SEMESTER WISE COURSE STRUCTURE

&

EVALUATION SCHEME

For

B. TECH. Hons. DEGREE

IN

CHEMICAL TECHNOLOGY

PLASTIC TECHNOLOGY

(Effective from the session 2022-23)

DEPARTMENT OF PLASTIC TECHNOLOGY

SCHOOL OF CHEMICAL TECHNOLOGY

HARCOURT BUTLER TECHNICAL UNIVERSITY

KANPUR-208002

UTTAR PRADESH

Department of Chemical Technology-Plastic Technology

Vision:

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

Mission:

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

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

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

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

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

Program Educational Objectives (PEOs)

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

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

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

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

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

Program Specific Outcomes:

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

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

Consistency of PEOs with Mission of the Department

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

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

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

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

PO1: Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.

PO2: Problem Analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)

PO3: Design/Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified with consideration for the public health and safety, whole-life cost, net zero needs carbon, culture, society and environment as required. (WK5)

PO4: Conduct Investigations of Complex Problems: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).

PO5: Engineering Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)

PO6: The Engineer and The World: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).

PO7: Ethics: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)

PO8: Individual and Collaborative Team work: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

PO9: Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences

PO10: Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

PO11: Life-Long Learning: Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

Knowledge and Attitude Profile (WK)

WK1: A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.

WK2: Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.

WK3: A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.

WK4: Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.

WK5: Knowledge, including efficient resource use, environmental impacts, whole-life cost, reuse of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.

WK6: Knowledge of engineering practice (technology) in the practice areas in the Engineering discipline.

WK7: Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.

WK8: Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.

WK9: Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

HARCOURT BUTLER TECHNICAL UNIVERSITY KANPUR

SCHOOL OF CHEMICAL TECHNOLOGY
B.TECH. PLASTIC TECHNOLOGY
Semester wise course structure
(Applicable from Session 2022-23 for new entrants)

For B.Tech. Hons. Degree in Chemical Technology (Plastic Technology) students can choose additional 20 credits from the list of following courses

Sl. No.	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
				L	T	P	MSE	TA	Lab	Total		
1	Process Equipment Design (PED)	NHCT 322	3	3	0	0	30	20	-	50	50	100
2	Process Modeling & Simulation (PMS)	NHCT 324	3	3	0	0	30	20	-	50	50	100
3	Process Optimization (PO)	NHCT 326	3	3	0	0	30	20	-	50	50	100
4	Plastic Packaging (PP)	NHPL 421	4	3	1	0	30	20	-	50	50	100
5	Polymer Adhesives (PA)	NHPL 423	4	3	1	0	30	20	-	50	50	100
6	Plastic Product Technology (PPT)	NHPL 425	4	3	1	0	30	20	-	50	50	100
7	Fiber and Film Technology (FFT)	NHPL 441	3	3	0	0	30	20	-	50	50	100
8	Polymer Coating Technology (PCT)	NHPL 443	3	3	0	0	30	20	-	50	50	100
9	Polymer Foams (PF)	NHPL 445	3	3	0	0	30	20	-	50	50	100
10	High Performance Polymer Materials (HPPM)	NHPL 461	3	3	0	0	30	20	-	50	50	100
11	Polymer Nano-composites (PNC)	NHPL 463	3	3	0	0	30	20	-	50	50	100
12	Polymer Blends (PB)	NHPL 465	3	3	0	0	30	20	-	50	50	100
13	Plastic Waste Management (PWM)	NHPL 422	4	3	1	0	30	20	-	50	50	100
14	Characterization of Polymers (COP)	NHPL 424	4	3	1	0	30	20	-	50	50	100
15	Specialty Polymers (SP)	NHPL 426	4	3	1	0	30	20	-	50	50	100

HARCOURT BUTLER TECHNICAL UNIVERSITY KANPUR
SCHOOL OF CHEMICAL TECHNOLOGY
B.TECH. PLASTIC TECHNOLOGY

Semester wise course structure

(Applicable from Session 2022-23 for new entrants)

For B.Tech. Hons. Degree in Chemical Technology (Plastic Technology)

Odd Semester

Sl. No.	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
				L	T	P	MSE	TA	Lab	Total		
1	Plastic Packaging (PP)	NHPL 421	4	3	1	0	30	20	-	50	50	100
2	Polymer Adhesives (PA)	NHPL 423	4	3	1	0	30	20	-	50	50	100
3	Plastic Product Technology (PPT)	NHPL 425	4	3	1	0	30	20	-	50	50	100
4	Fiber and Film Technology (FFT)	NHPL 441	3	3	0	0	30	20	-	50	50	100
5	Polymer Coating Technology (PCT)	NHPL 443	3	3	0	0	30	20	-	50	50	100
6	Polymer Foams (PF)	NHPL 445	3	3	0	0	30	20	-	50	50	100
7	High Performance Polymer Materials (HPPM)	NHPL 461	3	3	0	0	30	20	-	50	50	100
8	Polymer Nano-composites (PNC)	NHPL 463	3	3	0	0	30	20	-	50	50	100
9	Polymer Blends (PB)	NHPL 465	3	3	0	0	30	20	-	50	50	100

Even Semester

Sl. No.	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
				L	T	P	MSE	TA	Lab	Total		
1	Process Equipment Design (PED)	NHCT 322	3	3	0	0	30	20	-	50	50	100
2	Process Modeling & Simulation (PMS)	NHCT 324	3	3	0	0	30	20	-	50	50	100
3	Process Optimization (PO)	NHCT 326	3	3	0	0	30	20	-	50	50	100
4	Plastic Waste Management (PWM)	NHPL 422	4	3	1	0	30	20	-	50	50	100
5	Characterization of Polymers (COP)	NHPL 424	4	3	1	0	30	20	-	50	50	100
6	Specialty Polymers (SP)	NHPL 426	4	3	1	0	30	20	-	50	50	100

Course Code: NHCT 322
PROCESS EQUIPMENT DESIGN

L T P C
3 0 0 3

Course Objective: The objective of this course is to acquire basic understanding of design parameters, complete knowledge of configuration and design procedures for commonly used process equipment in important operations.

