SEMESTER WISE COURSE STRUCTURE

&

EVALUATION SCHEME

For

B. TECH. DEGREE PROGRAMME

IN

CHEMICAL TECHNOLOGY

PLASTIC TECHNOLOGY

(Effective from the session 2022-23)

DEPARTMENT OF PLASTIC TECHNOLOGY

SCHOOL OF CHEMICAL TECHNOLOGY

HARCOURT BUTLER TECHNICAL UNIVERSITY

KANPUR-208002

UTTAR PRADESH

Department of Chemical Technology-Plastic Technology

Vision:

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

Mission:

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

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

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

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

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

Program Educational Objectives (PEOs)

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

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

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

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

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

Program Specific Outcomes:

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

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

Consistency of PEOs with Mission of the Department

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

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

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

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

Program Outcomes (POs)		Graduate Attributes(GAs)
PO1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	Engineering Knowledge
PO2	Identify, formulate, review research literature, and analyses complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	Problem Analysis
PO3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	Design/Development of solutions
PO4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	Conduct Investigations of complex problems
PO5	Create, select and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.	Modern Tool Usage
PO6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	The Engineer & Society
PO7	Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	Environment and sustainability
PO8	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	Ethics
PO9	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	Individual and team work
PO10	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	Communication
PO11	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	Project management and finance
PO12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	Life-long learning

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

Year I, Semester I

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	BSC	Engineering. Physics	NPH 101	4	3	0	2	15	20	15	50	50	100
2.	BSC	Engineering Mathematics-I	BMA 151	4	3	1	0	30	20	-	50	50	100
3.	ESC	Introduction to Electrical Engineering	NEE 101	4	3	0	2	15	20	15	50	50	100
4.	ESC	Introduction to Mechanical Engineering .	NME 101	4	3	1	0	30	20	-	50	50	100
5.	HSMC	Professional Communication	NHS 101	4	2	1	2	15	20	15	50	50	100
6.	ESC	Engineering Graphics	NCE 103	2	0	0	4	30	20	-	50	50	100
Total Credits: 22													**600**

Year I, Semester II

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	BSC	Engineering. Chemistry	NCY 102	4	3	0	2	15	20	15	50	50	100
2.	ESC	Introduction to Computer Science & Engineering	NCS 102	4	3	1	0	30	20	-	50	50	100
3.	ESC	Introduction to Electronics Engineering	NTE 102	4	3	1	0	30	20	-	50	50	100
4.	ESC	Introduction to Civil Engineering	NCE 102	4	3	1	0	30	20	-	50	50	100
5.	ESC	Introduction to Chemical Engineering & Chemical Technology	NCT 102	4	3	1	0	30	20	-	50	50	100
6.	ESC	Workshop Practice	NWS 102	2	0	0	4	-	20	30	50	50	100
Total Credits: 22													**600**

HARCOURT BUTLER TECHNICAL UNIVERSITY
KANPUR
SCHOOL OF CHEMICAL TECHNOLOGY
B.TECH. PLASTIC TECHNOLOGY
Semester wise course structure
(Applicable from Session 2023-24 for new entrants)

Year II, Semester III

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	BSC	Engineering Mathematics-II	BMA 251	4	3	1	0	30	20	-	50	50	100
2.	ESC	Fluid Mechanics & Mechanical Operations (FMMO)	NCT 201	4	3	0	2	15	20	15	50	50	100
3.	PCC	Introduction to Polymer Chemistry (ITPC)	NPL 201	4	3	1	0	30	20	-	50	50	100
4.	PCC	Polymerization Engineering-I (PE-I)	NPL 203	4	3	0	2	15	20	15	50	50	100
5.	PCC	Chemical Process Calculations (CPC)	NPL 205	3	3	0	0	30	20	-	50	50	100
6.	HSMC	Industrial Economics & Management	NHS 201	3	3	0	0	30	20	-	50	50	100
7.	PCC	Polymer Chemistry LAB (PC LAB)	NPL 207	2	0	0	4	-	20	30	50	50	100
Total Credits: 24													**700**

Year II, Semester IV

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	BSC	Modern Analytical Techniques (MAT)	NCY 202	4	3	1	0	30	20	-	50	50	100
2.	ESC	Computer Oriented Numerical Methods(CONM)	BMA 204	4	3	0	2	15	20	15	50	50	100
3.	PCC	Processing of Polymers -I (PP-I)	NPL 202	4	3	0	2	15	20	15	50	50	100
4.	PCC	Chemical Engineering Thermodynamics (CET)	NPL 204	4	3	1	0	30	20	-	50	50	100
5.	PCC	Heat Transfer Operation (HTO)	NPL 206	3	3	0	0	30	20	-	50	50	100
6.	PCC	Polymerization Engineering-II (PE-II)	NPL 208	3	3	0	0	30	20	-	50	50	100
7.	PCC	Polymerization Engineering Lab (PE LAB)	NPL 210	2	0	0	4	-	20	30	50	50	100
Total Credits: 24													**700**

HARCOURT BUTLER TECHNICAL UNIVERSITY KANPUR
SCHOOL OF CHEMICAL TECHNOLOGY
B.TECH. PLASTIC TECHNOLOGY
Semester wise course structure
(Applicable from Session 2024-25 for new entrants)

