRP polymerization and their applications.

Unit 4: Studies of Reaction kinetics
Reaction kinetics – rate equation ; reactions – mechanism .Temperature dependence of reaction rates .Analysis of experimental data – evaluation of reaction rates.

Unit 5: Copolymerisation &polymer modifications
Copolymerisation reactions, Effect of reactivity ratios on composition of copolymers ,block and graft copolymers. Recent developments in polymer modifications. Microwave Synthesis.

Unit 6 : Advanced Polymer Chemistry Lab
Synthesis of Addition polymer by advanced polymerization technique, Microwave synthesis of polymers, Emulsion polymerizations & Coplymerizations, etc.

Reference Books
1. Principle of Polymer Chemistry, P.J. Flory
2. Introduction to Polymer Science and Chemistry: A Problem-Solving Approach, Manas Chanda; CRC Press Inc; 2nd edition (2013)

Text books
3. Polymer Chemistry Sixth Ed.;Charles E. Carraher, Jr.; Marcel Dekker, Inc.;2003, N.y.
4. Handbook of Polymer Synthesis, Part A & B, Hans. R. Kricheldorf
5. Principles of Polymerization, Gorge Odeon
6. Introduction to Polymers, R.J. Young

NCH 503 ADVANCED CHEMICAL REACTION ENGINEERING

L	T	P	C
3	1	0	4

Assessment:

Sessional: 50 marks EndSemester:
50 marks

Course Objectives: To learn the heterogeneous catalyzed reactions and the models involved in reactor design. To appreciate the importance of both external and internal transport effects in gas-solid and liquid-solid systems.

Course Outcomes:

Students completing the course will be able to

CO1	Develop basic concepts involved in using reaction rate equations and kinetic constants for homogenous and heterogeneous reactions.	nderstand, Apply,
CO2	Perform model discrimination and parameter estimation for heterogeneous catalytic reactions and Predict the role of temperature, concentration, and interphase mass transfer in the rate equations.	Apply, Evaluate
CO3	Derive design equations and perform calculations for various multiphase reactors	Analyse, Evaluate
CO4	Determine optimal reactor configurations and operating policies for systems involving multiple reactions	erstand, Apply, Evaluate
CO5	Perform analysis of falling film catalytic wall reactors, trickle bed reactors and chromatographic reactors.	nderstand, Evaluate

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	3	-	-	-	-	-	-	-	1
CO2	3	3	2	2	-	-	-	-	-	-	-	-
CO3	3	3	2	3	-	-	-	-	-	-	-	-
CO4	3	3	1	3	-	-	-	-	-	-	-	-
CO5	3	3	2	3	-	-	-	-	-	-	-	-
Avg	3	3	1.8	2.8	0	0	0	0	0	0	0	1

Detailed Syllabus:
Module 1 (6 Lectures)

Kinetics of heterogeneous catalytic reactions, rate equations, model discrimination andparameter estimation.

Module 2 (7 Lectures)

Deactivating catalysts, mechanisms of catalyst deactivation, the rate and performanceequations, design.

Module 3 (7 Lectures)

Mass Transfer and Reaction in a packed bed, Stoichiometric table, Pressure drop in a Reactor, Ergun's equation, Flow through a packed bed.

Module 4 (10 Lectures)

Types of multiphase reactors, mass transfer reactors, mass transfer equations, Interfacial surface area, mass transfer between phases, multiphase reactor equations, equilibrium between phases, membrane reactors, falling film reactors, bubble column reactors.

Module 5 (10 Lectures)

Falling film catalytic wall reactor, trickle bed reactors, multiphase reactors with catalysts, other multiphase reactors, reactor-separator integration, catalytic distillation, chromatographic reactors, ironore refining, petroleum refinery.

Suggested Text Books

1. Levenspiel, O., Chemical Reaction Engineering, Wiley India, 1998.
2. Froment G. F. and Bischoff, K. B., Chemical Reactor Analysis and Design, John Wiley and Sons, 1979.

Suggested Reference Books

1. Fogler, H. S., Elements of Chemical Reaction Engineering, 2nd edition, Prentice-Hall, 2000.
2. Schmidt, Lanny D., The Engineering of Chemical Reactions, 2nd edition, Oxford UniversityPress, 2010.

NPL-505 ADVANCED POLYMER PROCESSING

L	T	P	C
3	1	0	4

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

- To analyze the concept of processing techniques polymers
- To learn the fundamentals of extrusion and different extrusion processes of thermoplastics.
- To learn the principle of molding processes for thermoplastics like the injection molding process; thermoforming; calendaring, rotational moulding, blow molding etc.
- To learn the principle of molding processes for thermosets like the compression and transfer molding process; injection molding

Course outcome

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

CO 1	Analyze the Extrusion process for different Pasic Extruded Products	Analyze
CO 2	Analyze the process of injection molding process for conversion of thermoplastic and analyze processing parameters and variables for modification and improvement of quality of products.	Analyze
CO 3	Analyze the production process plastic products by thermoforming and Calendaring process and analyze the parameters for good quality products	Analyze
CO 4	Analyze the molding process for conversion of thermoset materials like compression, transfer molding and casting.	Analyze
CO 5	Analyze the process for of hollow plastic products and analyze utility of various techniques, for quality products.	Analyze

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	1	1	1	3	1	1	1	1		2	3	2
CO2	3		1	1		3	1	1	1	1		2	3	2
CO3	3	3	1	1		3	2	1	1	1		2	3	2
CO4	3	3				3	1	1	1	1		2	3	2
CO5	3	3				3	1	1	1	2		3	3	2
Total	**3**	**3**	**1.5**	**1.5**	**1**	**3**	**1.3**	**1**	**1.3**	**1.3**	**1**	**2.3**	**3**	**2**

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

Syllabus

Unit I: Extrusion Technology

Fundamentals of Extrusion process; Constructional parts of Plasticating
Single-Screw Extruder, melting and flow mechanism in screw; design of different types of screw, Quantitative assessment of parameters, Screw design and elements to get different types of mixing depending upon polymer types.

Twin screw extruders and co-extrusion process

Plastic product formation by extrusion viz. film, pipe, lamination, sheet coating, profiles, wire and cable covering, granules, etc.: analysis of each process, associated problems and their remedies. Casting process for films.

Unit II: Injection Moulding Process

Principle of injection moulding of thermoplastic and thermoset polymers; Specifications for injection molding machine, theory of screw plasticization; injection moulding operation and moulding cycle for variety of plastic materials; Process variables and their importance for machine cycle and quality of product. Dimensional control, annealing, Types of clamping systems, Analysis of moulding defects and their remedies.
Gas assist and water assist injection moulding processes

Unit III: Thermoforming and Calendaring Process

Process details of Thermoforming process, various types of thermoforming methods. Thermoforming process variables affecting the product quality. Thermoforming faults and remedies. Thermoforming machines.
Calendaring : Introduction – type of calendars – roll configuration – definition of terms such as
calendar bank- calendaring process- process variables- application- troubleshooting.

Unit IV: Moulding Processes for Thermoset polymers

Analysis of compression and transfer Moulding process, the description of various types of processes and their utility; process parameters; faults and remedies. Concept of Injection Moulding of thermoset polymers and process details. Process description and utility of hand layup, spray layup, pultrusion, filament winding, autoclave and bag Moulding techniques.
Reaction injection moulding (RIM) Process, process parameters; process description and its utility for variety of products

Unit V: Moulding Process for hollow products

Fundamentals of Extrusion blow Moulding processes; various process parameters viz. blow ratio, die shaping, parison control,; blow Moulding faults and their remedies. Injection Blow Molding Process; Stretch blow Moulding process. Various types of stretch blow Moulding operation: their description, process parameters, and utility of the process for variety of products like multi layered bottles Process – Merits & demerits – Applications. Multi–layer Blow Moulding – Process - Applications
Rotational Moulding process: analysis of process parameters and utility of the process for variety of products

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 Beauregard; 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, 4th 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 Chanda; 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
3. https://nptel.ac.in/courses/112107221

NCH 507 ARTIFICIAL INTELLIGENCE IN CHEMICAL ENGINEERING

Assessment:
Sessional: 50 marks
End Semester: 50 marks

L	T	P	C
3	1	0	4

Course Objectives: This course provides an in-depth understanding of the applications of Artificial Intelligence (AI) in the field of Chemical Engineering. It aims to equip M.Tech. Chemical Engineering students with the necessary knowledge and skills to leverage AI techniques for solving complex problems in process design, optimization, control, and data analysis. The course covers various AI algorithms and methodologies and explores their practical implementation in chemical engineering applications. Through lectures, case studies, and hands-on exercises, students will develop a strong foundation in AI concepts and gain practical experience in applying AI techniques to chemical engineering problems.