Course Outcomes:

CO1	Understand the basics of process equipment design and important parameters of equipment design	Understand, Apply
CO2	Design internal pressure vessels and external pressure vessels.	Evaluate , Apply
CO3	Analyze, synthesize and design processes for process heat exchangers.	Understand, Apply, Evaluate
CO4	Integrate and apply techniques and knowledge acquired to design distillation	Analyze, Apply, Evaluate
CO5	Design of storage tanks, other important equipments : evaporator	Analyze, Apply, Evaluate

CO-PO Mapping

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	2	2	1	-	3	-	1	1	-	2	3	3
CO2	3	3	3	2	3	3	-	1	-	-	2	3	3
CO3	3	3	3	2	3	1	-	1	-	-	3	3	3
CO4	3	3	3	2	3	1	-	1	-	-	3	3	3
CO5	3	3	3	2	3	1	-	1	-	-	3	3	3
Avg	3	2.8	2.8	1.8	3	1.8	0	1	1	0	2.6	3	3

Syllabus

Module-I:

Introduction to Equipment Design Introduction: Classification of engineering materials, engineering properties of Ferrous metals, Non ferrous metals, alloys & Ceramic materials Structure-Property relationship in materials. Deformation of Materials Fracture: Elastic deformation, Plastic deformation, Creep. Corrosion And Prevention: Direct Corrosion, electro-chemical corrosion, Galvanic cells, High temperature corrosion, Passivity, factor influencing corrosion rate, Control and

of corrosion-modification of corrosive environment, Inhibitors, Cathodic protection, protective coatings. Corrosion charts, Metal forming & Metal joining techniques – Different types

Module-II:

Type of pressure vessels, Thin cylinder theory for internal pressure. Code & standard for pressure vessels (IS:2825: 1969), Design considerations, classification of pressure vessels as per codes, design of cylindrical and spherical shells under internal and external pressure, selection and design of heads such for pressure vessel**.**

Module-III

Introduction, Basic design procedure and theory, Heat exchanger analysis: the effectiveness NTU method, Overall heat-transfer coefficient, Fouling factors (dirt factors), Shell and tube exchangers: construction details, Tubes, Shells, Tubesheet layout (tube count), Shell types (passes), Shell and tube designation, Baffles, Support plates and tie rods, Tube sheets (plates), Shell and header nozzles (branches), Design methods, Kern's method, Bell's method, Shell and bundle geometry, Effect of fouling on pressure drop, Pressure-drop limitations.

Module-IV

Design methods for binary distillation systems, Basic equations, McCabe-Thiele method, The Smoker equations, Batch distillation, Steam distillation, Plate efficiency, Prediction of plate efficiency. Approximate column sizing, Plate contactors, Selection of plate type, Plate-design procedure.

Module-V

Storage Tanks: Introduction and Classification of storage tanks; Design of storage tanks and few other important equipments: Evaporator, Dryer, Centrifuge etc

Text Books

1. L. E. Brownell and E. H. Young, "Process Equipment Design", Wiley, 2004.
2. B. C., Bhattacharya "Introduction of Chemical Equipment Design", CBS Publishers, 2003.
3. D.Q., Kern, Process Heat Transfer, International Student Edition, McGraw Hill, 2002.
4. R.E. Treybal, "Mass Transfer Operations", 3rd ed. New York: McGraw-Hill, 2017.

Reference Books

1.M.V. Joshi "Process Equipment Design 2/e", Macmillan India, 1981(reprint 1985).
2. E. E. Ludwig, "Applied Process Design for Chemical and Petrochemical Plants", Vol. 2, 3rd Ed., Gulf Publishers. 1997

Web Links:

https://archive.nptel.ac.in/courses/103/107/103107207/
https://archive.nptel.ac.in/courses/103/105/103105210/

Course Code: NHCT 324
PROCESS MODELING AND SIMULATION

L	T	P	C
3	0	0	3

Course Objective:

This course explores the basic concepts and steady state equations of simple systems in chemical process industries. It deals with the techniques for derivation of system model equations, data analysis and visualization. The course aims to present the basic idea and concept on process model with detailed analysis and solution of model equations for steady operation.

Course Outcomes:

CO1	Understand create and analyze the conservation principles, classification of models and numerical methods	Understand, & Analyze
CO2	Understand, analyze & evaluate the degree of freedom, system design variables, and flow of information in system	Understand, Analyze & evaluate
CO3	Apply the concepts to analyze and create models giving rise to nonlinear algebraic equation (NAE) systems based upon input and output data.	Apply, Analyze & Design
CO4	Apply the concepts to analyze and create models giving rise to Differential Algebraic Equations (DAEs) & Partial Differential Equations (PDEs) systems based upon input and output data.	Apply, Analyze, Evaluate, Design
CO5	Develop simulation approaches based on the concepts to solve the model equations (ANE, DAE & PDEs)	Apply, Analyze,Evaluate

CO-PO Mapping

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	3	3	3	2	-	1	-	1	1	2	**3**	**3**
CO2	3	3	3	3	3	-	1	-	1	1	2	**3**	**3**
CO3	3	3	3	2	3	-	1	-	1	1	2	**3**	**3**
CO4	3	3	3	2	2	-	1	-	1	1	2	**3**	**3**
CO5	3	3	3	3	3	-	1	-	1	2	3	**3**	**3**
Avg	3	3	3	2.6	2.6	-	1	-	1	1.2	2.2	**3**	**3**

Syllabus

Module I (6 hours)

Introduction to mathematical modeling; Advantages and limitations of models and applications of process models of stand-alone unit operations and unit processes; Classification of models: Linear vs. Non-linear, Lumped parameter vs. Distributed parameter; Static vs. Dynamic, Continuous vs. Discrete; Numerical Methods: Iterative convergence methods, Numerical integration of ODE- IVP and ODE-BVP.

Module II (6 hours)

Concept of degree of freedom analysis: System and its subsystem, System interaction, Degree of freedom in a system e.g. Heat exchanger, Equilibrium still, Reversal of information flow, Design variable selection algorithm, Information flow through subsystems, Structural effects of design variable selection, Persistent Recycle.

Module III (6 hours)

Simple examples of process models; Models giving rise to nonlinear algebraic equation (NAE) systems, steady state models of flash vessels, equilibrium staged processes distillation columns, absorbers, strippers, CSTR, heat exchangers, etc. Review of solution strategies for nonlinear algebraic equation (NAE).

Module IV (6 hours)

Steady state models giving rise to differential algebraic equation (DAE) systems; Rate based approaches for staged processes; Modeling of differential contactors-distributed parameter models of packed bed; Packed bed reactors; Modeling of reactive separation processes; Review of solution strategies for Differential Algebraic Equations (DAEs) & Partial Differential Equations (PDEs).

Module V (6 hours)

Simulation and their approaches, Modular, Sequential, Simultaneous and Equation solving approach, Simulation software and their applications. Review of available numerical software libraries.

Text Books

[1] A. K. Jana, “Chemical Process Modelling and Computer Simulation”, PHI, 2011.
[2] Asghar Hussain, “Chemical Process Simulation”, Wiley Eastern Ltd., New Delhi, 1986.
[3] M.M. Denn, “Process Modelling”, Wiley, New York, 1990.

