हरकोर्ट बटलर प्राविधिक विश्वविद्यालय
नवाबगंज, कानपुर–208002, उ0प्र0, (भारत)
Harcourt Butler Technical University
Nawabganj, Kanpur-208002, U.P. (INDIA)
(Formerly Harcourt Butler Technological Institute, Kanpur)
Phone: +91-0512-2534001-5, Fax : +91-0512-2533812, Website : http://www.hbtu.ac.in E-mail : vc@hbtu.ac.in

Department: Plastic Technology

School: School of Chemical Technology

Name of Programme: B. Tech.

Academic Session 2021-22

Total no. of courses in the Programme: 60

% Change in the course curriculum : 12/60=20%

No. of courses where syllabus revision was carried out BoS		
S. No.	**Name of course**	**Course code**
1	Polymer Chemistry	TPL 201
2	Polymerization Engineering I	TPL 202
3	Polymer Processing I	TPL 301
4	Rheology and Testing of Polymers	TPL 303
5	Polymer Processing II	TPL 302
6	Structure & Property of Polymers	TPL 304
7	Polymerization Engineering II	TPL 306
8	Technology Of Elastomers	TPL 401
9	Advanced Polymeric Materials	TPL 403
10	Programme Elective Course II (Polymer Ahesives and Foams)	TPL 409
11	*Programme Elective Course III (Plastic Packaging & Waste Management)	TPL 402
12	PEC I (Polymer Blends & Alloys)	TPL 455

Number of Courses related with employability/ entrepreneurship/ skill development

Courses related with employability/ entrepreneurship/ skill development		
S. No.	**Name of course**	**Course code**
1	Polymer Chemistry	TPL 251
2	Polymer Chemistry Lab	TPL 253
3	Fluid Mechanics and Mechanical operation	TPL 255
4	Materials & Energy Balance	TPL 257
5	Polymerization Engineering I	TPL 252
6	Heat Transfer Operations	TPL 254
7	Chemical Engineering Thermodynamics	TPL 256

8	Polymer Processing I	TPL 351
9	Rheology and Testing of Polymers	TPL 353
10	Polymer Testing Lab	TPL 355
11	Mass Transfer Operations	TPL 357
12	Chemical Reaction Engineering	TPL 359
13	Polymer Processing II	TPL 352
14	Structure & Property of Polymers	TPL 354
15	Polymerization Engineering II	TPL 356
16	Plastic Product and Mold Design	TPL 358
17	Polymer Composite	TPL 360
18	Instrumentation & Process Control	TPL 362
19	Technology Of Elastomers	TPL 451
20	Advanced Polymeric Materials	TPL 453
21	Industrial Training	TPL 493
22	Seminar	TPL 495
23	Project	TPL 497

Elective courses in the programme

S. No.	Program Elective Courses	Name of Course	Course code
1	PEC I	Polymer Blends & Alloys Polymer Product Technology	TPL 455 TPL 457
2	PEC II	Polymeric Adhesives & Foams Polymer Nanocomposites	TPL 459 TPL 461
3	PEC III	Plastic Packaging & Waste Management Polymer Coating Technology	TPL 452 TPL 454
4	PEC IV	Process Modeling & Simulation Computer Aided Equipment Design	TPL 456 TPL 458

New courses introduced		
S. No.	Name of course	Course code
1	Polymer Product Technology	TPL 457
2	Polymer Nanocomposites	TPL 461
3	Polymer Blends and Alloys	TPL 455
4	Polymer Chemistry Lab	TPL 253
5	Polymer Testing Lab	TPL 355

Signature and Seal

Head of Department

Dr. Indira Nigam
Professor & Head
Dept. of Plastic Technology
H.B. Technical University, Kanpur

SEMESTER WISE COURSE STRUCTURE & EVALUATION SCHEME

B. TECH. CHEMICAL TECHNOLOGY- PLASTIC TECHNOLOGY

Semester-I

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab.	Total		
1	BSC	Engineering Chemistry	BCY 101	4	3	0	2	15	20	15	50	50	100
2	BSC	Mathematics I	BMA 101	4	3	1	0	30	20	-	50	50	100
3	ESC	Electronics & Instrumentation Engineering	EET 101	3	3	0	0	30	20	-	50	50	100
4	ESC	Engineering Graphics	ECE 101	3	0	0	6	30	20	-	50	50	100
5	ESC	Computer Concepts & Programming	ECS 101	4	3	0	2	15	20	15	50	50	100
6	ESC	Workshop Practice	EWS 101	2	0	0	4	--	20	30	50	50	100
7	MC (Non Credit)	Environment & Ecology	ECE 103	0	2	0	0	30	20	-	50	50	100
		Total Credits 20											**600**

Semester-II

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks ESE					Total Marks
					L	T	P	CT	TA	Lab	Total		
1	BSC	Physics	BPH 102	4	3	0	2	15	20	15	50	50	100
2	BSC	Mathematics II	BMA 102	4	3	1	0	30	20	-	50	50	100
3	ESC	Electrical Engineering	EEE 102	4	3	0	2	15	20	15	50	50	100
4	ESC	Engineering Mechanics	EME 102	3	3	0	0	30	20	-	50	50	100
5	HSMC	English Language & Composition	HHS 102	2	2	0	0	30	20	-	50	50	100
6	HSMC	Professional Communication	HHS 104	3	3	0	2	15	20	15	50	50	100
		Total Credits 20											**600**

Semester-III

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	BSC	Mathematics III	BMA 201	4	3	1	0	30	20	-	50	50	100
2	PCC	Polymer Chemistry	TPL 201	4	3	1	0	30	20	-	50	50	100
3	PCC	Polymer Chemistry Lab	TPL 203	2	0	0	4	-	20	30	50	50	100
4	ESC	Fluid Mechanics and Mechanical operation	TPL 205	5	3	1	2	15	20	15	50	50	100
5	PCC	Materials & Energy Balance	TPL 207	4	3	1	0	30	20	-	50	50	100
	HSMC	Organizational Behaviour	HHS 203	3	3	0	0	30	20	-	50	50	100
7	MC (Non Credit)	Cyber Security	ECS 205	0	2	0	0	30	20	-	50	50	100
	Total Credits 22												**600**

Semester IV

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	BSC	Modern Analytical Techniques	BCY 202	4	3	0	2	15	20	15	50	50	100
2	BSC	Computer Oriented Numerical Methods	BMA 202	4	2	1	2	15	20	15	50	50	100
3	PCC	Polymerization Engineering I	TPL 202	5	3	1	2	15	20	15	50	50	100
4	ESC	Heat Transfer Operations	TPL 204	3	2	1	0	30	20	-	50	50	100
5	PCC	Chemical Engineering Thermodynamics	TPL 206	3	2	1	0	30	20	-	50	50	100
6	HSMC	Engg Economics & Management	HHS 202	3	3	0	0	30	20	-	50	50	100
7	MC (Non Credit)	Indian Constitution	HHS 206	0	2	0	0	30	20	-	50	50	100
	Total Credits 22												**600**

Semester-V

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	PCC	Polymer Processing I	TPL 301	5	3	1	2	15	20	15	50	50	100
2	PCC	Rheology and Testing of Polymers	TPL 303	4	3	1	0	30	20	-	50	50	100
3	PCC	Polymer Testing Lab	TPL 305	2	0	0	4	-	20	30	50	50	100
4	PCC	Mass Transfer Operations	TPL 307	4	3	1	0	30	20	-	50	50	100
5	PCC	Chemical Reaction Engineering	TPL 309	4	3	1	0	30	20	-	50	50	100
6	OEC (Humanities)	Open Elective Course -I	HHS 341	3	3	0	0	30	20	-	50	50	100
	Total Credits				**22**								**600**

Semester-VI

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab.	Total		
1	PCC	Polymer Processing II	TPL 302	3	2	0	2	15	20	15	50	50	100
2	PCC	Structure & Property of Polymers	TPL 304	3	2	1	0	30	20	-	50	50	100
3	PCC	Polymerization Engineering II	TPL 306	4	3	0	2	15	20	15	50	50	100
4	PCC	Plastic Product and Mold Design	TPL 308	3	2	1	0	30	20	0	50	50	100
5	PCC	Polymer Composite	TPL 310	3	3	0	0	30	20	0	50	50	100
6	PCC	Instrumentation & Process Control	TPL 312	3	2	1	0	30	20	-	-	50	100
7	OEC (Maths)	Open Elective Course -II	BMA 342	3	3	0	0	30	20	-	50	50	100
		Total Credits			**22**								**700**