Course Outcomes:
Students completing the course will be able to

CO1	Introduce the fundamental concepts of Artificial Intelligence and its relevance to chemical engineering.	Remember,Understand
CO2	Familiarize students with various AI techniques and algorithms applicable to chemical engineering problems.	Understand, Apply
CO3	Develop an understanding of AI-driven modeling, optimization, control, and data analysis techniques.	Understand, Apply
CO4	Provide hands-on experience with implementing AI algorithms using software tools commonly used in the chemical engineering industry.	Apply, Evaluate,Create
CO5	Encourage critical thinking and problem-solving skills through the application of AI techniques to real-worldchemical engineering scenarios.	Create, Design

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	2	3	-	-	-	-	-	1	2
CO2	3	3	3	2	3	-	-	-	-	-	1	2
CO3	3	2	2	3	2	-	-	-	-	-	1	2
CO4	3	3	2	2	2	-	-	-	-	-	-	2
CO5	3	3	2	3	3	-	-	-	-	-	-	2
Avg	3	2.8	2.2	2.4	2.4	0	0	0	0	0	1	2

Module 1 (8 Lectures)
Introduction to the field of Artificial Intelligence
Historical development and current trends in AI, Relevance of AI in chemical engineering applications, Understanding the basic concepts of machine learning, supervised, unsupervised, and reinforcement learning, Applications of machine learning in chemical engineering, Data preprocessing and feature engineering for AI applications, Introduction to statistical analysis for AI in chemical engineering, Software tools for AI in chemical engineering.

Module 2 (8 Lectures)
AI Techniques for Modeling and Simulation
Supervised learning algorithms: regression, classification, and ensemble methods, Unsupervised learning algorithms: clustering and dimensionality reduction, Neural networks and deep learning for modeling chemical processes, Model validation and performance evaluation techniques, Introduction to AI modelingsoftware.

Module 3 (8 Lectures)
AI for Data Analysis and Predictive Modeling
Time-series analysis and forecasting using AI, Anomaly detection and fault diagnosis in chemical processes, AI-based predictive modeling for process performance and quality prediction, Handling big data in chemical engineering applications, Software tools for AI data analysis and predictive modeling.

Module 4 (8 Lectures)
AI in Process Safety and Sustainability
AI applications in hazard identification and risk assessment, Predictive maintenance and reliability analysis using AI, AI-driven approaches for energy efficiency and sustainability in chemical processes, Integration of AI techniques with safety management systems.

Module 5 (8 Lectures)
Case Studies and Practical Implementation
Analysis and discussion of case studies showcasing AI applications in chemical engineering. Practical implementation of AI algorithms using software tools
Ethical considerations and challenges in AI implementation in chemical engineering

Suggested Text Books
1. Edgar, Thomas F., and Davis L. South. Artificial Intelligence in Chemical Engineering. Wiley,2019.
2. Shmueli, G., and Bhushan G. Machine Learning for Chemical Engineering: Data Analysis, Modeling, and Prediction. Wiley, 2019.

Suggested Reference Books
1. Spiegel, M. R. Advanced Mathematics for Engineers and Scientists, SchaumOutline Series,McGraw Hill, 1971.
2. David M. Reklaitis and Ananth Y. Annaswamy, Data Driven Chemical Engineering, John Wiley &Sons, 2017.
3. Weifeng Z. and Huaixiu Z., Artificial Intelligence in Process Engineering by, Springer, 2019.

NPL 509 ADVANCED POLYMER COMPOSITES

L	T	P	C
3	1	0	4

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

- To understand concept of polymer composite and their basic additives.
- To understand the properties of various matrix resins and reinforcements for different end uses.
- To know the about the various production techniques for polymer composite formation.
- To learn testing and applications of different composite structures.

Course Outcome:

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

CO1	Understand the concept of composite, matrix and reinforcement.	Understand
CO2	Understand and apply the properties of reinforcements and matrix resin for different end uses.	Understand and Apply
CO3	Understand and apply different production techniques for composite structures like hand-layup, bag molding etc.	Understand and Apply
CO4	Understand and apply various testing method and standards.	Understand and Apply
CO5	Perform design and fabrication of different composite structures for specific applications	Apply

Course Articulation Matrix (CO-PO Matrix)

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**3**	**3**
CO1	3						1	1	-	-	-	3	3	3
CO2	3		2	1		2	1	1	-	-	-	3	3	3
CO3	2	1	2	1		2	1	1	-	-	-	3	3	3
CO4	2	1	2	1	1	2	1	1	1	-	-	3	3	3
CO5	2	2	2	1	1	2	1	1	1	-	-	3	3	3
Total	**2.4**	**0.8**	**1.6**	**0.8**	**0.4**	**1.6**	1	1	1	-	-	**3**	**3**	**3**

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

Syllabus

Module I : Introduction to Composites

Advantages of composites, characteristic properties of polymer Composites, classification of composites, additives for composites, concept of interface between polymer and reinforcements and coupling agents, theory of reinforcement, concept of alignment of fibers and its effect on properties of composites, Concept of nanofillers, examples of nanofillers, Utility of Polymer Nanocomposites.

Module II : Matrix and Reinforcement Materials for Polymer Composites

Properties and Applications of matrix materials for polymer composites, thermoset resins such as unsaturated polyester resin, epoxy resin, vinyl ester resin, etc., thermoplastic resins such as polycarbonate, PET, PEEK, polyimide, nylon, etc., reinforcement materials such as natural, glasses, carbon/graphite, aramid fibers, etc., woven and non-Woven fabrics of glass fiber.

Module III : Processing of Composites

Description, utility and important parameters of various processing techniques such as hand and spray layup, RTM, bag moulding, compression moulding; filament winding, pultrusion, concept of DMC, SMC, BMC, TMC.

Module IV : Testing and Quality Control of Composites

Testing methods and standards for mechanical, electrical, thermal, optical, and chemical properties of polymer composites, Non destructive testing, determination of shelf life and gel time of composites, environmental effects on composites, Failure analysis.

Module V : Application of polymer composites and nanocomposites in advanced areas

Composite propellant for modern-day missiles and space vehicles, sandwitch panels for military and space applications, graphene based composite for filtration and other applications, and adsorption, CNT based composite in supercapacitor,

Text 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. P.G. Kelleher, Reinforced Thermoplastics - Composition, Processing and Applications, New Jersey Polymer Extension Center, 1993.
4. S. Thomas, K. Joseph, S. K. Malhotra, K. Goda, and M. S. Sreekala, "Polymer Composites", Wiley VCH Verlag GmbH & Co. KGaA, 2013.
5. B. D. Agarwal, L. J. Broutman and K. Chandrashekra, "Analysis and Performance of Fiber Composites", Wiley, 2006.
6. Mechanics of composite materials by R.M. Jones.

. **Reference Books:**

1. R. K. Gupta "Polymer and composite & Rheology", CRC Press, 2014.
2. I. M. Daniel and O. Ishai, "Engineering Mechanics of Composite Materials, Second Ed", Oxford University Press, 2006.
3. E.S.Shand, "Glass Engineering HandBook", McGraw-Hill, 1958.
4. G. A. Grewell, A. Benatar and J. B. Park, "Plastics and Composites Welding Handbook, Vol 10", Hanser Publications, 2003.
5. D. V. Rosato and D. V. Rosato, "Reinforced Plastic Handbook, Third Ed.", Elsevier, 2004.