Year III, Semester V

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PCC	Processing of Polymers -II (PP-II)	NPL 301	4	3	0	2	15	20	15	50	50	100
2.	PCC	Plastic Mould Design and Dies(PMDD)	NPL 303	4	3	1	0	30	20	-	50	50	100
3.	PCC	Polymer Rheology and Testing (PRT)	NPL 305	3	3	0	0	30	20	-	50	50	100
4.	PCC	Mass Transfer Operation	NPL 307	3	3	0	0	30	20	-	50	50	100
5.	PCC	Chemical Reaction Engineering (CRE)	NPL 309	3	3	0	0	30	20	-	50	50	100
6.	PCC	Polymer Testing Lab (PT LAB)	NPL 311	3	0	0	6	-	20	30	50	50	100
7.	HSMC	Entrepreneurship Development(ED)	NHS 351	2	2	0	0	30	20	-	50	50	100
Total Credits: 22													**700**

Year III, 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	Instrumentation & Process Control (IPC)	NPL 302	4	3	0	2	15	20	15	50	50	100
2.	PCC	Structure & Properties Relationship of Polymers (SPRP)	NPL 304	4	3	1	0	30	20	-	50	50	100
3.	PCC	Rubber Technology (RT)	NPL 306	3	3	0	0	30	20	-	50	50	100
4.	PCC	Polymer Composite (PC)	NPL 308	3	3	0	0	30	20	-	50	50	100
5.	PCC	Polymer Characterization Lab (PC LAB)	NPL 310	3	0	0	6	-	20	30	50	50	100
6.	PEC-I	Program Elective –I											
		Process Equipment Design (PED)	NPL 322	3	3	0	0	30	20	-	50	50	100
		Process Modeling & Simulation (PMS)	NPL 324	3	3	0	0	30	20	-	50	50	100
		Process Optimization (PO)	NPL 326	3	3	0	0	30	20	-	50	50	100
7.	OEC-I	Introduction to Polymer Science (IPS)	OPL 302	2	2	0	0	30	20	-	50	50	100
Total Credits: 22													**700**

HARCOURT BUTLER TECHNICAL UNIVERSITY KANPUR
SCHOOL OF CHEMICAL TECHNOLOGY
B.TECH. PLASTIC TECHNOLOGY
Semester wise course structure
(Applicable from Session 2025-26 for new entrants)

Year IV, Semester VII

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PEC-II	Program Elective-II											
		Plastic Packaging (PP)	NPL 421	4	3	1	0	30	20	-	50	50	100
		Polymer Adhesives (PA)	NPL 423	4	3	1	0	30	20	-	50	50	100
		Plastic Product Technology (PPT)	NPL 425	4	3	1	0	30	20	-	50	50	100
2.	PEC-III	Program Elective-III											
		Fiber and Film Technology (FFT)	NPL 441	3	3	0	0	30	20	-	50	50	100
		Polymer Coating Technology (PCT)	NPL 443	3	3	0	0	30	20	-	50	50	100
		Polymer Foams (PF)	NPL 445	3	3	0	0	30	20	-	50	50	100
3.	PEC-IV	Program Elective -IV											
		High Performance Polymer Materials (HPPM)	NPL 461	3	3	0	0	30	20	-	50	50	100
		Polymer Nano-composites (PNC)	NPL 463	3	3	0	0	30	20	-	50	50	100
		Polymer Blends (PB)	NPL 465	3	3	0	0	30	20	-	50	50	100
4.	Industrial Training	Industrial Training (IT)	NPL 481	2	0	0	4	-	20	30	50	50	100
5.	OEC-II	Basics of Polymer Processing (BPP)	OPL 401	2	2	0	0	30	20	-	50	50	100
6.	Minor Project	Minor Project	NPL 491	6	0	0	12	-	20	30	50	50	100
7.	Seminar	Seminar	NPL 471	2	0	0	4	-	50	-	50	50	100
Total Credits: 22													**700**

Year IV, Semester VIII

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PEC-V	Program Elective -V											
		Plastic Waste Management (PWM)	NPL 422	4	3	1	0	30	20	-	50	50	100
		Characterization of Polymers (COP)	NPL 424	4	3	1	0	30	20	-	50	50	100
		Specialty Polymers (SP)	NPL 426	4	3	1	0	30	20	-	50	50	100
2.	OEC-III	Testing of Polymers (TOP)	OPL 402	2	2	0	0	30	20	-	50	50	100
3.	Project	Project	NPL 492	16	0	0	24	-	100	100	200	200	400
Total Credits: 22													**600**

Total Program Credits: 180

OEC

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	OEC-I	Introduction to Polymer Science (IPS)	OPL 302	2	2	0	0	30	20	-	50	50	100
2.	OEC-II	Basics of Polymer Processing (BPP)	OPL 401	2	2	0	0	30	20	-	50	50	100
3.	OEC-III	Testing of Polymers (TOP)	OPL 402	2	2	0	0	30	20	-	50	50	100

PEC-I

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PEC-I	Process Equipment Design	NPL 322	3	3	0	0	30	20	-	50	50	100
2.	PEC-I	Process Modeling & Simulation	NPL 324	3	3	0	0	30	20	-	50	50	100
3.	PEC-I	Process Optimization	NPL 326	3	3	0	0	30	20	-	50	50	100