Semester-VII

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	PCC	Technology Of Elastomers	TPL 401	2	2	0	0	30	20	-	50	50	100
2	PCC	Advanced Polymeric Materials	TPL 403	3	2	0	2	15	20	15	50	50	100
3	PEC	Programme Elective Course I (Polymer Blends & Alloys OR Plastic Product Technology)	TPL 405 OR TPL 407	3	3	0	0	30	20	-	50	50	100
4	PEC	Programme Elective Course II (Polymer Ahesives and Foams OR Polymer Nanocomposite)	TPL 409 OR TPL 411	3	3	0	0	30	20	-	50	50	100
5	OEC (Plastic Tech.)	Open Elective Course -III	TPL 415	3	3	0	0	30	20	-	50	50	100
6		Industrial Training	TPL 461	2	0	0	4	-	50	-	50	50	100
7		Seminar	TPL 471	2	0	0	4	-	50	-	50	50	100
8		Project	TPL 497	4	0	0	8	-	50	-	50	50	100
			Total Credits	**22**									**800**

Semester-VIII

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	PEC	*Programme Elective Course III (Plastic Packaging & Waste Management OR Polymer Coating Technology)	TPL 402 OR TPL 404	4	3	1	0	30	20	-	50	50	100
2	PEC	*Programme Elective Course IV (Process Modeling & Simulation Or Computer aided Equipment Design)	TPL 406 OR TPL 408	4	3	1	0	30	20	-	50	50	100
3	OEC (Chemical Engg.)	*Open Elective Course –IV (Transport Phenomena)	TCH 420	4	3	1	0	30	20	-	50	50	100
4		Project	TPL 498	10	0	0	20	-	50	-	50	50	100
			Total Credits	**22**									**400**

*** Online Courses**

List of Programme Elective Courses

S. No.	PEC Names	Subject Name	Subject Code	C (L-T-P)
1.	Programme Elective Course I	Polymer Blends & Alloys	TPL 405	3 (3-0-0)
		Polymer Product Technology	TPL 407	
2.	Programme Elective Course II	Polymeric Adhesives & Foams	TPL 409	3 (3-0-0)
		Polymer Nanocomposites	TPL 411	
3.	Programme Elective Course III	Plastic Packaging & Waste Management	TPL 402	4 (3-1-0)
		Polymer Coating Technology	TPL 404	
4.	Programme Elective Course IV	Process Modeling & Simulation	TPL 406	4 (3-1-0)
		Computer Aided Equipment Design	TPL 408	

List of Open Elective Courses

S. No.	OEC Names	Subject Name	Subject Code	C (L-T-P)
1.	Open Elective Course II (Humanities)	Entrepreneurship Development	HHS 341	3 (3-0-0)
2.	Open Elective Course II (Maths)	Operations Research	BMA 342	3 (3-0-0)
3.	Open Elective Course III (Plastic Technology)	Introduction to Polymer Technology	TPL 415	3 (3-0-0)
4.	Open Elective Course IV (Chemical Engg)	Transport Phenomenon	TCH 420	4 (3-1-0)

B. Tech. Chemical Technology - Plastic Technology

Semester- 3

TPL 201 POLYMER CHEMISTRY

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	PCC	Polymer Chemistry	TPL 201	4	3	1	0	30	20	-	50	50	100

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

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

Course Outcome

CO1	Understand the fundamentals types and properties of polymers.	Understand
CO2	Understand and apply the chain growth polymerization 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 and its types, ring opening polymerization.	Analyze

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 "-"*

Syllabus

Module-I: Basics of Polymer formation

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

Module-II: Introduction to polymerizations

Overview of polymer/petrochemical industries with reference to application, classification of polymers, stereochemistry of polymers, general theory of chain growth polymerization. Free radical polymerization, types of initiators. Kinetics of free radical polymerization, auto-acceleration.

Module -III: Condensation Polymerizations

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

Module-IV: Molecular Weight and its Control

Concept of Molecular weight of polymers, factors affecting molecular weight and molecular weight distribution, polydispersity. Chain transfer reactions, retarders, inhibitors, effect of temperature on polymerization

Module-V: Copolymerization and other Reactions

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

Reference Books and Suggested:

1. F. W. Billmeyer, "Text Book of Polymer Science ", John. Wiley & Sons, 1990.
2. Vasant R. Gowariker, "Polymer Science", New Age International, 1986.
3. Premamoy Ghosh, " Polymer Science and Technology ", Tata McGraw-Hill Education, 1990.
4. George Odian, " Principles of Polymerization ", Wiley, 1981.
5. Paul J. Flory, " Principles of Polymer Chemistry ", Cornell University Press, 1953.
6. Robert W. Lenz, " Organic Chemistry of Synthetic High Polymers ", John Wiley & Sons Inc, 1967.
7. D. Margerison, " An Introduction to Polymer Chemistry ", Pergamon, 1967.
8. Introduction to Polymers, R.J. Young & P.A. Livell Ch. & Hall, London, 1981
9. Polymer Chemistry, Seymour & Caraher, Marcel Decker, 2003

TPL 203 POLYMER CHEMISTRY LAB

L	T	P	C
0	0	4	2

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

- To apply laboratory methods of analysis for estimation of purity monomers, initiators and solvents used for polymerization.
- To apply laboratory techniques for determination of physical properties of monomers and solvents
- To apply analytical methods for identification of polymers

Course Outcome

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

CO1	apply laboratory methods of analysis for estimation of purity	Apply
CO2	apply laboratory techniques for determination of physical properties of monomers and solvents	Apply
CO3	apply analytical methods for identification of polymers	Apply

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

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

Module-VI: Laboratory Experiments

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

	Laboratory Experiments	
1	Determination of refractive index of organic compounds	03
2	Purification of monomers and determining the yield and refractive index of the purified monomer	06
3	Purification of solvent by washing and determination of yield	06
4	Determination of percentage purity of initiators, viz. benzoyl per oxide, AIBN, etc.	06
5	Determination of percentage purity of potassium persulphate	06

6	Determination of percentage purity of phenol	06
7	Determination of percentage purity of formaldehyde	06
8	Determination of density of given polymer sample	03
	Determination of specific gravity of given moulded sample of plastic	03
10	Identification of known and unknown polymer (unprocessed and processed) samples	12

Reference Books and Suggested :

1. George Odian, " Principles of Polymerization ", Wiley, 1981.
2. Paul J. Flory, " Principles of Polymer Chemistry ", Cornell University Press, 1953.
3. Robert W. Lenz, " Organic Chemistry of Synthetic High Polymers ", John Wiley & Sons Inc, 1967.

TPL 205 FLUID MECHANICS&MECHANICAL OPERATIONS

L	T	P	C
3	1	2	5

Assessment:

Sessional: 50 marks

End Semester: 50 marks

Course Objective:

To understand basic concept of fluid flow and its application to chemical process industries including pipe flow, fluid machinery and agitation & mixing.

Course outcomes:

CO 1	Understand the need of fluid mechanics for chemical engineers	Understand
CO 2	Understand the basic terms and their concepts of fluid flow	Understand
CO 3	Apply the knowledge to develop a dimensional number for the fluid flow	Apply, Create
CO 4	Understand the fundamentals in characterization and classification of solids	Apply, Analyze
CO 5	Understand the sieving performances using different sieve size	Analyze, Evaluate
CO 6	Calculate the crushing efficiency of different size reduction equipment using crushing laws	Analyze, Evaluate

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	3	1	1	-	-	2	-	-	1	-	2	**3**	**2**
CO2	3	3	3	-	-	1	1	-	-	1	-	2	3	3
CO3	3	3	3	3	2	1	1	-	-	1	-	2	3	2
CO4	3	2	1	-	-	2	2	-	-	1	-	2	3	3
CO5	3	3	1	3	1	2	1	-	-	1	-	3	3	2
CO6	3	2	2	2	1	2	1	-	3	1	-	3	3	3
Avg.	3.00	2.67	1.83	1.50	0.67	1.33	1.33	-	0.5	1	-	2.33	3	2.5

Syllabus

Module I (8 hours)

Introduction to process fluid mechanics; Fundamental concepts: Definition of a fluid; Continuum hypothesis; Velocity field; Stress field; Newtonian and non-Newtonian fluids, Fluid statics: pressure variation in a static fluid, hydrostatic forces on submerged surfaces, buoyancy, Manometers. Dimensional analysis and similitude: Buckingham Pi theorem and applications

Module II (8 hours)

Macroscopic Balances: derivation of integral balances for mass, energy and momentum; Derivation of engineering Bernoulli equation with losses, Application of macroscopic balances: Losses in expansion,

Force on a reducing bend, Diameter of a free jet; Jet ejector. Flow measurement: Orifice meter, venturi meter, Pitot tube, and Rota meter.