Reference Books

[1] C.D. Holland, “Fundamentals of Modelling Separation Processes”, Prentice Hall, (1975)
[2] D. F. Rudd and C. C. Watson, “Strategy of Process Engineering”, Wiley international, 1971
[3] W.L., Luyben “Process Modeling, Simulation, and Control for Chemical Engineering”, Mc Graw Hill.

Web Links

https://archive.nptel.ac.in/courses/103/107/103107096/

COURSE CODE: NHCT 326
PROCESS OPTIMIZATION

L	T	P	C
3	0	0	3

Course Objective

The primary goal of this course is to provide an overview of state-of-the-art optimization algorithms, and the theoretical principles that underpin them, and to provide students with the modeling skills necessary to describe and formulate optimization problems and their use for solving several types of practically relevant optimization problems arising in process systems engineering.

Course Outcomes:

CO1	To identify different types of optimization problems	Understand, Apply
CO2	To explain different optimization techniques	Apply, Evaluate
CO3	To solve various multivariable optimization problems	Analyze, Evaluate
CO4	To solve problems by using Linear Programming	Apply, Evaluate
CO5	To solve optimization problems of staged and discrete processes, understand the concept of specialized & Non-traditional Algorithm	Understand, Apply, Evaluate

Table: Correlation of POs, PSOs v/s COs

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO 2
CO1	3	1	2	2	1	-	1	3	-	-	3	2	2
CO2	3	3	3	3	2	-	1	3	-	-	3	2	2
CO3	3	3	3	3	3	-	1	3	-	-	3	2	2
CO4	2	3	3	1	3	-	1	2	-	-	3	2	2
CO5	2	3	3	1	2	-	1	1	-	-	3	3	3
Average	2.6	2.6	2.8	2	2.2	-	1	2.4	-	-	3	2.2	2.2

Syllabus

Module 1 (6 hours) Introduction to process optimization; formulation of various process optimization problems and their classification. Basic concepts of optimization-convex and concave functions, necessary and sufficient conditions for stationary points.

Module 2 (6 hours) Optimization of one- dimensional functions, unconstrained multivariable optimization-direct search methods. Bracketing methods: Exhaustive search method, Region elimination methods: Interval halving method, Fibonacci search method, Golden section search method.

Module 3 (5 hours) Linear Programming: Primal Simplex method, Artificial starting solution, Dual Simplex method, Primal-Dual relationship, Simplex method.

Module 4 (8 hours) Multivariable Optimization Algorithms: Optimality criteria, Unidirectional search, direct search methods, Powell's conjugate direction method. Gradient-based methods: Cauchy's (steepest descent) method, Newton's method. Constrained Optimization Algorithms: Kuhn-Tucker conditions, Transformation methods: Penalty function method, method of multipliers, Direct search for constraint minimization: Variable elimination method

Module 5 (5hours). Dynamic programming, Introduction to Specialized & Non-traditional Algorithms: Genetic Algorithm

Text Books

1 T.F. Edgar and D.M. Himmelblau, "Optimization of Chemical Processes", Mc Graw Hill, International editions, chemical engineering series, 2001

2. S. S. Rao, Engineering Optimization Theory and Practice, Fifth Edition, John Wiley & Sons, Inc., 2019

3. G.S. Beveridge and R.S. Schechter, "Optimization theory and practice", Mc Graw Hill, Newyork, 1970.

Reference book:

1. Hamdy A. Taha, " Operation Research", Pearson, 2008

Web Links

https://archive.nptel.ac.in/courses/103/105/103105139/

NHPL 421 PLASTIC PACKAGING (PP)

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

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

- To understand concept of packaging and utility of plastics in packaging.
- To analyze properties of polymers for their utility in packaging of variety of products.
- To understand the common techniques of plastic packaging
- To apply and understand the quality check of plastic packages
- To understand the recent development in plastic packaging sector

Course Outcome

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

CO1	Understand plastic packaging, scope, advantages and disadvantages of plastic packages, and application of polymer films for packaging.	Understand
CO2	Understand and analyze selection criteria for various household and industrial polymeric packages, utility on various fields.	Analyze
CO3	Understand the concept of common plastic Packaging Techniques	Understand
CO4	Apply and understand the Performance evaluation of packaging materials by quality check	Apply and understand
CO5	Understand the Recent Development in plastic packaging sector	Understand

Course Articulation Matrix (CO-PO Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3		2			3					3	3	3
CO2	3	2	2			3					3	3	3
CO3	3		2	1		3					3	3	3
CO4	3		2			3	1				3	3	3
CO5	3		2			3				1	3	3	3
Total	**3**	**2**	**2**	**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: Elements of packaging

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

Module-II: Polymer Packaging Materials
Selection criteria of various household and industrial polymeric packages. Polymers packaging materials: LLDPE, HDPE, PVC, nylon, PS and expanded polystyrene, etc.

Module-III: Packaging Techniques
Packaging techniques, Thermoforming, co-extrusion, extrusion-stretch blow molding, extrusion, calendaring, coating and laminating, etc. Production of BOPP films, Printing on polymeric packages.

Module-IV: Testing and quality control
Performance evaluation of packaging materials by impact test, bursting strength, tensile strength, tear strength, drop test, puncture test, etc.

Module-V: Recent Development in plastic packaging sector
Newer developments in polymer packaging, Global market of polymers in packaging, Active and intelligent packaging, Green plastics for food packaging, global policies and regulations.

Textbook:

1. Sir Geoffrey Allen, "Comprehensive Polymer Science"Vol.7,Pergamon Press, 1989.
2. C. R. Oswin, "Plastics film sand packaging", Wiley, 1975.
3. S. E. M. Selke, "Understanding Plastics Packaging Technology (Hanser Understanding Books)"Hanser Pub Inc; First edition, 1997.

Reference Books:

1. N. P. Cheremisinoff, "Hand Book of Polymer Science and Technology",V0l.4,CRC Press, 1989.
2. J. F. Hamlin, "Science and Technology of Polymer films", Wiley-Inter science, Vol. I, 1968.
3. C. R. Oswin, "Protective Wrapping",Cam[den] Publications, 1954.
4. Dr. O. G. Piringer, Dr. A. L. Baner, "Plastic Packaging: Interactions with Food and Pharmaceuticals", Second Edition, Wiley-VCH Verlag GmbH & Co. KGaA, 2008.
5. S. E. M. Selke, John D. Culter, Ruben J. Hernandez, "Plastics Packaging: Properties, Processing, Applications, and Regulations", Hanser Pub., 2004.