PEC-II

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PEC-II	Plastic Packaging (PP)	NPL 421	4	3	1	0	30	20	-	50	50	100
2.	PEC-II	Polymer Adhesives (PA)	NPL 423	4	3	1	0	30	20	-	50	50	100
3.	PEC-II	Plastic Product Technology (PPT)	NPL 425	4	3	1	0	30	20	-	50	50	100

PEC-III

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PEC-III	Fiber and Film Technology (FFT)	NPL 441	3	3	0	0	30	20	-	50	50	100
2.	PEC-III	Polymer Coating Technology (PCT)	NPL 443	3	3	0	0	30	20	-	50	50	100
3.	PEC-III	Polymer Foams (PF)	NPL 445	3	3	0	0	30	20	-	50	50	100

PEC-IV

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PEC-IV	High Performance Polymer Materials (HPPM)	NPL 461	3	3	0	0	30	20	-	50	50	100
2.	PEC-IV	Polymer Nano-composites (PNC)	NPL 463	3	3	0	0	30	20	-	50	50	100
3.	PEC-IV	Polymer Blends (PB)	NPL 465	3	3	0	0	30	20	-	50	50	100

PEC-V

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
1.	PEC-V	Plastic Waste Management (PWM)	NPL 422	4	3	1	0	30	20	-	50	50	100
2.	PEC-V	Characterization of Polymers (COP)	NPL 424	4	3	1	0	30	20	-	50	50	100
3.	PEC-V	Specialty Polymers (SP)	NPL 426	4	3	1	0	30	20	-	50	50	100

Courses for Minor Degree :

Name of Minor Degree : Plastic Processing Technology

Sl. No.	Course Type	Course Title	Subject Code	Credits	Periods			Sessional Marks				ESE	Total Marks
					L	T	P	MSE	TA	Lab	Total		
(i)	PCC	Introduction to Polymer Chemistry (ITPC)	NPL 201	4	3	1	0	30	20	-	50	50	100
(ii)	PCC	Processing of Polymers-I (POP-I)	NPL 202	4	4	3	0	2	15	-	50	50	100
(iii)	PCC	Processing of Polymers-II (POP-II)	NPL 301	4	4	3	0	2	15	-	50	50	100
(iv)	PCC	Plastic Mould Design and Dies(PMDD)	NPL 303	4	3	1	0	30	20	-	50	50	100
(vi)	PEC-III	Plastic Product Technology (PPT)	NPL 405	4	3	1	0	30	20	-	50	50	100
Total Credits: 20													**600**

Decisions of Course Structure Committee/ Committee of Implementation of NEP-2022

1. Award of certificate in Engineering and Technology on exit after completion of 1st year B. Tech. program.
2. Award of Diploma in the Branch of Study (Plastic Technology) after completion of 2nd year B. Tech. program.
3. The students of four year B.Tech. program completing courses with additional credits of 20 or more in their respective branch of study will be awarded degree of B. Tech. Honours. The students can opt for additional courses from the list of PEC or from the online platform.
4. The students of four year B. Tech. program completing courses with additional credits of 20 or more in the area other than their branch of study will be awarded degree of B. Tech with major in their respective branch of study along with Minor degree in the area of specialization of additional courses.

Syllabus for B. Tech. Chemical Technology - Plastic Technology

Year I, Semester I

NPH 101/102 ENGINEERING PHYSICS

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

Course Objective:

The objective of the course is to understand the basic concepts of nature around us and to synthesize the knowledge from different areas of physics for analysing and solving various critical problems.

Course Outcome (CO):

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

CO1	Understand and apply the principle of conservation of momentum, the theory of relativity.	K2, K1
CO2	Understand the basics of quantum mechanics and apply its principles to learn the phenomenon that occurs at subatomic dimensions.	K3, K1
CO3	Understand Maxwell's equations of electromagnetic theory with the aim to apply them in a communication system.	K5, K1
CO4	Apply the fundamentals of material science, especially to dielectric materials, semiconducting materials, nanomaterials, and Superconducting Materials.	K2, K1
CO5	Understand the statistical behavior of the constituent particles and apply the principles of statistical mechanics in the formation of materials and basics of LASERs	K4, K1

K1-Remember, K2- Understand, K3-Apply, K4-Analyse, K5-Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix)

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	1	2	1	2	-	-	-	-	-	3
CO2	3	3	1	2	1	2	-	-	-	-	-	3
CO3	3	3	1	2	1	2	-	-	-	-	-	3
CO4	3	3	3	2	1	3	3	-	-	-	-	3
CO5	3	3	2	3	3	3	-	-	-	-	-	3

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

Course Content

UNIT- 1

Relativistic Mechanics:

Inertial and Non- Inertial Frames of references, Galilean transformation equations, Michelson Morley Experiment, Lorentz Transformation equations, Length contraction, Time dilation and its experimental evidence, Relativistic velocity addition formula, Relativistic variation of mass with velocity, Evidence of variation of mass with velocity, Einstein's Mass-Energy equivalence, examples from nuclear physics,Relativistic energy momentum relation.

UNIT- 2

Quantum Mechanics:

Dual nature of matter & radiation, Heisenberg's uncertainty Principle and their applications, wave packet concept, Davisson-Germer experiment, Postulates of quantum mechanics, Significance of wavefunction, Derivation of Schrodinger equation for time independent and time dependent cases.

Applications of Schrodinger wave equation for a free particle, Particle in a box (one dimensional and three dimensional cases), Simple harmonic oscillator (one dimensional case).