Module III (8 hours)

Differential balances of fluid flow: derivation of continuity and momentum (Navier-Stokes) equations for a Newtonian fluid, Boundary layer theory, Pipe flows and fittings: laminar and turbulent flows; friction factor charts, losses in fittings, Fluid transportation: Valves and Pumps and Compressors.

Module IV (8 hours)

Flow through packed and fluidized beds: Flow through beds of solids, motion of particles through the fluid, Particle settling, Fluidization, minimum fluidization velocity, Mixing and Agitation- power consumption, mixing times, scale up

Module V (8 hours)

Filtration: Governing equations, constant pressure operation, constant flow operation, cycle time, types of filters. Centrifuges and Cyclones: Gravity settling, centrifugal separation, cyclone separations, separation efficiency, pressure loss,

Reference:

1. McCabe and Smith, Unit Operations of Chemical Engineering: McGraw Hill

2. Coulson & Richardson , Chemical Engineering Vol. I: Pergamon, 1979 McGraw hill

3. Gupta, Vijay and S. K. Gupta, “Fluid Mechanics and its Applications”, Wiley Eastern, New Delhi (1984).

4. W.L.Badger and J.T.Banchero, Introduction to Chemical Engineering, TMH (1979)

TPL 207 MATERIAL AND ENERGY BALANCE

L	T	P	C
3	1	0	4

Assessment:
Sessional: 50 marks
End Semester: 50 marks

Course Objective:

To understand and apply the basics of calculations related to material and energy flow in the processes.

Course Outcome

CO1	Demonstrate comprehensive understanding of material and energy balance equations for open and closed systems.	Understand, Apply, Remember
CO2	Select appropriate basis and conduct degree of freedom analysis before solving material and energy balance problems.	Apply, Evaluate
CO3	Make elementary flow-sheets and perform material and energy balance calculations without and with chemical reactions, and involving concepts like recycle, bypass and purge.	Analyse, Evaluate
CO4	Perform process calculations utilizing psychometric charts and steam tables.	Understand, Apply, Evaluate
CO5	Apply simultaneous material and energy balance calculations for steady state continuous flow systems and unsteady state systems	Understand, Apply, Evaluate

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	3	2	1	-	-	-	-	-	-	1	1	**1**	**3**
CO2	3	3	3	2	-	-	-	-	-	-	-	1	2	3
CO3	3	3	3	3	2	2	1	-	-	1	1	1	2	3
CO4	3	3	2	2	1	-	-	-	-	1	1	1	1	3
CO5	3	3	2	1	-	-	-	-	-	-	1	1	2	3
Avg	3	3	2.4	1.8	0.6	0.4	0.2	-	-	0.4	0.8	1	1.6	3

Syllabus

Module 1 (9 hours)

Dimensions, system of units and their conversions, Mass and volume relations, Basic stoichiometric principles, limiting and excess reactants, Degree of completion, Conversion, selectivity, yield. Ideal gas law, Dalton's Law, Amagat's Law, Introduction to degrees of freedom analysis.

Module 2 (7 hours)

Vapor pressure of liquids and solids, Vapor pressure plot (Cox chart), Vapor pressures of miscible and immiscible liquids and solutions, Raoult's Law and Henry's Law. Humidity and saturation use of humidity charts for engineering calculations.

Module 3 (8 hours)

Material balance without chemical reactions and its application to unit operations like distillation, absorption etc. Material balance with chemical reaction Recycle, bypass and purging.

Module 4 (8 hours)

Heat capacity of gases, liquids and solutions Heat of fusion and vaporization. Steady state energy balance for systems with and without chemical reactions. Calculations and application of heat of reaction combustion, formation, neutralization and solution. Enthalpy-concentration charts. Orsat analysis Calculation of theoretical and actual flame temperatures

Module 5 (8 hours)

Simultaneous material and energy balance. Introduction to Unsteady state material and energy balance.

Suggested Text books

1. Hougen, O.A., Watson, K.M and Ragatz, R.A., " Chemical Process Principles Part-I ",John Wiley and Asia Publishing, 1970.
2. Himmelblau, D.M., "Basic Principles and Calculations in Chemical Engineering" ,sixth Edition, Prentice Hall Inc., 1996.
3. Felder, R.M. & Rousseau, R.W. "Elementary Principles of Chemical Processes ", 3rd edition. JohnWiley. (1999)
4. Bhatt, B.L., VORA, S.M., "Stoichiomentry ", Tata McGraw-Hill, 1976.

Suggested Reference Books

1. Venkataramani, V., Anantharaman, N., Begum, K. M. MeeraSheriffa, "ProcessCalculations" , Second Edition, Prentice Hall of India.
2. Sikdar, D. C., "Chemical Process Calculations", Prentice Hall of India.

Semester- 4

TPL 202 POLYMERIZATION ENGINEERING – I

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
3	PCC	Polymerization Engineering I	TPL 202	5	3	1	2	15	20	15	50	50	100

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

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

Course Outcome

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

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

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				3	3	3
CO4	3	3				2		1				3	3	3
CO5	3	3	3	2	1	2				1	1	3	3	3
CO6	3	3	2	2		2			2			3	3	3
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 "-"*

Syllabus

Module-I: Industrial Polymerization

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

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

Module-III: Production of Commodity Thermoplastics
Manufacturing processes, properties and applications of various polyolefins such as LDPE, HDPE, and their copolymer grades, polypropylene and its copolymer grades.

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

Module-V: Production of polymers and copolymers of styrene & Vinyl chloride
Production technology, properties and application of polystyrene, poly(vinyl_chloride), and their copolymer grades.

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

Reference Books and Suggested Readings :

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

TPL 204 HEAT TRANSFER OPERATIONS

L	T	P	C
2	1	0	3

Assessment:

Sessional: 50 marks

End Semester: 50 marks

Course Objective: To understand the fundamentals of heat transfer mechanisms in fluids and solids and their applications in various heat transfer equipment in process industries.

Course outcomes:

CO 1.	Understand different modes of heat transfer.	Understand
CO 2	Apply the concepts of one-dimensional and multi-dimensional; steady and unsteady state conduction heat transfer, and relevant boundary and initial conditions in problem solving.	Apply, Analyze ,Evaluate
CO 3.	Apply the knowledge of analytical and graphical (temperature charts) techniques in solving specific transient heat conduction problems, including lumped and one-dimensional systems	Apply, Evaluate
CO 4	Understand the concept of temperature-dependent buoyancy which causes natural free convection, and apply the dimensionless Grashof number used in correlations for free convective heat transfer calculations	Understand, Analyze, Evaluate
CO 5.	Understand phase-change phenomena and latent heat of vaporization, including free convective, nucleate and film boiling, as well as dropwise and film condensation	Understand, Analyze

		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1		3	2	1	1	-	-	2	-	-	1	-	1	**1**	**2**
CO2		3	3	3	3	2	1	1	-	-	1	-	1	2	2
CO3		3	3	3	3	3	1	1	-	-	1	1	1	1	2
CO4		3	2	3	3	3	2	2	-	-	1	1	1	2	2
CO5		3	3	3	3	1	2	1	-	-	1	1	1	1	2
Avg.		3	2.6	2.6	2.6	1.8	1.2	1.4	-	-	1	0.6	1	1.4	2

Syllabus

Module 1 (6 hours)

Introduction ot heat transfer and general concepts of heat transfer by conduction, convection and radiation, Conduction: Basic concepts of conduction in solids, liquids, gases, steady state temperature fields and one dimensional conduction without heat generation e. g. through plain walls, cylindrical and spherical surfaces, composite layers, Insulation materials, critical and optimal, insulation thickness, Extended surfaces, fins and their applications, Introduction to unsteady state heat transfer.

MODULE 2 (6 hours)

Convection: Fundamentals of convection, Basic concepts and definitions, natural and forced convection, hydrodynamic and thermal boundary layers, laminar and turbulent heat transfer inside tubes, Dimensional analysis, determination of individual and overall heat transfer coefficients, heat transfer in molten metals.

MODULE 3(6 hours)

Radiation: Basic laws of heat transfer by radiation, black body and gray body concepts, view factors, Kirchoff's law, solar radiations, combined heat transfer coefficients by convection and radiation.

MODULE 4(6 hours)

Heat Transfer by phase change: Condensation of pure vapours, film wise and drop wise condensation, eat transfer in boiling liquids, boiling heat transfer coefficients, Evaporation: Elementary principles, types of evaporators, Single and multiple effect evaporators.

MODULE 5(6 hours)

Heat exchangers: Types of heat exchangers, Principal components of a concentric tube & shell-and-tube heat exchangers, baffles, tube and tube distribution, tubes to tube sheet joint, heat exchanger with multiple shell and tube passes, log-mean temperature difference, overall heat transfer coefficient, fouling factors, design of double pipe and shell and tube heat exchangers.