Web links:

1. https://www.youtube.com/watch?v=VjKRPOUMu-8

NHPL 423 POLYMER ADHESIVES (PA)

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

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

- To understand concepts of adhesion and adhesives.
- To understand the types of adhesives and their applications, surface treatments and preparation for adhesive bonding.
- To understand formulation and production techniques for variety of adhesives.
- To understand adhesives for biomedical applications& Sealants.

Course Outcome:

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

CO1	Understand the concept of adhesion, adhesive joints and mechanism of adhesives.	Understand
CO2	Understand and apply the surface preparation and surface treatments for various substrates.	Apply
CO3	Understand the principle of adhesives formulation and production techniques.	Understand
CO4	Analyze properties of polymers for constitution of variety of adhesives.	Analyze
CO5	Introduction to Biomedical Adhesives & Sealants.	Understand and Analyze

Course Articulation Matrix (CO-PO Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3					2					3	3	3
CO2	3					2					3	3	3
CO3	3					2					3	3	3
CO4	3	2	1			2					3	3	3
CO5	3			1		2					3	3	3
Total	**3**	**2**	**1**	**1**		**2**					**3**	**3**	**3**

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

Detailed Syllabus

Module – I: Introduction and adhesion theories

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

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

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

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

Module – V: Introduction to Biomedical Adhesives and Sealants
Introduction to Biomedical Adhesvies, Types of Cynoacrylates, Biopolymer based on Gelatin, Protein & Polysachride, Photo crosslinkables Sealants.

Textbooks:

1. S. Wu, "Polymer Interface and Adhesion", CRC Press, 1982.
2. P. Ghosh, "Adhesives and Coatings Technology", Publisher: TMH, 2008.
3. K. L. Mittal, F. M. Etzler, "Adhesion in Pharmaceutical, Biomedical and Dental Fields" Wiley-Scrivener, 2017.

Reference Books:

1. Skiest, "Handbook of Adhesives", Springer New York, NY, 1990.
2. R. Dulac "Industrial Cold Adhesive", Sagwan Press, 2015.
3. E. W. Flick "Handbook of Adhesives Raw material", Book News, Inc., Portland, 1982.
4. H.A. Perry, "Handbook of Sealants & Adhesives", McGraw Hill Professional, 2007.
5. S. Ebnesajjad, "Adhesives Technology Handbook", Second Edition, William Andrew Inc. 2009.

Web links:

1. https://www.digimat.in/nptel/courses/video/105106205/L64.html

NHPL 425 PLASTIC PRODUCT TECHNOLOGY (PPT)

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

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

- To understand the necessity of plastic product design
- Understand basic and important plastic product design features.
- Apply the plastic product design features for practical situations.
- Apply knowledge of design feature in complex and assembly products.
- Understand capabilities of computer program based design soft wares

Course Outcome

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

CO1	Understand the basic requirements designing of a plastic product.	Understand
CO2	Understand the difference in design of plastic products in comparison on to other materials.	Understand
CO3	Understand the design guidelines of various product design features.	Apply
CO4	Global Trends in Product Design	Apply
CO5	Understand the applications of materials data based product and mould designing software's (eg. Moldflow).	Apply

Course Articulation Matrix (CO-PO Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3			1		2					3	3	3
CO2	3	1		1	1	2					3	3	3
CO3	3		1	1	1	2		1			3	3	3
CO4	3			1		2					3	3	3
CO5	3			1	1	2			1		3	3	3
Total	**3**	**1**	**1**	**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

Module-I: Plastic product design criteria

Design of polymeric products, design criteria based upon product functions and geometry, material selection by property assessment, Global Trends in Product Design

Module-II: Product Design Features

Moulding consideration: Draft, radii, dimensional tolerances, wall thickness, ribs and bosses, inserts, sink marks, undercuts, feeding system, gate location, flow pattern, shrinkage and post moulding shrinkage.

Module-III: Injection Mold Design
Injection mould design: single, multi cavity, semi- automatic and automatic moulds, Types of injection moulds, their applications, Cost of molding

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

Module-V: Computer Aided Design
Concept of CAD/CAM in product design and moulding. Modeling and Simulation applications for plastic product designing, such as PROE, CATIA, CREO, NX, Solid works, Solid Edge, etc.

Text books:

1. R. D. Beck., "Plastic Product Design", Van Nostrand Reinhold Inc., U.S., 1971.
2. R.G.W. Pye. "Injection mould Design", East-West Press Pvt., 2000.
3. N. P. Cheremisin off, "Product Design and Testing of Polymeric Materials", Marcel Dekker, Inc, New York, 1990.
4. P.C. Sharma, "A Text Book of Production Technology", S. Chand and Company, 4th Edition, 2008.
5. HMT – "Production Technology", Tata McGraw-Hill, 2001.

Reference Books:

1. Rosato & Rosato, "Injection Moulding", 3rd edition, Kluwer Academic Publishers, 2000.
2. R.K. Jain, "Production Technology", vol. 1, 2019.

Web Links:

1. https://www.youtube.com/watch?v=QxZ54WgYhnA

PEC-III

NHPL 441 FIBRE AND FILM TECHNOLOGY (FFT)

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

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

- To understand the basics of fibre technology.
- 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
- To understand the recycling and biodegradation of plastics.

Course Outcome

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

CO1	Understand the fundamentals of fibre technology.	Understand
CO2	Understand and apply fibre manufacturing and processing of various synthetic fibre.	Understand and Apply
CO3	Understand and apply finishing and dyeing of fibre along with different finishing techniques.	Understand and Apply
CO4	Understand and apply principle, technology and operation of equipment and machinery for processing of films.	Understand, and Apply
CO5	Understand and apply various types of films and their applications in various sectors.	Understand and Apply

Course Articulation Matrix (CO-PO Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3										3	3	3
CO2	3					1				1	3	3	3
CO3	3	2		1		2		1	1	1	3	3	3
CO4	3		2		1	2	1	1	1	1	3	3	3
CO5	3		2			2	1	1	1	1	3	3	3
Total	**3**	**2**	**2**	**1**	**1**	**1.75**	**1**	**1**	**1**	**1**	**3**	**3**	**3**

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

Detailed Syllabus

Module-I: Basic Concepts of Fibre Technology

Introduction to natural and synthetic fibres. Essential characteristics and molecular architecture of fibre forming polymers. Concept of Filament and Yarn. Concept of order in fibre, crystallinity and orientation, physical structure of natural and synthetic fibres, optical properties. Spinneret, Fibre drawing, heat setting, texturing.