Weblink:

1. Processing of Polymers and Polymer Composites - Course (nptel.ac.in)

NPL 513 POLYMER PROCESSING

L	T	P	C
3	1	0	4

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

- To Understand the basic concepts of polymer processing and their applications
- To Understand the process details of extrusion, injection moulding and compression moulding
- To Understand the difference between processing of thermoplastics and thermoset and selection of a particular process for a particular end product
- To Understand other polymer process such as blow moulding, rotational moulding, transfer molding

Course Outcome:

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

CO1	Understand fundamentals of polymer processing and the concept of Extrusion Process for continuous plastic products	Understand
CO2	Understand details of plastic injection moulding process and their application in article making	Understand
CO3	Understand the fundamental knowledge for formation of hollow plastic products and analyze utility of various techniques, for production of hollow products.	Analyze
CO4	Understand the processing techniques for conversion of thermoset materials like compression, transfer molding and casting	Understand
CO5	Analyze process of calendaring and thermoforming process and analyze utility of these process for different applications.	Understand

Course Articulation Matrix (CO-PO Matrix)

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	1	1	1	3	1	1	1	1		2	3	2
CO2	3		1	1		3	1	1	1	1		2	3	2
CO3	3	3	1	1		3	2	1	1	1		2	3	2
CO4	3	3				3	1	1	1	1		2	3	2
CO5	3	3				3	1	1	1	2		3	3	2
Total	**3**	**3**	**1.5**	**1.5**	**1**	**3**	**1.3**	**1**	**1.3**	**1.3**	**1**	**2.3**	**3**	**2**

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

Syllabus

Unit I: Introduction to Polymer Processing and Extrusion

Basics Concepts of Extrusion process for plastics- basic operation and analysis, components of extruder, Overall extruder performance,. Different types of screw. Extrusion process for production of viz. film, pipe, amination, sheet coating, profiles, wire and cable covering, granules, etc. Concept of twin screw extruders and co-extrusion process; Casting process for films;

Unit II: Injection Moulding Process

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

Unit III: Moulding Process for hollow products
General description of blow moulding processes, Extrusion and Injection blow Moulding Processes; faults and their remedies of each. Stretch blow Moulding process. Concepts of stretching temperature, transparency, etc. various types of stretch blow Moulding operation Rotational Moulding process description and features of rotational Moulding machines.

Unit IV: Moulding Processes for Thermoset polymers
Concept of Injection Moulding of thermoset polymers and process details. General concept of compression and transfer Moulding process, the description of various types of compression and transfer Moulding processes and their utility in processing of thermosetting materials Concept of hand layup, spray layup, pultrusion, filament winding, autoclave and bag Moulding techniques.
Concept of Injection Molding process for thermosets and process description
Concept of reaction injection Moulding (RIM) Process, process parameters; process description and its utility for variety of products

Unit V: Calendaring and Thermoforming
Concept of Calendaring process for plastic sheet forming, calendar roll arrangements, application of Calendaring process
Concepts of thermoforming process and various means of forming. Description of various thermoforming methods. Thermoforming process variables affecting the product quality. Thermoforming faults and remedies. Thermoforming machines.

Reference Books and Suggested Readings:

1. Plastics Extrusion, by Allen Grief
2. Plastic Engineering Handbook (SPI), by Frados
3. Screw extrusion of Plastics, by Jacobi
4. Injection and Compression Moulding Fundamentals, by Isayev.
5. Encyclopedia of Polymer Science and Technology Vol. 1-23, by Mark &Overberger.
6. HandBook of Injection Moulding, by Rosato&Rosato.
7. Practical Thermoforming Principles & Applications, by J. Florian.

NPL 515 HIGH POLYMER CHEMISTRY

L	T	P	C
3	1	2	5

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.
- Synthesis of Addition polymer by advanced polymerization technique

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 step growth polymerization, its kinetics, mechanism and crosslinking.	Apply
CO3	Understand and apply the chain growth polymerization and it's kinetics.	Apply
CO4	Coordination polymerization and advances	Analyze
CO5	Understand and analyze co-polymer composition and types	Analyze
CO6	Synthesis of Addition polymer by advanced polymerization technique	Apply

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus

Unit 1: Introduction to polymers

Introduction to polymer, polymer classifications based on occurrence, types, , concept of macromolecules and their molecular weights, polymer physical state, application of polymers.

Unit 2: Step polymerizations

Introduction to step polymerization, kinetics of step polymerization, self-catalyzed polymerization, external catalysis of polymerization, molecular weight control in linear polymerization, crosslinking reactions.

Unit 3 : Addition polymerizations

Kinetics and mechanism of free radical, initiation mechanisms, molecular weights and its distribution of free radical

polymer, chain transfer reactions, inhibition and retardation, effect of temperature and pressure on polymerization, Auto-acceleration, Ionic polymerization, cationic, anionic polymerization.

Unit 4: Coordination polymerizations

Coordination polymerization, properties of stereoregular polymers, traditional Ziegler–Natta polymerization of nonpolar alkene monomers, propagation at carbon–transition metal bond, effects of components of Ziegler–Natta initiator, kinetics, metallocene polymerization and their commercial applications.

Unit 5: Copolymerization Reactions

Chain copolymerization and its general considerations, copolymer composition, types of copolymerization behaviour, variation of copolymer composition with conversion, effect of reaction conditions, applications of copolymerization.

Unit 6 : Advance Polymerization lab

Synthesis of Addition polymer by advanced polymerization technique, synthesis of Epoxy resins having different epoxide equivalent weights, Microwave synthesis of polymers, New types of Emulsion polymerizations etc.

Reference Books

1. Principle of Polymer Chemistry, P.J. Flory
2. Principles of Polymerization, Gorge Odeon

Text Books

1. Text Book of Polymer Science, F.W. Billmeyer
2. Polymer Science ; Vasant R. Gowariker, N. V. Viswanathan, Jayadev Sreedhar; New Age International, India, 1986
3. Polymer Science and Technology - Plastics, Rubbers, Blends and Composites (Ghosh Premamoy) McGraw Hill Education India.

NPL 517 POLYMER RHEOLOGY

L	T	P	C
3	1	0	4

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

- To understand the basic rheological concepts.
- To understand the viscoelasticity and co-relation of mechanical models with rheology.
- To understand the dyanamic properties of polymers.
- To understand the concept of viscometry and rheometry and to apply the knowledge in handling viscometer and rheometer to measure rheological properties.
- To understand the application of rheological studies on polymer processing.

Course Outcome:

CO1	Understand the basic concepts of rheology	Understand
CO2	Understand the correlation between Linear viscoelasticity with mechanical models and apply these models to interpret the flow behavior of polymer melts	Understand and Apply
CO3	Understand and apply the dynamic properties of polymers through rheology	Understand and Apply
CO4	Understand the concept of viscometry and rheometry and apply the knowledge in handling viscometer and rheometer to measure rheological properties	Understand and Apply
CO5	Apply the role of rheology in polymer processing	Apply

Course Articulation Matrix (CO-PO Matrix)

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2		1		2						3	3	3
CO2	3	2	3	3		2						3	3	3
CO3	3	3	3	3	2	2	1	1				3	3	3
CO4	3	2	3	2	2	2	1	1	3			3	3	3
CO5	3	3	3	1	2	2	1		3	1		3	3	3
Total	**3**	**2.4**	**2.4**	**2**	**1.2**	**2**	**0.6**	**0.4**	**1.2**	**0.2**		**3**	**3**	**3**

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

Syllabus

Module I : Basic Rheological Concepts

Polymer flow, the ideal elastic and viscous responses, Newtonian and Non-Newtonian flow, pseudoplastic, bingham, and dilatants behavior, time independent and time-dependent fluids, dependence of various rheological parameters on viscosity of polymer melts and solutions.

Module II : Viscoelasticity and Mechanical Models

Origin of non-Newtonian flow, Factors influencing flow behaviour, concept of viscoelasticity, mechanical responses to dynamic loads and concept of storage and loss modulus, loss tangent and complex modulus, mechanical models for linear viscoelastic response, Maxwell and Voigt models.

Module III : Superposition principles and Dyanamic Properties

Boltzmann superposition, time-temperature superposition, WLF equation, definition for storage and loss modulus, loss tangent and complex modulus.