BOOKS:

1. "Heat Transfer principles and applications" Dutta, B. K., PHI
2. "Heat Transfer" Holman J. P, 9th Ed. McGraw Hill.
3. "Process Heat Transfer". Kern D. Q. McGraw Hill Book
4.Heat and Mass Transfer Fundamentals and Applications, Cengel Y. A. and Ghajar A. J., McGraw Hill,5th edition, 2016.

TPL 206 CHEMICAL ENGINEERING THERMODYNAMICS

Assessment:
Sessional: 50 marks

End Semester: 50 marks

L	T	P	C
2	1	0	3

Course Objective:

To understand the theory and applications of classical thermodynamics, thermodynamic properties, equations of state, methods used to describe and predict phase equilibria.

Course outcomes:

CO 1	Understand the basic of thermodynamics and the terminology associated with engineering thermodynamics	Understand
CO 2	Understand the knowledge of contemporary issues related to chemical engineering thermodynamics	Understand
CO 3	Understand and apply the knowledge of phase equilibria in two-component and multi-component systems	Understand, Apply
CO 4	Analyse the thermodynamic properties of substances in gas or liquid state of ideal and real mixture	Apply
CO 5	Understand intermolecular potential and excess property behaviour of multi-component systems	Understand

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	2	1	1	-	-	1	-	-	1	-	1	**1**	**2**
CO2	3	1	1	1	-	3	3	-	-	1	-	1	2	2
CO3	3	3	2	2	3	-	-	-	-	1	-	1	1	2
CO4	3	3	3	2	3	1	1	-	-	1	-	1	2	2
CO5	3	2	2	3	2	1	1	-	-	1	-	1	2	2
Avg.	3	2.2	1.8	1.8	1.6	1	1.2	-	-	1	-	1	1.6	2

Syllabus

Module 1 (8 hours)

Basic Concepts & First Law of Thermodynamics: Scope of thermodynamics, System & Surroundings, Properties -Force, Temperature & pressure, Equilibrium, Processes- Reversible & Irreversible, Work, Heat, Energy ,Phase rule, Joule's Experiment, Internal energy, Enthalpy, Heat capacities, Application of first law to closed & open systems.Volumetric properties of pure fluids: PVT behavior of pure substances, Virial equation of state and its application ,ideal gas and cubic equation of state, Generalized correlations for gases and liquids.

Module 2 (6 hours)

Second Law of Thermodynamics: Heat engine and its efficiency, Heat pump, Refrigerator, COP, Second law of Thermodynamics, Kelvin–Planck statement &Clausius Statement, Carnot's cycle and Carnot theorems, Clausius inequality, Entropy balance for open systems, ideal work and lost work, Principle of entropy.

Module 3 (6 hours)

Residual properties, two phase systems: Clapeyron equation, Estimation of thermodynamic properties by using graphs and tables.Solution thermodynamics Theory: Fundamental property relation, Chemical potential and phase equilibria ,Partial properties ,Ideal gas mixture model.

Module 4 (6 hours)

Fugacity and fugacity coefficient for pure species and in solution, Ideal solution model and excess properties.Solution thermodynamics Application: Liquid phase properties from VLE data, Models for the excess Gibbs energy, Property changes of mixing.

Module 5 (4 hours)

Phase Equilibria: Nature of equilibrium, phase rule, VLE qualitative behavior, Simple Models for VLE, VLE by Modified Raoultslaw and VLE from K-value charts.

Reference

1. "Introduction to Chemical Engineering Thermodynamics" by J.M. Smith and H.C. Van Ness, McGraw Hill International Ltd, 2005.

2. "Chemical Engineering Thermodynamics" by Y.V.C. Rao, Universities Press (India) Ltd. Hyderabad.

3. "Chemical and Process Thermodynamics", Kyle B.G., 3rd ed., Prentice Hall. 1999

4. "Chemical Engineering Thermodynamics", by Narayanan, K.V., Prentice Hall. 2007

SEMESTER- 5

TPL 301 POLYMER PROCESSING – I

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	PCC	Polymer Processing 1	TPL 301	5	3	1	2	15	20	15	50	50	100

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

- To understand the various processing techniques used for polymer processing.
- To learn the fundamentals of extrusion and different extrusion processes of thermoplastics.
- To learn the basic principle of compounding of thermoplastics and calendaring process.
- To process plastics on different types of moulding machines and prepare simple articles.

Course Outcome

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

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

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

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

Course Level Assessment Questions

Syllabus

Module-I: Introduction to Polymer Processing and Extrusion

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

Module-II: **Fundamentals of Extrusion Process of Polymers**
Fundamentals of single screw extrusion, twin screw extrusion and co-extrusion operation; Construction of Barrel and screw for commodity, heat sensitive and engineering plastics.

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

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

Module-V: Calendaring of plastics

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

Module VI: Laboratory Experiments

Preparation of simple plastic products and test specimen on Extrusion; Preparation of Fiber reinforced plastic sheet by using glass fiber mat and unsaturated polyester resin; Preparation of sheet by Hydraulic press/Two Roll Mill

Reference Books and Suggested Readings :

1. Plastics Extrusion, by Allen Grief
2. Plastic Engineering Handbook (SPI), by Frados
3. Screw extrusion of Plastics, by Jacobi
4. Plastic materials and processes (a concise encyclopedia), by Charles Harper
5. Polymer Mixing and Extrusion Technology, by Nicholas Cheremisinoff
6. Plastics Extrusion Technology, Hanser SPE, 1996
7.

TPL 303 RHEOLOGY AND TESTING OF POLYMERS

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	PCC	Rheology and Testing of Polymers	TPL 303	4	3	1	0	30	20	-	50	50	100

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

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

Course Outcome

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

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

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

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

Syllabus

Module -I: Fundamentals of Polymer Rheology

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

Module-II: Mechanical Models and Polymer Rheology

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

Module – III: Measurement of viscosity and Rheometers

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

Module-IV: Testing of Polymer Properties

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

Module-V: Characterization of Polymers

Introduction to polymer characterization by instrumental techniques such as IR, NMR, DSC, TGA, etc.

Reference Books and Suggested Readings :

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

TPL 305 POLYMER TESTING LAB

L	T	P	C
0	0	4	2

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

- To determine various mechanical properties of plastic and rubber materials
- To determine the rheological properties of polymers
- To determine the thermal properties of polymers.

Course Outcome

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

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

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

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

Course Outcome

Determination of various mechanical properties of polymers and rubbers by standard test methods
Determination of viscosity and melt flow index of polymers.
Determination of various thermal properties of polymers by standard test methods
Analyze properties for their correlation with actual performance

Module-VI: Laboratory Experiments
Determination of Tensile Strength and Percent Elongation of polymer film/sheet/molded plastic/rubber specimen
Determination of the Izod/Charpy Impact Strength of given specimen,
Determination of the Vicat Softening point/
Melt Flow Index of given plastic sample,
Determination of the Shore A Hardness of Rubber Sheet,

Determination of the Percent Water Absorption in 24 hours of Molding Plastic samples, Determination of the Falling Dart Impact Strength of polyethylene film,
Determination of viscosity of polymer by Brookefield viscometer,

	Laboratory Experiments	
1	Determination of Tensile Strength and Percent Elongation of polymer film/sheet	06
2	Determination of the Vicat Softening point of given plastic sample on Vicat Softening Point apparatus	06
3	Determination of Tensile strength, Modulus and Percent Elongation of moulded plastic specimen	06
4	Determination of the Izod/Charpy Impact Strength of given specimen	06
5	Determination of the Melt Flow Index of polymer raw material by MFI tester	06
6	Determination of the Shore A Hardness of Rubber Sheet	06
7	Determination of the Percent Water Absorption in 24 hours of Moulding Plastic samples	06
8	Determination of the Falling Dart Impact Strength of polyethylene film using Falling Dart Impact Tester	06
	Determination of viscosity of polymer by Brookefield viscometer	06
10	Determination of Tensile strength, Modulus and Percent Elongation of rubber specimen	06
	Total hours	**60**

TPL 307 MASS TRANSFER OPERATION

L	T	P	C
3	1	0	4

Assessment:

Sessional: 50 marks

End Semester: 50 marks

Course Objectives: The purpose of this course is to introduce the undergraduate students with the most important separation equipments in the process industry, and provide proper understanding of unit operations.