Module-II: Processing and Manufacturing of Fibres
Melt, dry and wet spinning of fibres. Effect of spinning on filament structure and properties. Manufacturing details, properties and applications of fibres based on polyethylene, polyamide, polypropylene, polyester, acrylic, polylactic acid. Production of staple yarns of natural and synthetic fibres. Global, Indian and Local Scenario of fibre industries.

Module-III: Finishing and Dyeing of Fibres
General principles of finishing and dyeing of fibres. Types of finishes applied to textile fibres. Dyeing of synthetic fibres in loose and yarn form. Carrier dyeing. High temperature dyeing. Acid and base dyeing. Thermosets process for dyeing.

Module-IV: Film forming polymers as packaging material
Structure, property, and morphology of film forming polymers used as packaging materials. Equipment and machinery for processing of films, principle, technology and operation of equipment, economics of packaging, the design of film making. Packaging for electronic goods, commodity materials, medicines and food products. Global, Indian and Local scenario of packaging industries.

Module-V: Types of Films and Details
Blown Film: principle, technology and operation of equipment for processing of blown film. Melt Processed Film: materials, processes, equipment and machinery for melt processing of film. Multi Layered Films: materials and equipment for multi layered films, applications of multi layered films. Tetra-packs.

Text Books:

1. H. F. Mark, S. M. Atlas, and E. Cernia, “Man-made fibres: Science and technology”, Wiley Inter science, 1968.
2. R. W. Moncrieff, “Man-made fibres”, Haywood Books, 1975.
3. A. A. Vaidya, “Production of synthetic fibers”, , Prentice Hall, 2001.
4. V. B. Gupta and V. K. Kothari, “Manufactures fiber technology”, Chapman and Hall, 2003.
5. J. H. Bryston, “Plastic films”, 2003.
6. D. Brooks and G. Giles, “PET packaging technology”, Sheffield Academic Press, 2002.
7. J. Osswald, Hanser Gardner, “Polymer processing fundamentals”, 2004.
8. J. Lagaron, “Multifunctional and nanostructured polymers for food packaging”, Woodhead Publishing Ltd., 2011.

Reference Books:

1. B. L. Deopura, R. Alagirusamy, N. Gupta and M. Joshi, “Fibrous Materials : Polyesters and Polyamides”,Woodhead Publishing Ltd and CRC Press, 2008.
2. F. Fourne,“Synthetic Fibres, Machines and Equipment, Manufacture, Properties”, Hanser Publishers, 1999.
3. B. P. Corbman,“Textiles : fibre to fabric”, McGraw Hill, 1983.

Web Links:

1. https://nptel.ac.in/courses/116102010
2. https://nptel.ac.in/courses/116102026

NHPL 443 POLYMER COATING TECHNOLOGY (PCT)

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

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

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

Course Outcome:

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

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

Course Articulation Matrix (CO-PO Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3					1					2	3	3
CO2	3					1					2	3	3
CO3	3					1					2	3	3
CO4	3		1			1					2	3	3
CO5	3	2	1			1					2	3	3
Total	**3**	**2**	**1**			**1**					**2**	**3**	**3**

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

Detailed Syllabus

Module-I: Elements of surface coatings

Development of surface coating, basic components of paint, varnishes and lacquers. Functions of coatings and mechanism of film formation. Characteristics of binders for coating and paints.

Module-II: Pigments and Pigmentation

Types of Pigment and pigmentation. Dispersion techniques, role of wetting agents, driers, solvent

and plasticizers in coatings.

Module-III: Formulation and Manufacture of coatings
Coating formulation and function of its components. Antifouling Coating, sustainable Resource based coatings, Compounding of coating formulations, Machines/Ball milling, Coating Processes: Roller coating, powder coating, etc. Global policies and regulations for Safety, health and hazards.

Module-IV: Surface Preparation and Pre-treatments
Requirement of surface preparation, Surface preparation and pretreatment techniques, Rhelogical behaviour and testing of coatings, Application methodology and curing mechanism for coatings.

Module-V: Industrial and Specialty Coatings
Application of Specialty coatings: water based coating, powder coating and high solid content coating etc. Utility of Industrial and architectural coatings and finishes.

Textbook:

1. H.F.Pyne, "Organic Coating Technology Vol.I & II", Wiley, 1954.
2. J.J.Mattiello, "Protective and Decorative coatings",Mcgraw-hill Book Company,inc,NY.1942.
3. V.C.Bidlack & E.W. Fasig, "Paint and Varnishes Production Manual",Wiley, 1951.
4. A. D. Wilson, "Surface Coatings—2", Springer Science & Business Media, 2012.
5. A. A. Tracton,"Coatings Technology Handbook", CRC Press, 2005.

Reference Books:

1. G. dewith, "Polymer Coatings: A Guide to Chemistry, Characterization, and Selected Applications", John Wiley & Sons, 2018.
2. S. M. Rangappa, J. Parameswaranpillai, S. Siengchin, "Polymer Coatings: Technologies and Applications", CRC Press, 2020.
3. Inamuddin, R. Boddula, Mohd Imran Ahamed, A. M. Asiri, "Polymer Coatings: Technology and Applications", Scrivener Publishing LLC, 2020.

Web Links:
1. https://www.digimat.in/nptel/courses/video/112105053/L35.html
2. https://www.youtube.com/watch?v=tyKtUoQo9VM

NHPL 445 POLYMER FOAMS (PF)

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

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

- To understand the basics of polymer foams, application area and production technology.
- To understand the chemistry of foam formation, significance of cell structure and size on the properties of polymer foams.

Course Outcome

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

CO1	To understand the basics of polymer foams and chemistry of foam formation	Understand
CO2	To understand the various types of foam technologies and analyze its commercial importance	Understand and analyze
CO3	To develop the concept of cell design in view of cell size, cell morphology and apply its knowledge for modification of foam properties	Understand and apply
CO4	To understand the synthesis and properties of common polymer foams such as EVA foams, LDPE foams, PS foams, PU foams, etc.	Understand
CO5	To understand and analyze the local and international market for polymer foams.	Understand and analyze

Course Articulation Matrix (CO-PO Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3										3	3	3
CO2	3					1					3	3	3
CO3	3	2				1		1			3	3	3
CO4	3		1			1		1			3	3	3
CO5	3		1			1		1			3	3	3
Total	**3**	**2**	**1**			**1**		**1**			**3**	**3**	**3**

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

Detailed Syllabus

Module-I: Introduction to Polymer Foams

Basics of polymer foams, Foaming agents, Physical and Chemical blowing agents, Chemistry of foam formation: Cell nucleation, growth and cell stabilization**.**

Module-II: Foaming Technologies

Industrial foam technologies: Foam extrusion molding, Foam injection molding, Testing and quality control.