Module IV : Measurement of viscosity and Rheometers

Concept of viscometry and rheometry, Poiceuille and Couette flow, Rheometric analysis of these flows, Measurements of Rheological properties by various Rheometers: Measurement of rheological properties by Capillary Rheometer, Parallel Plate Rheometer and Cone and Plate Rheometer.

Module V : Application of Rheological Studies on Polymer Processing

Application of rheology on polymer processing techniques such as extrusion, injection molding, blow moulding etc., structure-rheology relationship for product development in polymer processing, rheology on filled polymer.

Text books:

1. J.D.Ferry," Visco-elastic properties of polymers", Wiley,1980.
2. C. D. Han, “Rheology and Processing of Polymeric Materials:Vol 1 Polymer Rheology”, Oxford University Press, 2007.
3. J-M. Piau and J-F. Agassant (Eds.), “Rheology of Polymer Melt Processing : Rheology Series 5”, Elsevier, 1996.
4. W. Christopher & Macosko,“Rheology, Principles, measurements and Applications",Wiley-VCH,1994.
5. R. S. Lenk, “Polymer Rheology”, Springer Neatherland, 1978.
6. B. R. Gupta, “Rheology Applied in Polymer Processing 1st Edition”, CRC Press, 2022.

Reference books:

1. J. Fergusonand, Z.Kemblowski,“Applied fluid rheology",Springer Netherlands,1991.
2. J. M. Dealy, Kurt F. Wissburn,“Melt Rheology & its Role in Plastics processing theory & applications", Springer Netherlands, 1998.
3. J. A. Brydson, "Flow Properties of Polymer Melts", CBLS,1970.
4. Y. G. Yanovsky, “Polymer Rheology : Theory and Practice”, Springer Link, 1993.

Web Links:

1.https://nptel.ac.in/courses/103103139
2.https://nptel.ac.in/courses/103107139

NPL 519 POLYMER ADDITIVES AND COMPOUNDING

L	T	P	C
3	1	0	4

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

- To understand the selection criteria and mechanism of action of various additives utilized in plastic compounding.
- To understand the techniques of compounding and its utility and challenges.

Course Outcome

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

CO1	Understand the fundamentals of Plastic Additives and its types.	Understand
CO2	Understand and apply the chemistry of mechanism of different plastic additives.	Understand and Apply
CO3	Understand and apply the method of evaluation of plastic additives.	Understand and Apply
CO4	Understand and apply the techniques for plastic compounding and associated challenges.	Understand and Apply
CO5	Understand and apply the concept of multifunctional additives for plastic compounding.	Understand and Apply

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus:

Unit 1: Introduction to Additives

Introduction to Plastic additives and its types; Utility, properties and application of plastic additives; selection criteria of additives for plastic compounding; Local and Global market for plastic additives.

Unit 2: Chemistry of Additives

Chemistry and mechanism of action of various additives e.g. Antioxidants, antiozonants, plasticizers, lubricants, UV absorbers, flame retarders, anti-block and antislip agents, processing aids, nucleating agents, Rheology modifiers, anti-microbial, Compatibilizers, Oxygen scavengers, Coupling agents, Impact modifiers, Master batches and colorants; Black and non-black fillers in rubber compounding; etc.

Unit 3: Evaluation of Additives

Evaluation and functions of various additives; Reverse Engineering of Plastic Additives by Soxlet extraction, microwave extraction, etc. Qualitative and quantitative estimation of plastic additives using advanced characterization tools.

Unit 4: Compounding Techniques

Selection of compounding ingredients; Scope and challenges associated with compounding; Method of mixing; Mixing equipments, mixers, blenders, mills, extruders, etc.; Compounding recipes of various plastics e.g. thermoplastics and thermosets and elastomers; Finishing and decorative methods for plastic compounds.

Unit 5: Newer Trends in Additives and Compounding

Examples of Multifunctional additives and their mode of Action; Nano-additives for Plastics e.g. nanofilers, graphene, carbon nano-materials, layered silicates, etc.; Surface functionalization of nanofillers and improvement of interfacial properties of plastic compounded parts.

References:

1. R. Gachter and H. Muller, Plastics Additives Hand Book, Hanser Publishers, Munich, 1993.
Additives & Compounding - by R. Gachter & H. Muller
2. John Murphy, The Additives for Plastics Hand Book, Elsevier Advanced Technology, Oxford, 1996.
3. Jesse Edenbaum, Plastics Additives and Modifiers Hand Book, Chapman & Hall, London,1996.
4. Ernest W. Flick, “Plastics Additives”.
5. J.A. Brydson, “Plastics Materials” Buterworth – Heinmann, Oxford (1999).
6. Ica Manas - Zloczower and Zehev Tadmor, Mixing and Compounding of Polymers, Hanser Publications, Munich, 1995.

NCH 513 INSTRUMENTAL METHODS OF ANALYSIS

Assessment:
Sessional: 50 marks End Semester: 50 marks

L	T	P	C
3	1	0	4

Course Objective:
This course introduces theoretical principles behind modern analytical instrumentation techniques and practical considerations, scope and limitations of each of them.

Course Outcomes:
Students completing the course will be able to

CO1	Select a suitable method for analysis of a given sample	Understand, Apply
CO2	Analyze the data obtained from any technique to infer meaningful results.	Apply, Evaluate
CO3	Identify the scope and limitations of various techniques.	Analyze, Evaluate
CO4	Identify sources of error in each technique and minimize the errors incurred in analysis.	Understand, Apply, Evaluate
CO5	Design the instrument for basic parameters testing.	Apply, Evaluate

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	-	-	-	-	-	-	-	-
CO2	3	2	1	1	-	-	-	-	-	-	-	-
CO3	3	2	3	2	3	-	-	-	-	-	-	-
CO4	3	3	2	2	3	-	-	-	-	-	-	-
CO5	3	3	3	3	2	-	-	-	-	-	-	-
Avg	3	2.6	2.2	1.8	2.75	0	0	0	0	0	0	0

Detailed Syllabus:

Module 1 (9 Lectures)
Introduction to spectroscopic techniques, UV - Vis Spectrophotometry, Nephelometry, Turbidimetry,Reflectance Spectrometry, Fluorescence, Phosphorescence Spectrometry.

Module 2 (8 Lectures)
Flame Emission and Atomic Absorption Spectrometry, Electro thermal AAS, Hydride generation AAS and Flameless mercury analysis. Inductively Coupled Plasma Atomic Emission Analysis.

Module 3 (9 Lectures)
Infrared spectrometry, Introduction to X-Ray techniques, XRF. Introduction to NMR spectroscopy and mass spectrometry.

Module 4 (7 Lectures)
Electro analytical techniques: Potentiometry, Voltametry, Polarography Chromatographic analysis: GC,LC

Module 5 (7 Lectures)
Chromatographic analysis, HPLC, Hyphenated techniques. Errors, statistical methods of data handling

Suggested Text Books:
1. H.Willard, L.L Meritt, J.A Dean and F.A.Settle: Instrumental Methods of Analysis, 6th Edition,CBS.
2. A.I.Vogel: Quantitative Inorganic Analysis, 5th Edition, ELBS.

Suggested Reference Books:

1. G.W. Ewing: Analytical Instrumentation Hand book, Marcell Dekker, New York, 1990.

Year I, Semester II

(Applicable from session 2023-24 for new entrants)

NPL 502 ADVANCED POLYMERIZATION ENGINEERING

L	T	P	C
3	1	0	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 manufacturing of commodity plastics and significance of stereospecific polymerizations.
- To understand the manufacturing of engineering plastics
- To understand the manufacturing of thermosetting resins
- To understand the manufacturing of Speciality Plastic

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 the manufacturing of commodity plastics and significance of stereospecific polymerizations.	Understand
CO3	Understand and apply the production process for engineering thermoplastics.	Apply
CO4	Understand and apply the production process for common thermoset polymers.	Apply
CO5	Understand and apply the production process for speciality polymers and its utility.	Understand and Apply

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus:

Unit 1: Basics of Industrial polymerization

Industrial methods of polymerization, such as bulk, solution, suspension, slurry, gas phase and emulsion and

their recent developments. Layout and arrangement of polymer plants, reactor types and processes.