Course outcomes:

CO 1	Understand the principles of molecular diffusion and basic laws of mass transfer.	Understand,
CO 2	Ability to determine mass transfer rates using Fick's Law	Apply
CO 3	Estimate diffusion coefficients and apply to practical problems	Apply
CO 4	Ability to determine convective mass transfer rates	Apply
CO 5	Analyze the Similarity of mass, heat and momentum transfer – Analogy and understand the humidification processes and use of psychometric chart	Analyze

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	2	2	1	-	-	-	-	-	1	1	1	**1**	**2**
CO2	3	2	1	1	-	-	-	-	-	1	1	1	2	1
CO3	3	2	3	2	3	-	-	-	-	1	1	1	1	2
CO4	3	3	2	2	3	-	-	-	-	1	1	1	1	2
CO5	3	3	3	3	2	-	-	-	-	1	1	1	3	2
Avg	3	2.4	2.2	1.8	1.6	-	-	-	-	1	1	1	1.6	1.8

Syllabus

Module I (8 hours)

Mass Transfer and Diffusion: Steady-state ordinary molecular diffusion: Fick's law of diffusion; Velocities in mass transfer, Equimolar counter diffusion; unimolecular diffusion, Diffusion coefficients: Diffusivity in gas mixtures, diffusivity in liquid mixtures, Diffusivity in solids, One-dimensional, steady-state, molecular diffusion through stationary media, Mass transfer in turbulent flow: Reynolds analogy; Chilton-Colburn analogy; Other analogies, Models for mass transfer at a fluid-fluid interface: Film

theory; Penetration theory; surface-renewal theory; film-penetration theory, Two-film theory and overall mass transfer coefficients. Introduction to absorption.

Module II (8 hours)

Distillation: Pressure-composition, Temperature-composition, Enthalpy-composition diagrams for ideal and non-ideal solutions; Raoult's law and its application; Maximum and minimum boiling mixtures; Concept of relative volatility; Single Stage Distillation-Differential distillation, Flash vaporization; Vacuum, molecular and steam distillations.

Module III (8 hours)

Liquid-Liquid Extraction: Applications; Ternary liquid-liquid equilibria; Triangular graphical representation; Equipment used for single stage and multistage continuous operation; Analytical and graphical solution of single and multistage operation.

Module IV (8 hours)

Solid-Liquid Extraction: Applications; Solid-liquid equilibrium; Equipment used in solidliquid extraction; Single and multistage crosscurrent contact and countercurrent operations; Overall stage efficiency; Determination of number of stages. Introduction to Humidification and drying.

Module V (8 hours)

Adsorption: Description of adsorption processes and their application, Types of adsorption, Nature of adsorbents; Adsorption isotherms and adsorption hysteresis; Stagewise and continuous contact adsorption operations, Determination of number of stages, Equipments; Ion exchange, Equilibrium relationship; Principle of ion-exchange, techniques and applications. Introduction to Crystallization theory.

BOOKS:

1. Treybal, R.E. "Mass Transfer Operations", 3rd ed. New York: McGraw-Hill, (1980).

2. Seader, J.D. and Henley, E.J., "Separation Process Principles", 2nd ed., Wiley India Pvt. Ltd., New Delhi (2013).

3. Sherwood, T. K., Pigford, R. L. and Wilke, C.R. "Mass Transfer" McGraw Hill (1975).

4. Geankoplis, C.J. "Transport Processes and Separation Process Principles", 4th ed., PHI Learning Private Limited, New Delhi (2012).

TPL 309 CHEMICAL REACTION ENGINEERING

L	T	P	C
3	1	0	4

Assessment:

Sessional: 50 marks
End Semester: 50 marks

Course Objective: To apply knowledge from calculus, differential equations, thermodynamics, general chemistry, and material and energy balances to solve reactor design problems, To examine reaction rate data to determine rate laws, and to use them to design chemical reactors, To simulate several types of reactors in order to choose the most appropriate reactor for a given need, To design chemical reactors with associated cooling/heating equipment.

Course Outcomes:

CO 1	Able to develop an understanding of the basic concepts involved in using reaction rate equations and kinetic constants	Understand, Apply
CO 2	Perform derivations of rate equations for non-elementary reactions both in homogenous and in heterogeneous reacting systems	Apply
CO 3	Able to understand the role of temperature and concentration in the rate equation	Understand
CO 4	Perform constant volume batch reactor calculations	Apply
CO 5	Develop calculations using the integral method and applying differential method of analysis using reactions with different orders	Understand, Apply

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	2	3	-	-	-	-	-	-	1	-	1	**1**	**2**
CO2	3	3	3	1	-	1	-	-	-	1	-	1	2	1
CO3	3	3	3	2	-	2	-	-	-	1	-	1	1	2
CO4	3	3	1	-	2	1	-	-	-	1	-	1	1	2
CO5	3	3	2	2	2	1	-	-	2	1	-	3	3	2
Avg.	3	2.8	2.4	1	0.8	1	-	-	0.2	1	-	1.4	1.6	1.8

Syllabus

Module I (8 hours)

Rate of Reaction, Elementary and non-elementary homogeneous reactions, Molecularity and order of reaction, Mechanism of reaction, temperature dependency from thermodynamics, collision and activated complex theories. Integral and differential methods for analyzing kinetic data, interpretation of constant

volume reactor, zero, first, second and third order reactions, half life period, irreversible reaction in parallel and series, catalytic reaction, auto catalytic reaction, reversible reactions.

Module II (8 hours)

Interpretation of variable volume batch reactions for zero, first and second order reactions, Space-time and state-velocity, design equation for ideal batch, steady-state continuous stirred tank, steady-state plug flow reactors for isothermal reaction.

Module III (8 hours)

Design for single reactions, Size comparison of single reactors, Multiple reactor systems, plug flow/mixed flow reactors in series and parallel, reactors of different types in series, optimum reactor size, recycle reactor, autocatalytic reactions.

Module IV (8 hours)

Introduction to multiple reactions, qualitative discussion about product distribution, quantitative treatment of product distribution and of reactor size, selectivity, the side entry reactor, irreversible first-order reactions in series, Quantitative treatment: plug flow or batch reactor, Quantitative treatment: mixed flow reactor, Successive irreversible reactions of different orders, reversible reactions, irreversible series-parallel reactions, the Denbigh reactions and their special cases, Heat of reaction from thermodynamics, equilibrium constants from thermodynamics, General graphical design procedure for non-isothermal reactors, Optimum temperature progression, Heat effects: Adiabatic operations and non-adiabatic operations, Exothermic reactions in mixed flow reactors.

Module V (8 hours)

Residence time distribution of fluids in vessels, State of aggregation of the flowing systems, Earliness of mixing, Role of RTD, State of Aggregation and earliness of mixing in determining reactor behavior, E, F and C curves, Conversion in Non-ideal flow reactors.

Reference Books:

Levenspiel, O., “Chemical Reaction Engineering”, 3rd edition, John Wiley (1998).

SEMESTER- 6

TPL 302 POLYMER PROCESSING – II

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab.	Total		
1	PCC	Polymer Processing II	TPL 302	3	2	0	2	15	20	15	50	50	100

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

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

Course Outcome

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

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

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	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
CO6	3	3	3	3	1	3	2	1	3	2	1	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

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

Module-II: Molding Processes for Thermoset polymers
Concept of Injection molding of thermoset polymers and process details. General concept of compression and transfer molding process, the description of various types of compression and transfer molding processes and their utility in processing of thermosetting materials.

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

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

Module-V: In-situ Reaction Molding process

Reaction injection molding (RIM) Process, its basic principles, process description and utility. Concept of Casting of polymers, description of process for polymers like epoxy resins, nylons, polyurethanes, etc.

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

Reference Books and Suggested Readings :

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

TPL 304 STRUCTURE AND PROPERTY OF POLYMERS

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab.	Total		
2	PCC	Structure & Property of Polymers	TPL 304	3	2	1	0	30	20	-	50	50	100

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

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

Course Outcome

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

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

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

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

Syllabus

Module-I: General Structural Features of Polymers

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

Module-II: Molecular weight averages and Molecular mass heterogeneity
Molecular weight averages and distributions. Determination of molecular weight averages. Polydispersity and MWD.

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

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

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

Reference Books and Suggested Readings :

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

TPL 306 POLYMERIZATION ENGINEERING – II

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab.	Total		
3	PCC	Polymerization Engineering II	TPL 306	4	3	0	2	15	20	15	50	50	100

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

- To understand synthesis, , manufacturing process, properties and applications of engineering plastics.
- To learn the manufacturing of thermoset resins and their applications.
- To understand the synthesis and manufacturing of flexible and rigid polyurethanes and analyze their properties and applications.