Module-III: Concept of Cell Design
Concept of cell size, cell type, cell morphology; rigid and flexible foam, effect of cell design on foam properties.

Module-IV: Common polymer foams
Synthesis and properties of different types of polymeric foams: EVA foams, LDPE foams, PS foams, PU foams, memory foams, silicone foams, synthetic viscoelastic urethane polymer, etc.

Module-V: Market for Polymer foams
Application of polymer foams in transportation, building and construction, furtinutes, bedding, medical, packaging, etc. Recent advancements in Polymer Aerogels.

Textbook:

1. D. Eaves, "Handbook of Polymer Foams", Rapra Technology, 2004
2. B. Obi,"Polymeric Foams Structure-Property-Performance A Design Guide", Elsevier Science, 2017.
3. N. S. Ramesh, S.-T.Lee, "Polymeric Foams Mechanisms and Materials" CRC Press, 2004.
4. S.Sinha Ray, R. Banerjee, "Foamability of Thermoplastic Polymeric Materials" Elsevier Science, 2021.

Reference Books:

1. S.-T.Lee, "Polymeric Foams Innovations in Processes, Technologies, and Products", CRC Press, 2016.
2. K.Ashida, K.Ashida, "Polyurethane and Related Foams Chemistry and Technology" CRC Press, 2006.
3. S.-T. Lee, "Polymeric Foams Innovations in Technologies and Environmentally Friendly Materials", CRC Press, 2022.
4. Robert J. Pugh, "Bubble and Foam Chemistry (eBook)",Cambridge University Press, 2016.
5. "Handbook of Foaming and Blowing Agents" 1st Edition, Chem Tech Publishing, 2017.

Web Links:
1.https://www.youtube.com/watch?v=62czT-p7JLE

NHPL 461 HIGH PERFORMANCE POLYMER MATERIALS (HPPM)

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

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

- To understand the basic chemistry and synthesis, and applications of high performance polymers.
- To understand the synthesis and applications of thermally stable and high performance polymers.

Course Outcome

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

CO1	Understand chemistry and synthesis of polymers for high tech applications and analyze the properties of high performance polymers for specific application like aerospace, telecomm, biomedical, defense etc.	Understand and Apply
CO2	Understand and apply chemistry, preparation, properties and applications of high temperature resistant polymers such as PEEK, polyetherimide, polyarylether ketone, superior PTFE, polyoxymethylene (POM).	Understand and Apply
CO3	Understand the preparation, properties and applications of liquid crystalline polymers, silicone polymer, etc. Nano-fillers and nano-composites, their processing and economics.	Understand and Apply
CO4	Understand and analyze self-reinforced polymer composite, high energy absorbing polymer, super absorbent polymers, self-healing polymer, and polymers for biomedical applications.	Understand and Analyze
CO5	Understand modification techniques for preparation of specific polymers like polymer blends & alloys, hydrophilic plastic materials as liberating material, etc.	Understand

Course Articulation Matrix (CO-PO Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3					3						3	3
CO2	3	2		2		3					3	3	3
CO3	3	2				3	1				3	3	3
CO4	3	2				3	1				3	3	3
CO5	3	3	2			3		3	1	1	3	3	3
Total	**3**	**2.3**	**2**	**2**		**3**	**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: Role of Polymers for High-tech areas

Chemistry and synthesis of polymers for high tech applications, properties of high performance polymers and advanced polymeric composites for specific application like aerospace,

telecommunications, microelectronics, insulations, optical fibre cables, biomedical, defense, etc. and their future prospective.

Module-II: High performance polymers – I

Chemistry, preparation, properties and applications of high temperature resistant polymers like polyetherether ketone (PEEK), polyetherimide, polyarylether ketone, superior PTFE, polyoxymethylene (POM), polyphenylenesulphide**,** polysulphones, polyphenyleneoxide.

Module-III: High performance polymers – II

Preparation, properties and applications of liquid crystalline polymers, silicone polymer, and other newly developed material. Nanofillers and nanocomposites, their processing and economics.

Module-IV: High performance polymers – III

Self-reinforced polymer composite. High energy absorbing polymer. Super absorbent polymers. Polymers for biomedical applications. Conducting polymers-properties and applications. Self-healing polymers. Self-reinforced polymer composite. High energy absorbing polymer.

Module-V: Modification of Polymers

Polymer blends and alloys, theories of polymer miscibility, various commercial blends and their applications, methods of blending. Molecularlarly designed synthesis and characterization of light sensitive and photoconducting polymers and their applications. Hydrophilic plastic materials as liberating material.

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

NHPL 463 POLYMER NANOCOMPOSITES (PNC)

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

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

- To understand the basic of Nanoscience and nanotechnology and its application for the preparation of polymer nanocomposites.
- To understand the synthesis and characterization of nanomaterials and polymer nanocomposites and its utility.

Course Outcome

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

CO1	To understand about the importance of Nano science and nanotechnology and nanocomposites	Understand
CO2	To understand about the Concept of dispersion in Polymer nanocomposites	Understand
CO3	To understand about the Synthesis of Nanomaterials and Nanocomposites	Understand
CO4	To apply the concept of Characterization of Nanomaterials and Nanocomposites	Apply
CO5	To analyze the application of Polymer Nanocomposites	Analyze

Course Articulation Matrix (CO-PO Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3					3					3	3	3
CO2	3					3			1		3	3	3
CO3	3					3	1		1		3	3	3
CO4	3					3	1	1	1	1	3	3	3
CO5	3					3	1	1	1	1	3	3	3
Total	**3**					**3**	**1**	**1**	**1**	**1**	**3**	**3**	**3**

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

Detailed Syllabus

Module-I: Basics concept to Nanoscience and nanotechnology

Introduction to Nano science and nanotechnology, ethical issues in nano science and nanotechnology, Nanomaterials and its classification, concept of nanocomposites, significance of nanocomposites, impact of nanomaterials on sustainability.

Module-II: Concept of dispersion in Polymer nanocomposites
Concept of dispersion, functionalization of nanomaterials to improve dispersion, Rule of mixing of composites, improvement in dispersion by different techniques such as ultrasonication, high speed mixing, etc.

Module-III: Synthesis of Nanomaterials and Nanocomposites
Synthesis of nanomaterials by different techniques such as sol-gel, hydrothermal, chemical vapor deposition, etc. Synthesis of polymer nanocomposites by melt blending, solution bleding, in situ polymerization, etc.

Module-IV: Characterization of Nanomaterials and Nanocomposites
Basic characterization of nanomaterials and polymer nanocomposites by structural characterization by XRD, Morphological characterization by SEM and TEM; Mechanical characterization by UTM; thermal characterization by DCS and TGA, etc.