Unit 2: Manufacturing Technology of Commodity Plastics

Manufacturing of various polyolefins, such as LDPE, HDPE, LLDPE, PP, PS and copolymeric grades, their production technology, properties and application of commodity plastics and utilization in different application sectors; Stereospecific Polymerization and its utility.

Unit 3 Manufacturing Technology of Engineering Plastics

General characteristics of engineering plastics, synthesis, properties, fabrication techniques and application of common engineering plastics such as ABS, polycarbonate, polyamide, PMMA, polyesters, polyimide, etc.

Unit 4: Manufacturing Technology of Thermosetting Plastics

Characteristics of thermosetting resin; Fabrication techniques, properties and application of various thermosetting resins; phenol formaldehyde, urea formaldehyde, melamine formaldehyde, epoxy, unsaturated polyester; Preparation of moulding powder.

Unit 5: Manufacturing Technology of Speciality Plastics

Manufacturing details, properties and application of Teflon, PVDF, polyacetals, polyphenylenesulphide, and polyphenylene oxide, PDMS and its areas of application.

References:

1. Plastic Materials, J.A. Brydson
2. Polymer Production, Mayo & Smith
3. Macromolecular Synthesis, J A Moore
4. Handbook of Plastic Technology, M. Chandha
5. Handbook of Thermoplastics, Olagoke Olabisi
6. Plastic Materials and Processes, C. Harper
7. Material Science of Polymer of Engineers F A Osscoald & G menges, Plastic Tech. Handbooks J F engg. Ramirez

NPL-504 ADVANCED PLASTIC PRODUCT AND MOULD DESIGN

L	T	P	C
3	1	0	4

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

- To understand the concepts of product design and complex important design features.
- To understand various parts of injection molds and their types.
- To learn the designing related to mult-icavity injection molds
- To understand advanced design concept of Injection moulds.
- Application of CAD/CAM & Mould Flow software in different Moulds& extrusion dies

Course Outcome

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

CO1	Understand and apply design Plastic products, design criteria based upon end use.	Understand
CO2	Understand and apply Design Guidelines for structural Features of plastic products.	Understand
CO3	Understand and apply design concepts for structure of injection molds.	Apply
CO4	Understand concepts and apply in Advanced Injection Mould Design	Apply
CO5	Application of CAD/CAM & Mould Flow software in different Moulds & extrusion	Apply

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus

Unit 1:Product specifications and Design

Product specifications; Product Design Appraisal ; and Tolerances on Product. Product design criteria–Structural, Environmental, Assembly, Aesthetics & Decoration. Product design check list.

Unit 2:Design Guidelines for structural Features

Shrinkage, Wall thickness – variations in wall thickness – suggested wall thickness for various plastics materials – Tapers or draft angles. – Design of radii, fillets, ribs and bosses. Undercuts –Types and moulding considerations, Moulded threads and Inserts.

Unit 3: Injection Mould Design Basics

Basic construction of mould – Types of moulds & Mould plates, Sprue bush, locating ring, core and cavity, Guide pillar & guide bush etc. Bolsters, Feed System: Sprue , Runner & Gate ; runner layout – balancing of runners ; types of gates for various materials .

Unit 4: Advanced Injection Mould Design

Types of ejector grid – Ejector plate Assembly; Guiding & Supporting, Types of ejection; Mould cooling – Integer type cavity and core plates cooling etc. Two Plate and Three Plate Mould Designs,; External undercuts &Splits moulds.

Unit 5: CAD & other type moulds/Dies

Design concepts of Compression, Transfer and Blow moulds. Extruder Die Design basics, Computer Aided Mould Design, Use of Simulation software like Mould Flow cycle time and profitability in Mould Design.

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Reference Books

1. Injection Mould Design Hand book,-Rosato & Rosato
2. SPI Plastics Engineering Handbook of the Society of the Plastics Industry, Inc. by Michael L. Berins (Editor),Springer 2012

Text Books

1. Plastics Product Design, Beck R.D.
2. Plastic Mould Engineering Hand Book, - J. H. Dubois & W.I. Pribble
3. 5..Dies for Plastic Extrusion, - M. V. Joshi
4. Injection Mould Design – Pye R.G.W

NPL 506 POLYMER TESTING AND CHARACTERIZATION

L	T	P	C
3	0	2	4

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

- To understand the basic concepts of testing and standard specifications.
- To understand the various mechanical testing of polymers..
- To understand the various electrical, optical and chemical properties of polymers.
- To understand various characterization techniques to elucidate different properties of polymers.

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

CO1	Understand the basic concepts of testing and standard specifications.	Understand
CO2	Understand and apply the various mechanical testing of polymer materials.	Understand and Apply
CO3	Understand and apply the various electrical and optical properties of polymer materials.	Understand and Apply
CO4	Understand and apply the various chemical properties of polymer materials.	Understand and Apply
CO5	Apply different characterization techniques viz. FTIR, NMR, TGA & DSC to elucidate the properties of polymers.	Understand and Apply
CO6	Apply various testing and characterization techniques in the laboratory.	Apply

Course Articulation Matrix (CO-PO Matrix)

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	3	3	2	1	2						3	3	3
CO2	3	3	3	3	1	2						3	3	3
CO3	3	3	3	3	2	2	1	1				3	3	3
CO4	3	2	3	2	2	2	1	1	3	1		3	3	3
CO5	3	3	3	2	2	2	1		3	1		3	3	3
Total	**3**	**2.8**	**3**	**2.4**	**1.8**	**2**	**0.6**	**0.4**	**1.2**	**0.4**		**3**	**3**	**3**

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

Syllabus

Module I: Testing and Quality Control of Polymers

Concept of Testing of polymer materials, standard specifications viz. ASTM, ISO, etc. and their importance, preparation of test specimen and conditioning, importance of specifications and standards in quality control of

polymers and polymer products.

Module II: Mechanical Properties

Tensile, compressive and flexural response, stress strain behaviour, cold drawing, strain hardening, effect of temperature, plasticizer and additives on mechanical properties, brittleness, abrasion resistance, hardness tests, burst strength and edge crush.

Module III: Electrical and Optical Properties

Insulation resistance, power factor, permittivity, dielectric strength, tracking resistance, arc resistance and antistatic test, refractive index, luminous transmittance, haze.

Module IV: Chemical Properties

Chemical resistance, environmental stress cracking resistance, ageing, gas permeability, water vapour permeability and weathering, water absorption, moisture analysis.

Module V: Introduction to Polymer Characterization by Instrumental Techniques

Polymer characterization by instrumental techniques such as IR, NMR, mass UV-visible spectroscopic techniques, TGA, DTA, DSC, etc., Polymer surface and interface characterization by SEM, TEM, etc.

Module VI: Polymer Testing and Characterization Lab

Experiments related to tensile test, impact test, flexural strength, melt flow index, UV visible spectrophotometer, Differential scanning calorimetric (DSC) Analysis, Thermogravimetric Analysis (TGA).

Text books:

1. V. Shah, “Handbook of Plastic Testing Technology", Wiley- Blackwell,1998.
2. R. Brown, “Handbook of Polymer Testing : Physical Methods”, CRC Press, 2014.
3. M. Subramanian, “Basics of Polymers : Testing and Characterization”, Momentum Press, 2018.
4. S. K. Nayak, S. N. Yadav, and S. Mohanty, “Fundamentals of Plastic Testing”, Springer, 2020.
5. B. Wunderlich, “Thermal Analysis of Polymeric Materials”, Springer Link, 2005.
6. W. M. Groenewoud, “Characterization of Polymers by Thermal Analysis-First Edition”, Elsevier, 2001.
7. Y. Ozaki and H. Sato (Eds), “Spectroscopic Techniques for Polymer Characterization : Methods, Instrumentation, Applications”, Wiley-VCH GmbH, 2021.
8. J. L. Koening, “Spectroscopy of Polymers : Second Edition”, Elsevier, 1999.