UNIT- 3

Electromagnetic Theory:

Ampere's law and Faraday's law of electromagnetic induction, Derivation of Maxwell's equations and their physical significance, Correction of Ampere's law by Maxwell, Concept of displacement current, Poynting theorem, Maxwell's equations in free space & velocity of electromagnetic waves, Transverse character of the wave and orthogonality of E, H and k vectors, Maxwell's equation in dielectric medium and velocity of e.m. wave, Comparison with free space, Maxwell's equations in conducting media & solution of differential equation in this case, penetration depth & its significance.

UNIT- 4

Statistical Mechanics & Lasers:

Macrostates and Microstates, Phase space, probability of distribution, most probable distribution, Maxwell-Boltzmann Statistics, Applications of Maxwell-Boltzmann Statistics, derivation of average velocity, RMS velocity and most probable velocity in the above cases, Bose-Einstein Statistics & its application in case of black body radiation, distribution law of energy, Planck's radiation formula, derivation of Wien's law, Rayleigh-Jeans law and Stefan's law from Planck's radiation formula. Fermi – Dirac statics, application in case of free electrons in metals, energy distribution, Fermi energy.

Lasers: Spontaneous and stimulated emission of radiations, Einstein's theory of matter-radiation interaction, Einstein's coefficients and relation between them, Population inversion, components of a laser, different kinds of lasers, Ruby laser, He-Ne laser, solid state lasers, properties of laser beams, mono- chromaticity, coherence, directionality and brightness, applications of lasers in various technological applications.

UNIT- 5

Materials of Technological Importance:

Dielectric Materials: Electric field in presence of dielectric medium, concept of electric polarization,

different types of polarizations, behaviour of dielectric in a.c. field, concept of dielectric loss and loss energyand their importance.

Semiconducting Materials: Concept of energy bands in solids, carrier concentration and conductivity in intrinsic semiconductors and their temperature dependence, carrier concentration and conductivity in extrinsic semiconductors and their temperature dependence, Hall effect in semiconductors, compound semiconductors, amorphous semiconductors.

Nano Materials: Basic principles of nanoscience and technology, preparation, structure and properties of fullerene and carbon nanotubes, applications of nanotechnology.

Superconducting Materials: Resistivity and susceptibility of Superconductors, Type – I and Type – II superconductors, Meissner effect, Low temperature Superconductors, Organic Superconductors, Oxide Superconductors, High temperature Superconductors, BCS theory (Qualitative).

Text Books:

1. Engineering Physics, R. K. Shukla, Pearson Education, Vol.-II, 2014
2. Electrical Engineering Materials, R.K. Shukla, McGraw Hill, 1st Edition, 2012
3. Principles of Engineering Physics, R.K. Shukla, Ira Books, 1st Edition, 2011
4. Engineering Physics –I & II, S.K. Gupta, Krishna Prakashan Media (P) Ltd., 2014

References Books:

1. Fundamental university physics, Vol. - I: Mechanics, Marcelo Alonso, J. Finn Edwards, Addison-Wesley, 1st Edition, 1967
2. Concepts of Modern Physics, Arthur Beiser, McGraw Hill, 6th Edition, 2003
3. Introduction to Electrodynamics, David Griffiths, Cambridge University Press, 4th Edition, 2017
4. Introduction to Solid State Physics, Charles Kittel, Willey, 8th Edition, 2005
5. Introduction to Nanotechnology, Charles P. Poole Jr., Frank J. Owens, Wiley-Interscience, 1st Edition, 2003

Web Links:

1. https://nptel.ac.in/courses/122101002 [IIT Bombay, Prof. D.K. Ghosh]
2. https://nptel.ac.in/courses/122103011 [IIT Guwahati, Prof. Alika Khare , Prof. Pratima Agarwal, Prof. S. Ravi]
3. https://nptel.ac.in/courses/115105099 [IIT Kharagpur, Prof. Amal Kumar Das]
4. https://nptel.ac.in/courses/115101005 [IIT Bombay, Prof. D.K. Ghosh]
5. https://nptel.ac.in/courses/115106066 [IIT Madras, Prof. S. Lakshmi Bala]

BMA 151/152 ENGINEERING MATHEMATICS –I

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

OBJECTIVE: The objective of this course is to educate the students about:

- The convergence of infinite series, improper integrals and differential calculus.
- Partial differentiation, multiple integrals and Beta, Gamma functions.

Course Outcome

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

CO1	Find nth derivative, determine the expansion of functions and find convergence of series and improper integrals.	Understand, Apply
CO2	Find partial differentiation and evaluate area and volume using multiple integrals.	Apply, Evaluate
CO3	Convert line integrals to surface integrals and volume integrals, determine potential functions for irrotational force fields.	Apply, Evaluate
CO4	Solve linear system of equations and determine the eigen vectors of the matrix.	Apply, Analyse Evaluate,
CO5	Learn concept of optimization and optimization techniques.	Apply, Analyse, Evaluate,

Course Articulation Matrix (CO-PO Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	2	-	-	1	-	1	-	3
CO2	3	3	2	1	2	-	-	1	-	1	-	3
CO3	3	3	2	1	2	-	-	1	-	1	-	3
CO4	3	3	2	1	2	-	-	1	-	1	-	3
CO5	3	3	2	1	2	-	-	1	-	1	-	3
Average	3	3	2	1	2	-	-	1	-	1	-	3

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

Detailed Syllabus:

Unit I- Functions of One Real Variable

Successive differentiation, Leibnitz theorem, Mean value theorems, sequences and series, Expansion of functions, Improper integrals and their convergence.