Course Outcome

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

CO1	Understand concept of engineering plastics, synthesis and manufacturing of common engineering plastics and their properties for variety of applications.	Understand
CO2	Understand monomers and their properties, chemistry of synthesis and manufacturing of high performance thermoplastic materials and analyze their properties and utility for variety of application.	Analyze
CO3	Understand concept and characteristics of specialty plastics and their applications.	Understand
CO4	Understand monomers, chemistry of synthesis, manufacturing, curing and properties of high temperature thermoset polymers like epoxy resin, and analyze their properties and utility for variety of applications.	Analyze
CO5	Understand synthesis, manufacturing, properties and applications of specific polymers and analyze their utility to meet desired end use properties.	Understand
CO6	Apply polymerization techniques for synthesis of modified polymers.	Apply

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2	1			3	1	1		1		3	3	3
CO2	3	2	1			3	1	1		1		3	3	2
CO3	3	2	1			3	1	1	1	1		3	3	2
CO4	3	2	1	1		3	1	1		1		3	3	2
CO5	3	2	1	1	1	3	2	1	1	1		3	3	2
CO6	3	2	2	3	1	3	2	1	3	2	1	3	3	3
Total	**3**	**2**	**1.1**	**3**	**1**	**3**	**1.3**	**1**	**1.2**	**1.1**	**1**	**3**	**3**	**2.3**

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

Syllabus

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

Module-II: Engineering Thermoplastics-II
Monomers, chemistry of synthesis, manufacturing process, properties and applications of polyamides, polyesters, fluorine-containing polymers, etc.

Module-III: Specialty Thermoplastics
Monomers, chemistry of synthesis, manufacturing process, properties and applications of polyphenylene oxide, acetal resins, polysulphones and other specialty plastics.

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

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

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

Reference Books and Suggested Readings :

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

TPL 308 PLASTIC PRODUCT AND MOULD DESIGN

L	T	P	C
2	1	0	3

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

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

Course Outcome

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

CO1	Understand and apply design of polymeric products, design criteria based upon product functions and geometry.	Understand
CO2	Understand and apply design features for mold designs for plastic product.	Understand
CO3	Understand and apply design concepts for structure of injection molds with materials.	Apply
CO4	Understand concepts and apply design in structure of compression & transfer molds.	Apply
CO5	Understand and apply concepts in structure of extrusion dies.	Apply

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 "-"*

Syllabus

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

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

Module-III: Injection Mold Design

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

Module-IV: Design Concept of other Mold types

Design concepts for compression molds and transfer molds. Extradites dies basics, types and general structure.

Module-V:Computer Aided Design

Concept of CAD/CAM in product design moulding and plastic. Modeling and Simulation applications for mold designing, such as mould flow etc.

Reference Books and Suggested Readings :

1. Plastic Product Design, by R. D. Beck.
2. Injection mould Design, by R.G.W. Pye.
3. Plastic Mould Engg, Hand Book, by J. H. Dubois & W. I. Pribble.
4. Dies for Plastic Extrusion, by M. V. Joshi.
5. Injection Moulding Hand Book, by Rosato & Rosato.

TPL 310 POLYMER COMPOSITE

L	T	P	C
3	0	0	3

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

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

Course Outcome

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

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

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

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

Syllabus

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

Module-II: Reinforcements for Polymer composites
Types of reinforcement such as natural, glasses, carbon/graphite, aramid fibers boron fibers and their utility in polymer composites various forms of reinforcement and surface treatment of fibers

Module-III: Matrices for Polymer composites
Thermosetting and thermoplastic material used for the composites and their selection for a particular application

Module-IV: Production Techniques -I
Processing and production techniques like hand-layup, bag moulding, filament winding and pultrusion

Module-V: Production Techniques -II
Prepegs, their manufacture and characterization. Sheet moulding and dough moulding compounds and their processing. preform and resin transfer moldings.
Hybrid and sandwich type composites.

Reference Books and Suggested Readings :

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

TPL 312 INSTRUMENTATION & PROCESS CONTROL

L	T	P	C
2	1	0	3

Assessment:

Sessional: 50 marks

End Semester: 50 marks

Course Objectives:

To gain the knowledge of different process instruments and various control processes for closed loop and open loop systems..

Course outcomes:

CO1	Understand and interpret control diagrams	Understand
CO2	.Design and tuning of controllers for specific applications	Apply
CO3	Calculate the dynamic response of closed loop systems	Analyze
CO4	Understand the principles involved in measurements, Attain knowledge on different measurement methods employed in industrial processing and manufacturing.	Understand
CO5	Understand and Analyze the different temperature measurement devices in Chemical industries.	Understand and Analyze

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	1	-	-	-	-	1	1	2	**2**	**2**
CO2	3	3	3	2	3	-	-	-	-	1	1	2	2	2
CO3	3	3	3	3	3	-	-	-	-	-	-	2	2	2
CO4	3	1	1	-	-	-	-	-	-	1	1	2	2	2
CO5	3	2	1	2	2	-	-	-	-	-	-	2	2	2
CO6	3	3	3	2	2	-	-	-	3	2	1	2	2	2
Avg	3	2.5	2.16	1.83	1.83	-	-	-	0.5	0.83	0.66	2	**3**	**2**

Module 1 (8 hours)

Introduction to Process control systems, Use of Laplace & Inverse Laplace Transformation in study of Process Dynamics & Control. Characteristics of measurement system, classification of measuring instruments.

Module 2 (8 hours)

Dynamic Modeling of a Process, Dynamic behavior of First order system, First order systems in series & second & higher order systems for various kind of inputs, Linearization of nonlinear systems, Transportation & Transfer Lag.

Module 3 (8 hours)

Classification of control systems, Regulator & Servo control, Feed Forward & Feed backward control, Negative & Positive Feedback Control, Modes of control action, Controllers & Final control Elements, Reduction of Block & Signal Flow Diagrams.

Module 4 (8 hours)

Principles of measurements and classification of process control instruments, Functional elements of an instrument, Static & Dynamic Characteristics of instruments, Transducers, Error analysis, Measurement of temperature: expansion thermometers, Resistance Thermometers, thermocouples, Thermistors, Pyrometers.

Module 5 (8 hours)

Flow measurement: Inferential flow measurements, Quantity flow meters, Mass flow meters. Flow measurement, head types-area flow meters, mass flow meters, positive displacement type flow meters, electrical type flow meters and solid flow measurement.

Suggested Text Books

1. Coughnour and Koppel, " Process Systems Analysis and Control ", McGraw-Hill, New York, 1986.
2. George Stephanopolous, " Chemical Process Control ", Prentice-Hall of India Pvt-Ltd., New Delhi, 1990.
3. Singh, S. K. , Industrial Instrumentation and Control , Prentice Hall of India, 2016

4 .Eckman, D.P., Industrial Instrumentation, Wiley Eastern Ltd., New York, 1990

SEMESTER- 7

TPL 401 TECHNOLOGY OF ELASTOMERS

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	PCC	Technology Of Elastomers	TPL 401	2	2	0	0	30	20	-	50	50	100

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

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

Course Outcome

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

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

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

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

Syllabus

Module-I: Introduction to elastomers and compounding

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

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

Module-III: Synthetic Rubber -I
Manufacturing processes, properties and application of synthetic elastomers viz. styrene-butadiene rubbers, acrylonitrile- butadiene rubber, butyl rubber, polychloroprene rubber.

Module-IV: Synthetic Rubber -II
Manufacturing processes, properties and application of ethylene-propylene rubber, polyurethane elastomers, chlorosulphonated polyethylene, polysulphide and silicon rubber, Concept of various types of thermoplastic elastomers and their applications, styrene butadiene TPE, polyurethane based TPE.

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

Reference Books and Suggested Readings :

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

TPL 403 ADVANCED POLYMER MATERIALS

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
2	PCC	Advanced Polymeric Materials	TPL 403	3	2	0	2	15	20	15	50	50	100

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

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

Course Outcome

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

CO1	Understand chemistry of synthesis of polymers for high tech applications and analyze the properties of high performance polymers for specific application like aerospace, telecomm, biomedical, defense etc.	Understand
CO2	Understand and apply chemistry, preparation, properties and applications of high 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 nano-composites, 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 polymers like polymer blends & alloys.	Understand
CO6	Characterize polymers using analytical instruments like DSC, TGA, UV spectrophotometer.	Analyze

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3					3							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 "-"*

Syllabus

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

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

Module-II: High performance polymers – I
Chemistry, preparation, properties and applications of high temperature resistant polymers like polyetherether ketone (PEEK), etc. Speciality polymers.

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.