Reference books:

1. M. L. Berins, “Plastics Engineering Hand book by Society of the Plastic Industry, Inc”, Springer-Verlag, 1991.
2. C. M. Swallowe, “Mechanical Properties and Testing of Polymers : An A-Z Reference”, Springer, 1999.
3. G. E. Zaikov and R. Kozlowski (Eds), “Chemical and Physical Properties of Polymers”, Nova Science Publisher Inc, USA, 2005.
4. S. L. Flegler, J. W. Heckman, and K. L., Klomparens, “Scanning and Transmission Electron Microscopy : An Introduction”, Oxford University Press Inc, 1993.
5. C. D. Craver (Ed), “Polymer Characterization : Spectroscopic, Chromatographic, and Physical Instrumental Methods (ACS No. 203)”, American Chemical Society, 1982.
6. ASTM, ISO, IS Standards

Web Links:
1.https://nptel.ac.in/courses/103103139
2.https://nptel.ac.in/courses/103107139

NCH 508 STATISTICAL DESIGN OF EXPERIMENTS

Assessment:
Sessionals: 50 marks
End Semester: 50 marks

L	T	P	C
3	1	0	4

Course Objectives: The aim of the course is to give competences in the field of applied statistical methods for work concerning planning and analysis of experiments, regression analysis, optimization of processes and multivariate analysis.

Course Outcome:
Students completing the course will be able to

CO1	Understand the importance of randomization and replication of experimental data set.	Understand, Apply
CO2	Estimate statistical variance and perform analysis of variance, regression analysis, correlation analysis on a given experimental data	Apply, Evaluate
CO3	Design full factorial and fractional factorial experiments and analyse the data	Analyse, Evaluate, Apply
CO4	Develop nested designs, block designs and response surface designs	Understand, Evaluate
CO5	Recognize what design was followed and perform the appropriate analysis given the description of how a set of data was collected.	Analyse, Apply, Evaluate

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	1	-	-	-	-	-	-	-
CO2	3	3	2	2	1	-	-	-	-	-	-	-
CO3	3	2	3	3	2	-	-	-	-	-	-	-
CO4	3	3	3	2	1	-	-	-	-	-	-	-
CO5	3	3	2	3	2	-	-	-	-	-	-	-
Avg	3	2.6	2.4	2.2	1.4	0	0	0	0	0	0	0

Detailed Syllabus:

Module 1 (7 Lectures)

Introduction to statistics for engineers: Simplest discrete and continuous distributions, Statistical inference, Statistical estimation, tests and estimates on statistical variance, Analysis of variance, Regression analysis (Simple linear, multiple, polynomial, nonlinear), Correlation analysis (Correlation in linear regression, correlation in multiple linear regression)

Module 2 (8 Lectures)

Design and analysis of experiments: Introduction to design of experiments, Preliminary examination of subject of research, Screening experiments

Basic experiment-mathematical modeling: Full factorial experiments and fractional factorial experiments, Second-order rotatable design (Box-Wilson design).

Module 3 (9 Lectures)

Orthogonal second order design (Box Benken design), D-optimality, Bk-designs and Hartleyssecond order design.

Statistical analysis: Determination of experimental error, Significance of the regression coefficients, Lack of fit of regression models

Module 4 (7 Lectures)
Experimental optimization of research subject: Problem of optimization, Gradient optimization method, canonical analysis of response surface.

Module 5 (9 Lectures)
Mixture design `composition-property: Screening design `composition-property', Simplex lattice design, Scheffe simplex lattice design, Simplex centroid design, Extreme vertices design, D- optimal design, Draper-Lawrence design, Factorial experiments with mixture, Full factorial combined with mixture design.

Suggested Text Books:
1. Z. R. Lazic, Design of experiments in chemical engineering: A practical guide, Wiley,2005.

NPL 510 ADVANCED RUBBER TECHNOLOGY

L	T	P	C
3	1	0	4

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

- To provide the knowledge rubber materials and the need of various additives and compounding of rubbers and vulcanization
- To provide knowledge of vulcanization of rubbers
- To provide knowledge of manufacturing process of natural rubber and different synthetic rubbers.
- To enable the students to analyze rubber products and their manufacturing processes

Course Outcome:

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

CO1	Analyze the characteristic properties of elastomers, utility of compounding ingredients for variety of applications.	Analyze
CO2	Analyze the source, procurement process, properties, vulcanization and applications of natural rubber.	Analyze
CO3	Analyze the chemistry of synthesis, manufacturing process, properties and applications of synthetic rubbers.	Analyze
CO4	Analyze the compounding and processing machines.	Analyze
CO5	Analyze the production of different rubber products.	Analyze

Course Articulation Matrix (CO-PO Matrix)

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

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

Syllabus

Unit 1: Introduction and Compounding of Rubber

Definition of rubber elasticity. Compounding of rubbers; functions of additives – Antioxidants, Stabilizers, Plasticizers, Impact Modifiers ,Lubricants, Antistatic agents, Anti blocking agents, processing aids, Blowing agents, Flame Retardants, Master batch/ Colorants, General effect of these on Properties of rubber. Carbon black-its types, manufacture and characteristics- mechanism of reinforcement of a rubber, non black fillers in rubbers

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Unit 2: Natural rubber

Production of different grades of natural rubber from latex, Standard grades of natural rubber and newer technologies for production of dry rubber. Application of latex, technically specified rubber, Vulcanizing agents and mechanism and chemistry of vulcanization and various vulcanization

techniques, role of accelerators and activators and effect of vulcanization techniques on cross link density and properties of rubber

Unit 3: Synthetic Rubbers

Polymerization techniques involved in production of general purpose synthetic rubbers like SBR, Polybutadiene, EPDM; heat resistant synthetic rubbers like butyl rubber, silicone rubber, polysulphide rubbers, fluorine containing rubbers, and solvent resistant synthetic rubbers like polychloroprene rubbers, nitrile rubbers, hypalon, etc.; polyurethane rubbers, their vulcanization, properties and applications, speciality and modified rubbers, thermoplastic elastomers

Unit 4: Processing of Rubbers

Compounding techniques and mechanism of mixing and dispersion, stabilization, coagulation, etc. Machinery used for mixing, two roll mill, internal mixers and continuous mixers, extrusion technology, calendering and different types of calenders.

Moulding: Compression, transfer and injection moulding, different methods of vulcanization such as rotocure, autoclave open steam, high energy radiation, etc.

Unit 5: Rubber Product Manufacture

Manufacturing methods for the products like rubber tyres – design and construction, reinforcing system, building and curing of various types of tyres; conveyor and transmission beltings; hoses and tubings; wire and cables coating; rubber to metal bonded articles; mechanical seals, cellular products, shoe soles; manufacture of latex products like foam, dipped goods, latex thread, etc.

Text Books:

1. Rubber Technology & Manufacture, by C. M. Blow; Newnes-Butterworth; 1982.
2. Rubber Technology, by Maurice Morton; Springer Link, 1999.
3. Synthetic Rubbers: their Chemistry and Technology, by D.C. Blackley; Springer; 1983.
4. The Science and Technology Of Rubber; James E Mark, Burak Eman and C. Michael Roland; Academic Press; 2013.
5. The Complete Book on Rubber Processing and Compounding Technology; NIIR Board of Consultants and Engineers; Asia Pacific Business Press Inc.; 2006

Reference Books:

1. Encyclopedia of Polymer Science & Tech., Vol 1-23, by HF Mark, NM Bikales and Over-berger Wiley-Interscience, New York; 1985.
2. Hand Book of Rubber Formulations : Rubber Technology; Shrikant P. Athavale; Notion Press; 2018.
3. Anil K. Bhowmic, Howard L. Stephens (Edt), Handbook of Elastomers – New
4. Developments & Technology, Marcel Decker Inc.; New York; 1988.

Web link:

1. https://erp.iitkgp.ac.in/CEP/getbrochure.htm?course_code=3084
2. https://nptel.ac.in/courses/113105028

NPL 512 STRUCTURE– PROPERTY RELATIONSHIP IN POLYMERS

L	T	P	C
3	1	0	4

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

- Ability to understand the general structural features, configuration/conformation, chemical and geometrical structural features of polymers.
- Ability to understand molecular mass heterogeneity and structure properties of polymers.
- Ability to understand the thermodynamics and factors affecting dissolution.
- Ability to understand the polymer chain flexibility, thermal properties, intermolecular order, solution properties and the crystalline properties of polymers.