Unit II- Functions of Several Real Variables

Limit, Continuity, Partial differentiation, Total differential and approximations, Jacobian, Euler's theorem Expansion of functions, Beta and Gamma Functions, Multiple integral, Change of order, Change of variables, Applications to area, volume, mass, surface area etc. Dirichlet's Integral & applications.

Unit III- Vector Calculus

Point functions, differentiation, Gradient, Directional derivative, Divergence and Curl of a vector and their physical interpretations, Solenoidal & irrotational fields, Integration, Line, Surface and Volume integrals Green's. Stoke's and Gauss Divergence theorems (without proof) and applications.

Unit IV- Matrices and Linear Algebra

Vector space and subspace, linear dependence, dimensions and basis, Linear transformation and its matrix representation, Elementary transformations, Echelon form, rank & nullity, Consistency of linear system of equations and their solutions, characteristic equation, Cayley Hamilton theorem, Real and complex eigenvalues and eigenvectors, diagonalisation, quadratic forms, complex, orthogonal, and unitary matrices, Application to Cryptography, discrete, Compartmental models and system stability.

Unit V- Optimization

Engineering applications of optimization, statement and classification of optimization problems, Optimization techniques, single variable optimization, multi variable optimization with no constraint, with equality and inequality constraints, Linear Programming Problems, Graphical method and Simplex method.

Books Recommended:

1. R.K. Jain & S. R. K. lyengar; Advanced Engineering Mathematics, Narosa Publishing House 2002.
2. Erwin Kreyszig: Advanced Engineering Mathematics. John Wiley & Sons 8th Edition.
3. Dennis G. Zill & Michael R Cullen; Advanced Engineering Mathematics, Jones & Bartlett Publishers, 2nd Edition.
4. S.S. Rao; Optimization: Theory & application Wiley Eastern Limited.
5. T.M. Apostol, calculus, Vol. I, 2nd ed., Wiley 1967.
6. T.M. Apostol, Calculus, Vol. II, 2nd ed**.,** Wiley 1969.
7. Gilbert Strang, Linear Algebra & its applications, Nelson Engineering 2007.
8. Calculus & Analytic Geometry, Thomas and Finny.

NEE 101/102 INTRODUCTION TO ELECTRICAL ENGINEERING

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

Course Objectives

The goal of the course is to make the students understand the basic principles of electrical engineering.

Course Outcomes

At the end of the course the students will be able to:

CO1. apply Mesh and Nodal Methods of Analysis and Network Theorem in DC Network.

CO2. understand and analyze the ac circuit and calculate the various parameters.

CO3. understand and analyze the 3-phase connections of source and load, and, measurement of 3-phase power.

CO4. understand the magnetic circuit with working & applications and to calculate the various parameters of magnetic circuits and transformer efficiency.

CO5. understand the basic principles of AC & DC Machines

Course Articulation Matrix (CO-PO Matrix)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		2		1					2		2
CO2	3	1			1					2		2
CO3	3			3	1					2		2
CO4	3				1					2		2
CO5	3		2		1					2		2

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

Course Content

UNIT 1 - DC Circuit Analysis and Network Theorems

Circuit Concepts: Concepts of Network, Active and Passive elements, voltage and current sources, concept of linearity and linear network, unilateral and bilateral elements. R L and C as linear elements. Source Transformation. Kirchhoff's Law, loop and nodal methods of analysis; star – delta transformation; Network Theorems: Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem. (Simple Numerical Problems)

UNIT 2 - Steady State Analysis of Single Phase AC Circuits

Sinusoidal, Square and Triangular waveforms – average and effective values, form and peak factors, concept of phasors, phasor representation of sinusoidally varying voltage and current. Analysis of series, parallel, and series – parallel RLC Circuits: Apparent, Active & Reactive Powers, Power factor, causes and problems of low power factor, power factor improvement. Resonance in Series and Parallel Circuits. (Simple Numerical Problems)

UNIT 3 - Three Phase AC Circuits

Three Phase System – its necessity and advantages, meaning of phase sequence and star and delta connections, balanced supply and balanced load, line and phase voltage / current relations, three phase power and its measurement. (Simple Numerical Problems)

UNIT 4 - Magnetic Circuits and Transformer

Magnetic Circuit: Magnetic circuit concepts, analogy between Electric & Magnetic circuits, Magnetic circuits with DC and AC excitations, Magnetic leakage. B-H curve, Hysteresis and Eddy Current losses, Magnetic circuit calculations.

Single Phase Transformer: Principle of Operation, Construction, e.m.f. equation, Power losses, efficiency. (Simple Numerical Problems)

UNIT 5 - Electro Mechanical Energy Conversion

Basic Principles of electro mechanical energy conversion.

DC Machines: Types of DC machines, e.m.f. equation of generator and torque equation of motor, Speed-Torque characteristics of DC Series and Shunt Motors, Applications of dc motors. (Simple Numerical Problems).

Three Phase Induction Motor: Types, Principle of Operation, Slip – torque Characteristics, applications. (Simple Numerical Problems).