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

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

Reference Books and Suggested Readings :

1. Encyclopedia of polymer science and technology, Vol. 14, H. F. Mark, N. G. Gaylord and N. M. Bikales, Eds., Interscience Publishers, 1971.
2. Plastic Materials, J. A. Brydson, Butterworth-Heinemann, 1999.
3. Principles of Polymers - A Advance Book, D S Bag, Nova Science publishers , N Y 2013
4. Macromolecular Synthesis, by J.R. Fllyott
5. Hand Book of Fibre glass and Advanced Plastic Composites, by G. Lubin
6. Polymer modification by John J. Merister
7. Polymer gels and Network by Yoshihido osada

1. Polymer Blends Hand Book – Vol. I & II, by L.A.Utracki

PROGRAMME ELECTIVE COURSE_I

TPL 407 POLYMER BLENDS AND ALLOYS

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

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

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

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

Syllabus

Module – I: Introduction to polymer blends

Definition of blends and alloys, reasons for blending, classification of blends; historical outline of industrial development of polymer alloys and blends; how to select blend components fundamental principles for development of polymer alloys and blends

Module – II: Miscibility/ Immiscibility of polymers

Definition of miscibility; Miscible Blends and Immiscible Blends - Difference Between Miscible and Immiscible Blends - Properties of Miscible and Immiscible Blends; Phase Equilibria Calculation; Huggins - Flory Theory; Measurement of Polymer/Polymer Interaction Parameter ; Factors Affecting Miscibility of Polymer Blends; concept of Compatibility of polymers

Module – III: Blending process

Methodsof blending; Types and Role of Compatibilizer; Compatibilization Methods; Mechanism and Properties of Compatibilized Blends; Mechanism and Theory of Toughing;
Blend preparation equipments: mixers' and their various types like banbury, hot and cold mixers, twin screw compounders, and two- roll mills, etc.Toughening of Thermoplastics and Thermosets; Thermoplastic Elastomers; Properties and Uses Interpenetrating polymer network:

Module – IV: Properties and application of polymer blends
Mechanical and thermal properties of polymer blends; Rheological Models for Miscible and Immiscible Blends, Applications of blends and alloys Automotive , Electrical and Electronics, Medical, Building and Construction, Business Machines and Communications,
Packaging

Module – V: Characterization of polymer blends
Methods of Measurements of Crystallization, Morphological and Melting Behavior of Polymer Blends, use of SEM, TEM, for characterization of blends

Reference Books and Suggested Readings :

1. L. A. Utracki, Polymer blends and alloys, Hanser Publishers, New York, 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
4. L. A. Utracki, Polymer Blends Hand book, Kluwer academic publichers, UK, 2002
5. D R Paul and S Newman, Polymer Blends Vol. I and II, Academic Press Inc, 1978.

PROGRAMME ELECTIVE COURSE_I

TPL 405 Plastic Product Technology

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
3	PEC	Programme Elective Course I Plastic Product Technology	TPL 405	3	3	0	0	30	20	-	50	50	100

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

- To understand necessity of plastic product design for efficient working.
- 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 softwareseg.

Course Outcome

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

CO1	Understand the basic requirements pricer to 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	Apply design concepts in design of simple and complex and assembly plastic products.	Apply
CO5	Understand the applications of materials data based product and mould designing software's (eg. Moldflow).	Apply

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

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

Syllabus

Module-I: Plastic product design criteria

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

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

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

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

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

Reference Books and Suggested Readings :

1. Plastic Product Design, by R. D. Beck.
2. Injection mould Design, by R.G.W. Pye.
3. Plastic Mould Engg, Hand Book, by J. H. Dubois & W. I. Pribble.
4. Dies for Plastic Extrusion, by M. V. Joshi.
5. Injection Moulding Hand Book, by Rosato & Rosato.

PROGRAMME ELECTIVE COURSE II

TPL 409 POLYMERIC ADHESIVES AND FOAMS

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
4	PEC	Programme Elective Course II Polymer Ahesives and Foams	TPL 409	3	3	0	0	30	20	-	50	50	100

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

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

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

CO1	Understand the concept of 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	Understand concept of polymer foams and their utility in variety of applications and analyze production, process and properties of Polyurethane, Polystyrene and Epoxy foams .	Understand and Analyze

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

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

Syllabus

Module – I: Introduction and adhesion theories

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

Module – II: Surface preparation and surface treatments

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

Module – III: Adhesives formulation and production techniques

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

Module – IV: Characteristics and applications of adhesives

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

Module – V: Polymeric foams

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

Reference Books and Suggested Readings :

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

PROGRAMME ELECTIVE COURSE II

TPL 411 POLYMER NANOCOMPOSITES

L	T	P	C
3	0	0	3

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

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

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

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

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

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

Syllabus

Module-I:Concept of Nano materials and nanocomposites

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

Module-II:Polymer clay nanocomposties

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

Module-III:Carbon based polymer nanocomposites

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

Module-IV:Metal based polymer nanocomposites

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

Module-V:Characterization of polymers nanocomposites

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

Reference Books and Suggested Readings:

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

OPEN ELECTIVE (PLASTIC TECHNOLOGY)

TPL 415 INTRODUCTION TO POLYMER TECHNOLOGY

L	T	P	C
3	0	0	3

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

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

Course Outcome

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

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

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

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

Syllabus

Module -I: Introduction to Polymers/Plastics
Polymeric Materials and their macro molecular nature (e.g. Plastics, rubber, fibers), concept of polymer structure, classification of polymers.

Module -II: Chemistry of polymerizations
Principle of addition and condensation polymerization, different techniques of polymerization, chemistry and kinetics of polymerization, copolymerization.

Module -III: Thermoplastic resins
Chemistry and manufacturing process of some important thermoplastic polymers such as polyethylene, polystyrene, polyvinylchloride etc., their properties and applications.

Module -IV: Thermoset resins
Chemistry and manufacturing process of some important thermoset polymers such as phenol-formaldehyde, urea-formaldehyde and melamine formaldehyde resin.

Module -V: Processing of Plastics
Processing techniques for processing of thermosets and thermoplastics, Scope of polymeric materials industries in India.

Reference Books and Suggested Readings :

References

1. Text Book of Polymer Science, F.W.J. Billmeyer, John Wiley & Sons, 1984
2. High Polymer (His chemistry in industry P. Tooley, J. murray 1971
3. Principle of Polymer Chemistry, P.J. Flory Cornell University Press, NY, 1953
4. Handbook of Polymer Synthesis, Part A & B, Hans. R. Kricheldorf, John Wiley & Sons 1991
5. Principles of Polymerization, Gorge Odeon, 2004
6. Introduction to Polymers, R.J. Young & P.A. Livell Ch. & Hall, London, 1981
7. Polymer Chemistry, Seymour & Caraher, Marcel Decker, 2003

TPL 461 INDUSTRIAL TRAINING

L	T	P	C
0	0	4	2

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

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

Course Outcome

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

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

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

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

TPL 471 SEMINAR

L	T	P	C
0	0	4	2

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

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

Course Outcome

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

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

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3			1		2	3					3	3	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 "-"*

TPL 497 PROJECT

L	T	P	C
0	0	8	4

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

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

Course Outcome

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

CO1	Understand a topic of latest developments/innovative technology.	Understand
CO2	Apply the knowledge to prepare a feasibility/dissertation report on this topic.	Apply 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

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

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

SEMESTER- 8

PROGRAMME ELECTIVE COURSE III

TPL 402 POLYMER PACKAGING AND WASTE MANAGEMENT

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	CT	TA	Lab	Total		
1	PEC	*Programme Elective Course III Plastic Packaging & Waste Management	TPL 402 OR TPL 404	4	3	1	0	30	20	-	50	50	100

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 know various sources of plastics waste generation and its management.
- To understand the recycling techniques used for various plastics.

Course Outcome

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

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

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

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

Syllabus

Module-I: Elements of packaging

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

Module-II: Polymer Packages and Quality Control

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

Module-III: Plastic waste management

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

Module-IV: Recycling Technology

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

Module-V: Biodegradable Polymers

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

Reference Books and Suggested Readings :

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

PROGRAMME ELECTIVE COURSE III

TPL 404 POLYMER COATING TECHNOLOGY

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

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

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

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

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

Syllabus

Module-I: Elements of surface coatings

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

Module-II: Pigments and Pigmentation

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

Module-III: Formulation and Manufacture of coatings
Principles of coating formulation. Coating manufacture. Machines/Ball mills used in making coating formulations. Safety, health and hazards.

Module-IV: Surface Preparation and Pre-treatments
Surface preparation and pretreatments. Rhelogical behaviour and testing of coatings. Application methods and curing techniques for coatings.