Module-V: Application of Polymer Nanocomposites
Local and global market for polymer nanocomposites, Application of nanocomposites in medical, energy, electronics, industrial and structural applications; Recent development in the area of sensors, actuators, robotics, etc.

Textbook:

1. R. K. Gupta, E. Kennel, K.J. Kim, "Polymer Nanocomposites Handbook" 1st Edition, CRC Press, 2010.
2. X. Huang, C.Zhi,"Polymer Nanocomposites: Electrical and Thermal Properties", Springer Cham, 2016.
3. J. H. Koo, "Polymer Nanocomposites: Processing, Characterization, And Applications", McGraw Hill Professional, 2010.
4. Y.W. Mai, Z. Z. Yu "Polymer Nanocomposites", Woodhead Publishing 2006.

Reference Books:

5. Dr. V. Mittal "Polymer Nanocomposites: Emerging Applications", 2018 ISBN: 978-1-925823-15-8, sales@centralwestpublishing.com.
6. R. Pandey, K. K., Kar, K. Jitendra, Sravendra, "Handbook of Polymer Nanocomposites. Processing, Performance and Application", Springer, 2014.
7. S. K. Sharma, D. S. Verma, L. U. Khan, S. Kumar, S. B. Khan, "Handbook of Materials Characterization", Springer, 2018.
8. K. K. Kar and A. Hodzic, "Developments in Nanocomposites".Research Publishing Services, 2014.

NHPL 465 POLYMER BLENDS (PB)

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

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

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

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

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

Course Articulation Matrix (CO-PO Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3					1					3	3	3
CO2	3					1					3	3	3
CO3	3					1					3	3	3
CO4	3	2	1			1					3	3	3
CO5	3			1		1					3	3	3
Total	**3**	**2**	**1**	**1**		**1**					**3**	**3**	**3**

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

Detailed Syllabus

Module – I: Introduction to polymer blends
Definition of blends and alloys, global need for blending, classification of blends; examples of different types of polymer blends, selection criteria of blend components, fundamental principles of blending, national and international market of polymer alloys and blends;

Module – II: Miscibility/ Immiscibility of polymers
Concept of miscibility; Classification of polymer blends, Miscible Blends and Immiscible Blends - characteristics of Miscible and Immiscible Blends; Phase Equilibria, Huggins - Flory Theory;

Factors Affecting Miscibility of Polymer Blends

Module – III: Blending process

Methods of blending; concept of Compatibilizers, Significance of Compatibilizer; Compatibilization Methods; methods of blending, equipments for blending: mixers' and their various types like banbury, hot and cold mixers, twin screw compounders, and two- roll mills, etc.

Module – IV: Properties and application of polymer blends

Mechanical, thermal and rheological properties of polymer blends; Applications of blends and alloys in emerging sectors like Automotive , Electrical and Electronics, Medical, Building and Construction, Business Machines and Communications, Packaging

Module – V: Characterization of polymer blends

Characterization of blends, Measurements of Crystallization, Morphological and Melting Behavior of Polymer Blends.

Textbook:

1. L.A.Utracki,"Polymer blends and alloys",HanserPublishers,NewYork,1979
2. L.M.Robeson,"Polymer blends" Hanser publications,USA,2007
3. M.J.Folkes, P.S. Hope, "Polymer blends and alloys",Springer,London,2012

Reference Books:

1. L.A.Utracki, "Polymer Blends Handbook", Kluwer academic publichers, UK, 2002
2. D.R.Paul and S.Newman, "Polymer Blends Vol. I and II", Academic Press Inc, 1978.
3. L. A. Utracki, "Polymer Blends Handbook" 1st Edition, Springer, 2002.
4. C. Vasile , K. Kulshreshtha , "Handbook of Polymer Blends and Composites: v. 1",SmithersRapra Technology, 2002.

Web Links:

1. https://www.youtube.com/watch?v=JYOxeMr2UqI

NHPL 422 PLASTIC WASTE MANAGEMENT (PWM)

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

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

- To understand the plastic waste production 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
- To understand the recycling and biodegradation of plastics.

Course Outcome

CO1	Understand the fundamentals of plastic waste management and plastic waste separation technologies.	Understand
CO2	Understand and apply the plastic resource recovery.	Understand and Apply
CO3	Understand and apply social and environmental challenges of plastic waste.	Apply
CO4	Understand the recycling of plastic waste and apply and analyze various recycling processes.	Understand, Apply and Analyze
CO5	Understand and apply biodegradable plastics for multifarious applications.	Understand and Apply

Course Articulation Matrix (CO-PO Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	1				2		1	1		3	3	3
CO2	3	1				2		1	1		3	3	3
CO3	3	1				2		1	1		3	3	3
CO4	3	1			1	2	1	1	1		3	3	3
CO5	3	1	2	2		2	1	1	1		3	3	3
Total	**3**	**1**	**2**	**2**	**1**	**2**	**1**	**1**	**1**		**3**	**3**	**3**

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

Detailed Syllabus

Module-I: Introduction to Plastic Waste Management

Global, Indian and Local Scenario of plastic production and consumption, Sources of plastic waste, Plastic waste composition, quantities, Disposal alternatives, Waste separation technologies, viz. Sorting – Manual, automated, Density separation, Flotation, Solvent separation, Melt filteration.

Module-II: Plastic Waste Management

4 R and I approach, viz. Source reduction, Reuse, Repair, Recycling, and Incineration with examples, Single-used plastic and its impact on environment. Conversion of plastic waste into value added products, Case studies of plastic waste management, success stories of various Indian cities.

Module-III: Global 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. Extended producer responsibility (EPR) for plastic waste management.

Module-IV: Recycling Technology

Recycling and recovery of various plastics items/materials-their effect on environment. Recycling methods. Mechanical recycling of commonly used plastics. Chemical recycling/feedstock recycling. Recycling of thermosets and used rubber tyres, Pyrolysis and energy recovery.

Module-V: Biodegradable Polymers

Biodegradable polymers - prospects & utilization, Environmental issues, policies and legislations in India. Prospects for biodegradable plastics based on renewable resource polymers. Biodegradable polymers for various applications viz. food packaging, agriculture, etc. Green Plastics.