Single Phase Induction Motor: Basic Principles of 1-phase Induction Motor and its applications

Three Phase Synchronous Machines: Principle of Operation of alternator and synchronous motor and their applications.

List of Experiments

1. Verification of Kirchhoff's laws.
2. Verification of Superposition Theorem.
3. Verification of Thevenin's Theorem.
4. Verification of Maximum Power Transfer Theorem.
5. Measurement of power and power factor in a 1 – Ø ac series inductive circuit and study improvement of power factor using capacitor.
6. Study of phenomenon of resonance in RLC series circuit and obtain the resonant frequency.
7. Measurement of power in 3 – Ø circuit by Two Wattmeter method and determination of its power factor.
8. Determination of parameter of ac 1 – Ø series RLC Circuit.
9. Determination of Efficiency by load test of a 1 – Ø Transformer.
10. To study running and speed reversal of a 3 – Ø induction motor and record its speed in both direction.

Note:

a. Department may add any three experiments in the above list.
b. Minimum eight experiments are to be performed out of the above list.

Text books:

1. V. Del Toro, "Principles of Electrical Engineering" Prentice Hall International
2. I. J. Nagarath, "Basic Electrical Engineering" Tata Mc - Graw Hill
3. D. E. Fitzgerald & A. Grabel Higginbotham, "Basic Electrical Engineering" Mc - Graw Hill
4. B. L. Theraja and A. K. Theraja, "Basic Electrical Engineering: July 1999.

Reference books:

1. Edward Hughes, "Electrical Technology" Longman

2. T. K. Nagsarkar & M. S. Sukhija, “Basic Electrical Engineering” Oxford University Press
3. H. Cotton, “Advanced Electrical Technology” Wheeler Publishing
4. W. H. Hayt & J. E. Kennely, “Engineering Circuit Analysis” Mc - Graw Hill

NME 101/102 INTRODUCTION TO MECHANICAL ENGINEERING

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

Course Objectives:

To explain the basic fundamentals of forces, moments, stresses, strains, fundamental of fluid and fluid flow application, fundamentals of thermodynamics and mode of heat transfers.

Course Outcomes (CO):

At the end of this course students should be able to:

CO1	Understand the basic laws concepts of mechanical systems.	K2, K1
CO2	Determine resultants and apply conditions of static equilibrium to plane force systems.	K3, K1
CO3	Analyze beam for shear force and bending moment along the span and analyze trusses for axial forces.	K4, K1
CO4	Evaluate the structural properties centroid and moment of inertia	K5, K1
CO5	Stress analysis for one- and two-dimensional stress systems.	K3, K1

K1- Remember, K2- Understand, K3-Apply, K4-Analyse, K5- Evaluate, K6- Create

Course Articulation Matrix (CO-PO Matrix)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3			1	1	1	1	1		1
CO2	3	3	3									1
CO3	3	3	3									1
CO4		3	2	2								1
CO5		3	2	2								1

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

Course Content:

UNIT-1: Fundamental Concepts and Definitions:

Mechanical Engineering: Scope and expanse

Concept of machines and mechanisms, classification of machines. Thermodynamic systems, Laws of thermodynamics. Introduction to modes of heat transfer, applications. Materials, classification, selection of materials in design of components. Manufacturing processes, mechanical working of metals.

UNIT-2:

Two-Dimensional Force Systems: Basic concepts, laws of motion, Principle of transmissibility of forces, transfer of a force to parallel position, resultant of a force system, simplest resultant of two dimensional concurrent and non-concurrent force systems, distributed force system, free body diagrams, equilibrium and equations of equilibrium, applications.

Friction: Introduction, Laws of Coulomb friction, Equilibrium of bodies involving dry-friction, belt friction, applications.

UNIT-3:

Beam: Introduction, Shear force and bending moment, differential equations for equilibrium, shear force and bending moment diagrams for statically determinate beams.

Trusses: Introduction, simple truss and solution of simple truss, Method of joints and method of sections.

UNIT-4: Centroid and Moment of Inertia: Centroid of plane, curve, area, volume and composite bodies, Moment of inertia of plane area, Parallel Axes theorem, Perpendicular axes theorems, Principal moment of inertia, mass moment of inertia of circular ring, disc, cylinder, sphere and cone about their axis of symmetry.

UNIT-5: Introduction to Strength of Materials: Introduction, normal and shear stresses, stress-strain diagrams for ductile and brittle material, elastic constants, One Dimensional loading of members of varying cross- sections, strain energy, 2D state of plane stress, Principal stresses and strains.

Text books:

1. Engineering Mechanics by Abhijit Chanda and Debabrata Nag, Wiley India Pvt. Ltd, 2018, Kindle -Edition, ISBN: 9788126570935.
2. Engineering Mechanics: Statics by J L Meriam. L G Kraige. Virginia Polytechnic Institute and State University, John Wiley & Sons, 2017.ISBN-978-8126564033.
3. Engineering Mechanics of Solids, Egor P. Popov, PHI Publications, 1990.
4. Theory of Machines and Mechanisms by J.E. Shigley, Oxford University Press, 5th Edition, 2017.
5. Engineering Thermodynamics by P K Nag, TMH Publication, 4th Edition, 2008.