Course Outcome

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

CO1	Understand the basic concept of structural features	Understand
CO2	Apply mathematical equations to interpret the concept of molecular weight averages and apply different techniques to measure molecular weight of polymers. Polymer heterogeneity.	Understand and Apply
CO3	Understand the concept of polymer crystallinity and its role to analyze polymer properties.	Understand and Analyze
CO4	Understand the concept of polymer-in-solution and apply mathematical equations to analyze polymer solution properties.	Understand, Apply and Analyze
CO5	Understand and apply the concept of flexibility to interpret the glass transition temperature and polymer properties.	Understand, Apply

Course Articulation Matrix (CO-PO Matrix)

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	2				3	3					3	2	3
CO2	2	3		2		3		1				3	3	2
CO3	2	2	3	2	2	3		1	2			3	3	3
CO4	2	3	3	2	2	3			2	1	1	3	2	3
CO5	2	2	3	2	2	3			2			3	2	3
Total	**2**	**2.4**	**1.8**	**2**	**1.2**	**3**	**3**	**1**	**2**	**1**	**1**	**3**	**2.4**	**2.8**

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

Detailed Syllabus

Module-I: Basic Structural Features of Polymers

Basic concept of structural features, historical background, classification of polymers, property relationship of linear, branched, and crosslinked polymers, chain extending bond, intermolecular forces, chemical stability; Effect of structural features on mechanical, thermal, electrical properties of polymers.

Module-II: Molecular mass heterogeneity

Concept of average molecular weight in polymers, mathematical equations of molecular weight averages and the calculation of average molecular weight of polymer. Importance of average

molecular weight in polymer processing. Determination of molecular weight averages by various techniques such as end-group analysis, etc. Concept of molecular weight distribution and it's role on polymer properties, concept of fractionation process.

Module -III: Crystallinity in Polymers

Concept of degree of crystallinity and crystallizability, concept of crystalline solids and their behavior towards X-rays, polymers and X-ray diffraction, polymer crystallization, structural regularity and crstallisability, polymer single crystal.

Module-IV: Polymer solution properties

Concept of polymer solution, Polymer-solvent interaction, good and poor solvents, thermodynamics of dissolution, factors effecting dissolution and swelling of polymers, phase equilibrium of polymer-solvent systems, Florry-Huggins theory.

Module-V: Flexibility and glass transition temperature of polymers

Concept of flexibility, various factors deciding flexibility of polymers, polymer properties affected by flexibility, glass transition temperature (Tg), factors affecting polymer properties by glass transition temperature.

Text books:

1.F. W. Billmeyer, "Text Book of Polymer Science", John Wiley & Sons, 2009.
2.R.D. Deanin, "Polymer Structure, Properties and application", American Chemical Society 1974
3.A. T. Tobolsky,"Properties and structure of polymers",Wiley,NewYork,1960.
4.V. Krevelen, "Properties of Polymer; Correlations with Chemical Structurees and their numerical Estimation and Predication from Additive Group Contribution", Elsevier Publication Company, 1990.
5.M. P. Stevens, "Polymer Chemistry–An Introduction", Oxford University Press, 1990.
6.G. O. Shonaike and S.G.Advani, "Advanced Polymeric Materials: Structure property relationship", CRC Press, 2000.
7.S. Man, R.E., and R.J. Bishop, "Metals and Materials", Butterworth-Heinemann, Oxford University Press, 1995.
8. P. Ghosh, "Polymer Science and Technology", 2nd edition, Tata McGraw Hill, 2021.

Reference books:

1.Teraoka, Iwao, " Polymer Solutions-Introduction to Physical Properties", John Wiley and Sons, 2002.
2.H.F.Mark, "Encyclopedia of Polymer science and Technology", 4th edition, vol. 15, 2014.
3.H. K. Dekker, "Hand book of Polymer Synthesis (Part B)", 2nd edition, 2004.
4.H. S. Nalwa, "Hand book of organic conductive molecules and polymers", Vol.-4, 1997.

Web Links:

1. https://www.youtube.com/watch?v=1HY9xe4x7Go

Year II, Semester III

(Applicable from session 2024-25 for new entrants)

NPL 601 TECHNOLOGY OF WASTE MANAGEMENT

L	T	P	C
3	1	0	4

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

- To understand the plastic waste management and disposal.
- To understand various techniques plastic waste reduction and conversion of plastic waste into value added products.
- To understand the policies and regulations of plastic waste management
- Understand the recycling technology of plastic waste.

Course Outcome

CO1	Understand the fundamentals of plastic waste management and plastic waste separation technologies.	Understand
CO2	Understand and apply various techniques plastic waste reduction and conversion of plastic waste into value added products.	Understand and Apply
CO3	Understand and apply social and environmental challenges of plastic waste and policies and regulations for waste control.	Apply
CO4	Understand the Disposal of Solid Municipal Waste.	Understand, and Analyze
CO5	Understand the Scope of Biodegradable Polymers and Recycled Polymers	Understand and Apply

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus:

Unit 1: Introduction to Plastic Waste Management

Concept of carbon footprint; Global, Indian and Local Scenario of plastic generation and utilization in different sectors, Sources of plastic waste, Sorting of Plastic wastes by different techniques

Manual, automated, Density separation, Flotation, Solvent separation, etc.

Unit 2: Plastic Waste Management and Recycling Technology

Waste management approach, viz. Source reduction, Reuse, Repair, Recycling, and Incineration. Single-used plastics. Plastic waste to value added products. Plastics and Environment. Recycling Techniques, Mechanical recycling, Chemical recycling/feedstock recycling, Pyrolysis and energy recovery.

Unit 3: Policies and Regulations

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

Unit 4: Disposal of Solid Municipal Waste

Disposal of solid municipal waste by biodegradation – composting (bioreactors)- deposition in landfills – microbial decomposition processes in anaerobic rubbish dumps. Ideal bioreactors – stirred tank reactor – batch and continuous operations – Fed - Batch operation - plug flow reactor,

Unit 5: Scope of Biodegradable Polymers and Recycled Polymers

Biodegradable polymers; types of biodegradable polymers; Utility of biodegradable polymers in agriculture, medicine, packaging. Introduction to Bio-based Polymers. Mechanisms of Polymer Degradation, Factors Affecting Biodegradability. National and International market for Recycled Plastics.

References

1. Gordon. L Robertson, Food Packaging, Taylor and Francis (2006)
2. G. J. L. Griffin, Chemistry and Technology of Biodegradable Polymers,
3. Gerald Scatt & Dan Gilad, Degradable Polymers – Principles & Applications
4. Catia Bastioli, Handbook of Biodegradable Polymers

NPL 603 TECHNOLOGY OF POLYMER BLENDS & ALLOYS

L	T	P	C
3	1	0	4

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

- To understand concept and technology of blends and alloys
- To understand the concept of miscibility and immiscibility of polymers and thermodynamics of blending
- To understand the types of blending techniques.
- To understand and analyze characterization techniques for blends and alloys

Course outcome:

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

CO1	Understand the concept and technology of blends and alloys	Understand
CO2	Understand the miscibility and immiscibility of polymers	Understand
CO3	Understand the methods of blending and alloying	Understand
CO4	Understand and Analyze the properties and application of commercial blends	Understand and Analyze
CO5	Understand and Analyze the characterization techniques for characterization of polymer blends.	Understand and Analyze

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus:

Unit 1 Introduction to Polymer Blends and Alloys

Definition for Blends and Alloys; Reason and advantages of Blending, Selection criteria of blending polymers and designing of blends; Classification of Polymer Blends; Miscible Blends and Immiscible Blends, Methods of blending: Melt blending, solution blending, Latex blending, powder blending, mechano-chemical blending; Selection of blend components; Economy of

blending.

UNIT II Polymer/polymer miscibility

Concept of miscibility, Phase Equilibria Calculation; Huggins - Flory Theory; Factors Affecting Miscibility of Polymer Blends, concept of Compatibility; composition of blends, Solubility Parameter; Interaction Parameter. Determination of miscibility by measurements of Refractive Index, Ultrasonic Velocity, Thermal and Optical Methods; transition temperature; molecular weight.