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

Reference Books and Suggested Readings :

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

PROGRAMME ELECTIVE COURSE I V

TPL 406 PROCESS MODELING AND SIMULATION

L	T	P	C
2	1	0	3

Assessment:
Sessional: 50 marks
End Semester: 50 marks

Course Objectives:
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:
Students completing the course will be able to

CO 1	Model deterministic systems and differentiate between nonlinear and linear models	Remember, Apply, Analyze
CO 2	Numerically simulate linear and non linear ordinary differential equations for deterministic systems	Apply, Analyze, Evaluate
CO 3	Estimate and validate a model based upon input and output data.	Apply, Analyze, Evaluate
CO 4	Create a model prediction based upon new input and validate the output data	Understand, Apply, Analyze, Evaluate, Create
CO 5	Develop steady state models for flash vessels, equilibrium staged processes, distillation columns, absorbers, strippers, CSTR, heat exchangers and packed bed reactors.	Remember, Apply, Analyze, Evaluate

	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	3	2	-	-	1	-	1	1	2	**1**	**1**
CO2	3	3	3	3	3	1	-	1	-	1	1	2	3	3
CO3	3	3	3	2	3	1	-	1	-	1	1	2	3	3
CO4	3	3	3	2	2	1	-	1	-	1	1	2	3	3
CO5	3	3	3	3	3	1	1	1	-	1	2	3	3	3
Avg.	3	3	3	2.6	2.6	0.8	0.2	1	-	1	1.2	2.2	3	3

Module1 (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.

Module2 (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.

Module3 (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 procedures and available numerical software libraries.

Module4 (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 beds; Packed bed reactors; Modeling of reactive separation processes; Review of solution strategies for Differential Algebraic Equations (DAEs), Partial Differential Equations (PDEs), and available numerical software libraries.

Module5 (6 hours)

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

Suggested Text Books

1. Luyben W.L., “Process Modeling, Simulation, and Control for Chemical Engineering”, Mc Graw Hill.
2. D. F. Rudd and C. C. Watson, “ Strategy of Process Engineering”, Wiley international.
3. M.M. Denn, “Process Modelling”, Wiley, New York, (1990).

Suggested Reference Books

1. A. K. Jana, “Chemical Process Modelling and Computer Simulation”, PHI,(2011)
2. C.D. Holland, “Fundamentals of Modelling Separation Processes”, Prentice Hall, (1975)
3. Hussain Asghar, “Chemical Process Simulation”, Wiley Eastern Ltd., New Delhi, (1986)

PROGRAMME ELECTIVE COURSE I V

TPL 408 COMPUTER AIDED EQUIPMENT DESIGN

	L	T	P	C
Assessment: Sessional: 50 marks End Semester: 50 marks	**2**	**1**	**0**	**3**

Course Objectives:

The objective of this course is to acquire basic understanding of design parameters, complete knowledge of design procedures for commonly used process equipment and their attachments (e.g. internal and external pressure vessels, tall vessels, high pressure vessels, supports etc.), and different types of equipment testing methods.

Course outcomes: Students completing the course will be able to

CO1	vUnderstand the basics of process equipment design and important parameters of equipment design	Understand
CO2	Understand the basics of process equipment design and important parameters of equipment design	Understand
CO3	Design special vessels such as tall vessels, self supporting vessels, and skirt (and other support for vertical vessels).	Apply
CO4	Design liquid and gas storage tanks with and without floating roof	Apply
CO5	Select standard piping, flanges, gaskets and bolts associated with the vessels and storage tanks.	Analyze

Syllabus

Module 1 (6 hours)

Introduction: Classification of engineering materials, properties of Ferrous metals, Non ferrous metals, alloys & Ceramic materials Structure-Property relationship in materials. Deformation of Materials Fracture: Elastic deformation, Plastic deformation, Creep, Visco-elastic deformation, Different types of fracture, 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 techniques (bending, Rolling, Forming) & Metal joining techniques, welding – such as Butt, Lap, fillet, corner. Inspection and testing of process vessel.

Module 2 (6 hours)

Pressure Vessels: 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 closures and heads such as Flat, hemispherical, tori-spherical, elliptical & conical.; Introduction to compensation for opening such as nozzles & manholes etc.

Module 3 (6 hours)

Flanges: Selection of gaskets, selection of standard flanges, optimum selection of bolts for flanges, design of flanges. Inspection and testing of vessels, heads and flanges as per code specifications. Piping: Pipe thickness calculation under internal and external pressure, introduction to flexibility analysis of piping system.

Module 4 (6 hours)

Tall Tower Design: Design of shell, skirt, bearing plate and anchor bolts for tall tower used at high wind and seismic conditions. Supports: Design of lug support and saddle support including bearing plates and anchor bolts.

Module 5 (6 hours)

Storage Tanks: Introduction to Indian standards, filling and breathing losses; classification of storage tanks; Design of liquid and gas storage tanks with and without floating roof. High-pressure vessels, Fundamental equations, Compound vessels, Liquid storage tanks, Mechanical design of centrifuges, Centrifugal pressure, Bowl and spindle motion: critical speed.

Suggested Text Books

1. Brownell L. E. and Young H. E., "Process Equipment Design", John Wiley and Sons. 2009.
2. Bhattacharya B. C., "Introduction of Chemical Equipment Design", 1st Edition, CBS Publisher. 2008.
3. I.S.:2825-1969, "Code for Unfired Pressure Vessels", Bureau of Indian Standards.1969.
4. I.S.:803-1962, "Code of Practice for Design, Fabrication and Erection of Vertical Mild Steel Cylindrical Welded Oil Storage Tanks", Bureau of Indian Standards.1962.

Suggested Reference Books

1. Moss D. R., "Pressure Vessel Design Manual", 3rd Edition, Gulf Publishers, 2004.
2. Annartone D., "Pressure Vessel Design", 3rd Edition, Springer 2007.
3. Joshi M.V., and Mahajani, V.V., "Process Equipment Design", 3rd Edition, Macmillan India, 2000.
4. Coulson, J.M., Richardson, J.F., and Sinnott, R.H., "Chemical Engineering Volume 6, 3rd revised Edition, Butterworth-Heinemann Ltd., 1999.

OPEN ELECTIVE COURSE IV

TCH 420 TRANSPORT PHENOMENA

L	T	P	C
2	1	0	3

Assessment:
Sessional: 50 marks
End Semester: 50 marks

Course Objectives:
This course will highlight coupling between three transport phenomena with applications in various disciplines in engineering and science, and will demonstrate to the students the common mathematical structure of transport problems. The course will deal with flow problems involving Newtonian and non-Newtonian fluids, solid-state heat conduction, forced and free convection, binary diffusion with or without chemical reaction.

Course Outcomes:

.

CO1	Perform basic vector and tensor analysis	Understand, Apply,
CO2	Solve transport problems using shell balances	Apply, Evaluate
CO3	Formulate and solve one-dimensional transport problems by using the conservation equations	Analyse, Evaluate
CO4	Formulate simple multi-dimensional transport problems	Apply, Evaluate, Create
CO5	Understand and apply the shell balance and boundary conditions on various types of system	Understand, Evaluate

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	3	3	2	1	-	-	-	-	-	-	1	**1**	**2**
CO2	3	3	3	2	2	1	-	-	-	1	1	1	3	3
CO3	3	2	2	2	2	1	-	-	-	1	1	1	3	3
CO4	3	3	1	2	2	1	-	-	-	1	1	1	3	3
CO5	3	3	1	2	2	1	-	-	-	1	1	1	3	3
Avg	3	2.8	2	2	1.8	0.8	-	-	-	0.8	0.8	1	3	3
													3	**3**

Syllabus

Module1 (7 hours)
Introduction to Newton's law of viscosity, non –Newtonian fluids, pressure & temperature dependence of viscosity, estimation of viscosity from critical properties. Shell momentum balances, boundary conditions, flow of a falling film, flow through a circular tube, flow through annular, creeping flow along a solid sphere.

Module2 (7 hours)
The equation of continuity, the equation of motion, use of the equations of change to set up steady flow problems and applications.

Module3 (4 hours)
Flow near a wall suddenly set in motion, Boundary layer theory and applications.

Module4 (6 hours)
Shell energy balances, temperature profiles, average temperature, energy fluxes at surfaces, Equations of change, equation of motion for forced and free convection and applications.

Module5 (6 hours)
Definitions of concentrations, velocities & mass fluxes, Fick's law of diffusion, Temperature & pressure dependence of mass diffusivity, Maxwell's law of diffusion. shell mass balance, boundary conditions, diffusion through a stagnant gas film and applications.

Suggested Text books

1. Bird, R. B., Stewart, W. E. and Lightfoot, E. N., "Transport Phenomena", 2nd edition John Wiley (1960).
2. Bannet, C. O. and Myers J. E., "Momentum Heat and Mass Transfer" Tata McGraw Hill, (1973).

Suggested Reference Books

1. RS Brodkey and HC Hersey, "Transport Phenomena: A Unified approach", McGraw-Hill Book,(1988).

TPL 498 PROJECT

L	T	P	C
0	0	20	10

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

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

Course Outcome

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

CO1	understand a topic of latest developments/innovative technology.	Understand
CO2	apply the knowledge to prepare a feasibility/dissertation report on this topic.	Apply Analyze
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

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

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