Reference Books:

1. Theory of Machines and Mechanisms by Amitabha Ghosh and Asok Kumar Mallick, Affiliated East-West Press, 3rd Edition, ISBN: 9788185938936.
2. Engineering Mechanics by Timoshenko S., McGraw-Hill Education – Europe, 5th Edition, 2013.
3. Engineering Mechanics by Nelson A, McGraw Hill Education India, 1st Edition, ISBN-978-0070146143, 2017
4. Materials and Manufacturing: An Introduction to How they Work and Why it Matters by Mark A Atwater McGraw-Hill Education, 1st Edition, ISBN: 9781260122312, 2018
5. Engineering Thermodynamics: Work and Heat Transfer by Rogers, Pearson Education India, 4th Edition, 2002.

Web Links:

1- https://nptel.ac.in/courses/112106286 [IIT Madras, Prof. K. Ramesh]
2- https://nptel.ac.in/courses/112103108 [IIT Guwahati, Prof. US Dixit]
3- https://nptel.ac.in/courses/112103109 [IIT Guwahati, Prof. US Dixit]
4- https://eng.utq.edu.iq/wp-content/uploads/sites/4/2019/09/engineering-mechanics-lectures.pdf[Thi-Qar University, Prof. Haider]
5- https://www.youtube.com/watch?v=tisNUzd_f1M&t=96s [Dr. V. P. Singh, HBTU, Kanpur]
6- https://www.youtube.com/watch?v=a6RNss9kBuI&t=11s [Dr. V. P. Singh, HBTU, Kanpur]

7- https://www.youtube.com/watch?v=LE1Lc6_640U[Dr. V. P. Singh, HBTU, Kanpur]

NHS 101/102 PROFESSIONAL COMMUNICATION

Course: B. Tech	**Branch:** All	**Year / Semester:** 1st Yr. / 1st Sem. /2nd Sem.
Sessional Marks:	50	**Credit:** 4
End Semester Exam:	50	**LTP:** 3 0 2

UNIT I Fundamentals of Technical Communication:

Process of communication, language as a tool of communication, levels of communication , flow of communication, barriers to communication, communication across cultures; Technical Communication: meaning, significance, characteristics, difference between technical and general communication.

UNIT II Elements of Written Communication:

Words and phrases, word formation, synonyms and antonyms, homophones, one word substitution, sentence construction, paragraph construction,

UNIT III Forms of Technical Communication:

(A) business letters, job application letter and resume, 7C's of letter writing, business letters: sales & credit letters, letters of enquiry, letters of quotation, order, claim and adjustment letters, official letters: D.O. letters, government letters, letters to authorities, etc. ,

(B) Technical Reports: general format of a report, formal and informal reports, memo report, progress report, status report, survey report, trip report, complaint report, , Joining Report ,laboratory report, research papers, dissertations and theses. E-mail writing

Technical Proposals: purpose, characteristics, types, structure

UNIT IV Presentation Strategies:

Defining the subject, scope and purpose, analysing audience & locale, collecting materials, preparing outlines, organising the contents, Pre-presentation strategies, during presentation strategies, nuances of delivery, verbal and non-verbal communication, Body language, paralinguistic features of voice, visual aids.

UNIT V Value-based Text Reading:

(A) Study of the following essays from the text book with emphasis on writing skills:

1. Man and Nature by J. Bronowski
2. The Language of Literature and Science by Aldous Huxley
3. The Aims of Science & The Humanities by Moody E Prior
4. Gods in this Godless Universe by Bertrand Russell
5. Science and Survival by Barry Commoner

(B) Readings of selected short stories:

1. The Renunciation by Rabindranath Tagore
2. The Lament by Anton P. Chekhov
3. The Barber's Trade Union by Mulk Raj Anand
4. The Eyes Are Not Here by Ruskin Bond

Text Books:

1. 'Improve Your Writing' ed. By V N Arora and Laxmi Chandra, Oxford University Press, New Delhi
2. 'An Anthology of English Short Stories', edited by R P Singh, Oxford University Press.
3. 'Technical Communication- Principles and Practices' by Meenakshi Raman & Sangeeta Sharma, OxfordUniversity Press, New Delhi.

Reference Books:

1. Effective Technical Communication, by Barun K Mitra, Oxford University Press
2. Business Correspondence & Report Writing by R.C. Sharma & Krishna Mohan, Tata McGraw Hill, N.D.
3. Developing Communication Skills by Krishna Mohan & Meera Banerjee, Macmillan India
4. 'Technical Communication- Principles and Practices' by M R S Sharma, Oxford University Press, New Delhi

PROFESSIONAL COMMUNICATION LABORATORY

Interactive practical sessions with emphasis on oral presentations/ spoken communication:Practical Sessions on:

1. Group Discussions: selected topical issues to be discussed in groups.
2. Mock interviews
3. Communication skills for seminars/conferences/workshops with emphasis on non-verbalskills.
4. Presentation skills for technical papers/project reports/professional reports.
5. Theme presentation/ key note presentation based on correct argumentation methodologies.
6. Argumentative skills
7. Role play
8. Comprehension skills based on reading and listening practice, asking questions.
9. Introduction to International Phonetics Alphabets
10. Audio Visual demonstration of effective communicative strategies & TED Talks

References:

1. Sethi and Dhamija, 'A Course in Phonetics and Spoken English', Prentice Hall of India,New Delhi.

2. Joans Daniel, 'English Pronouncing Dictionary', Cambridge University Press.

Additional Reference Books

1. R. K. Bansal & J.B. Harrison, Spoken English for India, Orient Longman
2. Excellence in Business Communication, Boeuve & Thill and Courtland

Course Objectives (COs)

At the end of this course students should be able to:

1. Effectively communicate their ideas in the contemporary global competitive environment.
2. Convey their messages through constructive writing.
3. Draft potent E-Mails, letters, proposals and reports.
4. Present their presentations along with using all nuances of delivery with clarity and thoroughness.
5. Solve problems based on real time situations and articulate them eventually.