Text Books:

1. M. Srinivasan and N. Subramaniam, "Plastic Waste Management", Wiley, 2019.
2. N. Mustafa, "Plastics Waste Management", Marcel Dekker, 1995.
3. Anthony L. Andrady,"Plastics and the Environment", Wiley Interscience, 2003.
4. N. Mustafa, "Plastics Waste Management, Disposal Recycling and reuse", Marcel Dekker, 1993.
5. Dr. J. S. Anand, "Recycling and Plastics Waste Management", CIPET, 1997.
6. A. C. Albertson and S. J. Huang, "Degradable polymers, Recycling and Plastic Waste Management", Taylor & Francis, 1995.
7. S. Ebnesjjad, "Handbook of Biopolymers and Biodegradable Plastics", Elsevier, 2012.

Reference books:

1. D. V. Rosato & R.T. Schwartz, "Environmental effect on polymeric materials", Interscience Publishers, 1968.
2. M. Forrest, "Recycling and Re-use of waste rubber", Smithers Rapra Technology, 2014.
3. J. Scheirs, "Polymer recycling-Science, Technology and Applications", John Wiley and Sons, 1988.

Web links:

1. https://onlinecourses.nptel.ac.in/noc20_ce13/preview

NHPL 424 CHARACTERIZATION OF POLYMERS (COP)

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

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

- To understand the importance of characterization techniques for polymers in different areas of application
- To understand the structural, spectroscopic, thermal, morphological, mechanical characterization of polymers.

Course Outcome

CO1	Understand the determination of molecular weight of polymers by modern characterization techniques.	Understand and apply
CO2	Understand the working principle and instrumentation of spectroscopic techniques.	Understand
CO3	Understand the Mechanical and Thermomechanical Characterization techniques for polymers.	Understand and apply
CO4	Understand the working principle and instrumentation of modern thermal characterization techniques.	Understand
CO5	Understand the working principle and instrumentation of microscopic techniques.	Understand

Course Articulation Matrix (CO-PO Matrix)

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**
CO1	3	1									3	3	3
CO2	3	1									3	3	3
CO3	3	1				2					3	3	3
CO4	3	1				2				2	3	3	3
CO5	3	1			1	2				2	3	3	3
Total	**3**	**1**			**1**	**2**				**2**	**3**	**3**	**3**

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

Detailed Syllabus:

Module-I: Determination of Molecular Weight

Determination of molecular weight by end group analysis, viscometry, light scattering, gel permeation chromatography, osmometry, etc.

Module-II: Spectroscopic Characterization
Sample preparation, Working principle, Instrumentation and identification of polymers by Infrared spectroscopy, UV-vis spectroscopy, Nuclear magnetic resonance spectroscopy, X-ray diffraction techniques.

Module-III: Mechanical and Thermomechanical Characterization
Sample preparation, working principle, Instrumentation of UTM. Determination of tensile strength, Young's modulus, strain strain behavior, etc. Sample preparation, Working principle, Instrumentation and importance of Dynamic mechanical analyzer.

Module-IV: Thermal Characterization
Sample preparation, Working principle, Instrumentation of Diffential scanning calorimerty, Thermogravimetric analyzer, Differential thermal analyzer, Limiting Oxygen Index.

Module-V: Morphological and Surface Characterization
Sample preparation, Working principle, Instrumentation of Scanning electron microscopy, Transmission electron microscopy, Atomic force microscopy.

Textbook:

1. D. Campell and J.R.White, "Polymer characterization, Physical Techniques", McGraw – Hill, New York, 1969.
2. M.Stamm, "Polymer Surfaces and Interfaces", Springer, 1st Ed., 2008.
3. L. HSperling, "Introduction to Physical Polymer Science," Wiley, 1986.

Reference Books and Suggested Readings:

1. S. R. Sandler, W. Karo, Jo-Anne Bonesteel and E. M. Pearce,"Polymer Synthesis and Characterization", Academic Press 1998.
2. B. H. Stuart,"Polymer Analysis", John Wiley & Sons, 2002.
3. H. Barth,"Modern Methods of Polymer Characterization", John Wiley & Sons, 1991.

Web Links:

1. https://archive.nptel.ac.in/courses/103/105/103105219/

NHPL 426 SPECIALTY POLYMERS (SP)

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

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

- To understand the utility of specialty polymers in modern areas of applications.
- To understand the concept of heat resistant polymers, conducting polymer, ionic polymers, etc.

Course Outcome

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

CO1	Understand the concept of heat resistant polymers	Understand
CO2	Understand the concept of conducting polymer	Understand
CO3	Understand the concept of ionic polymers	Understand
CO4	Understand the concept of high performance polymers	Understand
CO5	Understand the concept of colloids	Understand

Course Articulation Matrix (CO-PO Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3					3						3	3
CO2	3	2		1		3					3	3	3
CO3	3	2				3	1				3	3	3
CO4	3	2				3	1				3	3	3
CO5	3	2	2			3			1	1	3	3	3
Total	**3**	**2**				**3**	**1**		**1**	**1**	**3**	**3**	**3**

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

Detailed Syllabus:

Module-I: High Temperature Resistant

Structural Requirement of polymers for high temperature resistance, high temperature resistant thermoplastics like fluoropolymers, polysulphones, polyesters, polyphenylene sulphide, PEEK, polyimides, etc. their synthesis, properties & applications.

Module-II: Conducting Polymers

Structural requirement of polymer for conduction of electricity, mechanism of conduction and their utility in variety of applications. Synthesis and properties of conducting polymers like polyaniline, polyphenylene sulphide and poly 1,6 heptadiene, etc.

Module-III: Ionic polymers

Synthesis, physical properties and applications of ionic polymers, ion exchange resins, hydrophilicity, ionomers based on polyethylene, PS, PTFE, elastomeric ionomers, aromatic ionomers, polyelectrolytes, biological ionic polymers, inorganic polymers

Module-IV: High performance polymers

High performance polymers for engineering applications, synthesis, properties and applications of polymers for high-tech engineering applications, like construction, marine, automobile, space aviation and rockets, etc.

Module-VI: Polymer Colloids

Thermodynamics and stability of polymer colloids, kinetics of polymerization, coagulation, nucleation of aqueous and non-aqueous polymer colloids, applications of polymer colloids Characteristic properties and technologies used for characterization.

Textbook:

1. F. Mohammad, "Specialty Polymers: Materials and Applications". I. K. International Pvt. Ltd, 2007
2. R. K. Gupta, "Specialty Polymers Fundamentals, Properties, Applications and Advances", 1st Edition, CRC Press, 2023

Reference Books and Suggested Readings :

1. R. W. Dyson, "Specialty Polymers", Springer Science & Business Media, 2012.
2. J. A. Brydson, "Plastics Materials", Butterworth-Heinemann in Oxford, Toronto. 1999.
3. P. Ghosh, "Polymer Science and Technology", McGraw-Hill Education LLC, 1990.

Web Links:

1. https://archive.nptel.ac.in/courses/113/105/113105028/