UNIT III Thermodynamics, crystallization and melting of polymer blends

Introduction to Thermodynamic Principles of blending; Thermodynamics of a Single Component Systems; Phase Separation of polymers in blends; UCST and LCST, Binodal and Spinodal regions, Methods of Measurements; Crystallization, Morphological and Melting Behavior of Polymer Blends using advanced characterization tools.

UNIT IV C**ompatibilized blends and methods of toughening**

Concept of compatibility; Types and Role of Compatibilizer; Reactive blending; Methods of Compatibilization; Mechanism of Compatibilization; Properties of Compatibilized Blends; Mechanism and Theory of Toughing; Toughening of Thermoplastics. Commercial blends.

UNIT V Rheology and applications of polymer blends and alloys

Introduction to Rheology of Miscible and Immiscible Blends; Rheological models for miscible and immiscible polymer blends and alloys; Processing of polymer blends; Applications polymer blends and alloys in Automotive, Electrical and Electronics, Medical, Packaging, construction.

References:

1. L. A. Utracki, Polymer blends and alloys, Hanser Publishers, New York, 1979
2. L. A. Utracki, Polymer Blends Hand book, Kluwer academic publishers, UK, 2002
3. L. M. Robeson, Polymer blends Hanser publications, USA, 2007
4. M. J. Folkes, P. S. Hope, Polymer blends and alloys, Springer, London, 2012

OPL 601 ADVANCED POLYMER MATERIALS

L	T	P	C
3	0	0	3

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

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

Course Outcome

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

CO1	Understand chemistry of synthesis of polymers for high tech applications and analyze the properties of high performance polymers for specificapplication like aerospace, telecomm, biomedical, defense, etc.	Understand
CO2	Understand and apply chemistry, preparation, properties and applications ofhigh temperature resistant polymers.	Apply
CO3	Understand the preparation, properties and applications of liquid crystalline polymers, silicone polymer, and any newly developed material. Nano-fillers and Polymer nanocomposites, their processing and economics.	Understand
CO4	Understand and analyze self-reinforced polymer composite, high energy absorbing polymer, super absorbent polymers, and polymers for biomedical applications.	Analyze
CO5	Understand modification techniques for preparation of specific polymerslike polymer blends & alloys.	Understand

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus

Module-I: Advanced Polymers and their Application area
Significance of advanced polymers for high-tech areas such as aerospace, telecommunication, defence, medical, etc. Characteristics and Utility of Speciality Polymers.

Module-II: High performance polymers – I
Chemistry, preparation, properties and applications of high temperature resistant polymers likepoly ether ether ketone (PEEK), Polyimides, Polysulfones, etc.

Module-III: High performance polymers – II
Preparation, properties and applications of liquid crystalline polymers, silicone polymer, and other newlydeveloped material. Nanomaterials and Polymer nanocomposites, their processing and economics.

Module-IV: High performance polymers – III
Self-reinforced polymer composite, High energy absorbing polymer, Super absorbent polymers; Hydrogels, Characteristics and Utility of these polymers.

Module-V: Commercial Polymer Blends and Alloys
Concept of Polymer blends and alloys, Types of Polymer Blends, theories of polymer miscibility, Thermodynamics of blending, various commercial blends and their applications, methods of blending.

Text Books:

1. H. F. Mark, N. G. Gaylord and N. M. Bikales, "Encyclopedia of polymer science and technology", Vol. 14, Inter science Publishers, 1971.
2. J. A. Brydson, "Plastic Materials", Butterworth-Heinemann , 2019.
3. D. S. Bag, "Principles of Polymers - A Advance Book", Nova Science publishers , N.Y. 2013.
4. Y. Osada and A. R. khokhlov, "Polymer gels and Network" Taylor & Francis Group, 2002.
5. L. A. Utracki, "Polymer Blends Hand Book", Vol. I & II, Kluwer Academic Publishers, 2002.,
6. P. Chandrashekar, "Conducting Polymers, Fundamentals and Applications" , Springer, 2002.

Reference Books:
1. H. G. Elias, "Macromolecules Synthesis", vol. 2, Materials and Technology by, Wiley-VCH, 1984.
2. J. J. Meister, "Polymer modification" , Taylor Francis, 2014.
3. G. Erhstein, "Polymeric Materials", Hanser Gardner, 2001.

Web Links:
1. https://nptel.ac.in/courses/116102006

NPL 605 SEMINAR

L	T	P	C
0	0	2	1

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

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

Course Outcome:

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

CO1	Understand a topic of latest developments/innovative technology.	Understand
CO2	Apply the knowledge to prepare a dissertation report on this topic.	Apply
CO3	Deliver a lecture on the topic on power point format.	Apply
CO4	Improve the communication skill of the students.	Apply
CO5	Analyze environment and sustainability of related technology	Analyze

Course Articulation Matrix (CO-PO Matrix) :

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

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

Syllabus:

In the seminar, power point presentation shall be prepared on polymer oriented and advanced topics with references of journal papers. Presentation is to be planned for duration of 15 minutes including a question answer session of five minutes. The marks will be awarded based on the relevance and knowledge content; language and way of presentation of the seminar.

NPL 607 DISSERTATION / PROJECT

L	T	P	C
0	0	8	16

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

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

Course Outcome

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

CO1	Understand a topic of latest developments/innovative technology.	Understand
CO2	Apply the knowledge to prepare a feasibility/dissertation report on this topic.	Apply and Analyze
CO3	Deliver a lecture on the topic on power point format.	Apply
CO4	Improve the communication skills of the students.	Apply
CO5	Analyze environment and sustainability of related technology	Analyze

Course Articulation Matrix (CO-PO Matrix)

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

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

Syllabus:

The students shall be undertaking a research project for a period of 1 year either in a leading Industry/research Institution or in the department. The research work will be guided by one supervisor from the respective industry /Institution and one supervisor from the department .The student will have to submit an interim report at the end of third semester and give a presentation in the Department. The evaluation will be made based on the thesis, the presentation and the viva voce as per university guidelines. The report may include the aspects of the literature review, identification of problem, PET chart and work done. A comprehensive oral Viva-voce examination will be conducted to assess the student's, depth of understanding of problem.

Year II, Semester IV

(Applicable from session 2024-25 for new entrants)

NPL 602 DISSERTATION / PROJECT WORK

L	T	P	C
0	0	32	16

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

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

Course Outcome

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

CO1	Understand a topic of latest developments/innovative technology.	Understand
CO2	Apply the knowledge to prepare a feasibility/dissertation report on this topic.	Apply and Analyze
CO3	Deliver a lecture on the topic on power point format.	Apply
CO4	Improve the communication skills of the students.	Apply
CO5	Analyze environment and sustainability of related technology	Analyze

Course Articulation Matrix (CO-PO Matrix)

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

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

Syllabus:

The students shall be continuing the research project guided by one supervisor from the respective industry /Institution and one supervisor from the department .The student will have to submit final thesis at the end of fourth semester and give a presentation in the Department. The final evaluation will be made based on the thesis, the presentation and the viva voce as per university guidelines. The thesis shall include the report of third semester, methodology of work and findings in proper format. A comprehensive oral Viva-voce examination will be conducted to assess the student's depth of understanding in the specified field and findings of his work, etc. An internal and external examiner shall be appointed by the University for the Conduction of viva voce under University examination System.

References for Online Courses

MOOC Courses references

1. **Thermodynamics of materials**- https://www.edx.org/course/thermodynamics-of-materials-2
   https://www.edx.org/course/thermodynamics

2. **Transport Phenomenon** - https://www.edx.org/course/analysis-of-transport-phenomena-i-mathematical-met

NPTEL Courses references

1. **Processing of Polymers & Polymer Composites** – https://nptel.ac.in/courses/112/107/112107221/

2. **Introduction to Composites** - https://nptel.ac.in/courses/112/104/112104229/

3. **Introduction to Polymer Science** - https://nptel.ac.in/courses/104/105/104105124/

4. **Polymer Chemistry** - https://nptel.ac.in/courses/104/105/104105039/

5. **Science & Technology of Polymers** - https://nptel.ac.in/courses/113/105/113105028/