CO-PO Mapping

Co/PO	PO 1	PO 2	PO3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
CO1	0	0	0	0	0	0	0	0	2	3	0	1
CO2	0	0	0	0	0	0	0	0	2	3	0	1
CO3	0	0	0	0	0	0	0	0	2	3	0	1
CO4	0	0	0	0	0	0	0	0	2	3	0	1
CO5	0	0	0	0	0	0	0	0	2	3	0	1

NCE 103/104 ENGINEERING GRAPHICS

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

Course Outcomes

At the end of this course, students should be able:

CO1	To understand and apply the concepts of lettering, dimensioning, scales and geometric construction
CO2	To visualize the position and location of any point, line, plane, or surface and draw their orthographic projections
CO3	To visualize and draw/develop the true shape, size, and sections of solid objects the true shape, size, and specifications of physical objects
CO4	To apply the visualization skill, to draw a simple isometric and perspective projections
CO5	To understand and draw basic civil Engineering building components using AutoCAD

Course Articulation Matrix (CO-PO Matrix)

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	-	-	-	-	-	-	-	1	2	-	-
CO2	2	-	-	-	-	-	-	-	1	2	-	-
CO3	2	-	-	-	-	-	-	-	1	2	-	-
CO4	2	-	-	-	-	-	-	-	1	2	-	-
CO5	2	-	-	-	3	-	-	-	1	2	-	-

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

Course Content

Unit –I

Lettering and Dimensioning: Introduction, lettering practices, Rules of dimensioning – systems of dimensioning.
Geometric Constructions: Freehand sketching, Conic Sections, Special Curves.
Engineering Scales

Unit –II

Orthographic Projection
Projection of Points: First and Third Angle Projections; Projection of Points
Projection of Lines: Projection of straight lines (First angle projection only); Projection of lines inclined to one plane and both planes, true length and true inclinations.
Projection of solids: Classification of solids, Projection of solids in simple position, Projection of solids inclined to one plane.

Unit –III

Sections of Solids: Right regular solids and auxiliary views for the true shape of the sections.
Development of Surfaces: Development of surfaces for various regular solids.

Unit –IV

Isometric Projection: Isometric scales, Isometric projections of simple and combination of solids;
Perspective Projection: Orthographic representation of perspective views – Plane figures and simple solids – Visual Ray Method.
Conversion of pictorial view into orthographic Projection.

Unit –V

Introduction to Auto CAD, Drawings of Buildings and their components – front view, top view, and sectional views of a typical residential building using Auto CAD.
Detailed Drawing of RCC Design- Slab, beam, column, footings.

Textbooks

1. D.A. Jolhe (2008). '*Engineering Drawing- With an Introduction to AutoCAD.',* Tata Mcgraw, Delhi.
2. N D Bhatt and V M Panchal (2001). '*Engineering Drawing.'*, 43rd Ed., Charotar Publishing House, Anand, 2001.
3. M B Shah and B C Rana (2009). '*Engineering Drawing.',* 2nd Ed., Pearson Education, Delhi.

Reference Books

1. A Textbook of Engineering Graphics by K.V. Natarajan.
2. T E French, C J Vierck and R J Foster, *Graphic Science and Design*, 4th Ed., McGraw Hill, 1984.
3. W J Luzadder and J M Duff, *Fundamentals of Engineering Drawing*, 11th Ed., PHI, 1995.
4. K Venugopal, *Engineering Drawing and Graphics*, 3rd Ed., New Age International, 1998

Web Resources

1. https://nptel.ac.in/courses/112103019
2. https://nptel.ac.in/courses/112102304
3. https://nptel.ac.in/courses/112105294
4. https://archive.nptel.ac.in/courses/112/102/112102304/

Year I, Semester II
NCY 101 / 102 ENGINEERING CHEMISTRY

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

OBJECTIVE:

The objective of this course is to make students learn the laboratory skills needed to design safe conduction of reactions and experiments in Chemistry. The student will acquire a foundation of Chemistry to enable them to understand and critically interpret the primary research in Chemistry.

Course outcome

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

CO1	Interpret UV-Visible and IR-Spectra	K2, K4
CO2	Describe reaction rates for reactions of various orders	K2, K3, K4
CO3	Understand different aspects of corrosion and thermodynamic view of electrochemical processes, reversible, irreversible cells and nanochemistry	K2, K3
CO4	Understand the stereochemistry of molecules and identify organic reactions on the basis of their mechanism	K1, K3, K4
CO5	Distinguish between different polymeric structures, classify polymers, and analyze the polymerization mechanism and use of polymers in different walks of life. Knowledge of conductivity of polymer, biodegradable polymers and fibre reinforced plastics. Acquire knowledge about water and treatment of municipal water and solid waste management	K2, K3, K5, K6
CO6	To develop experimental skills to perform, monitor and manipulate the reactions.	K2, K4, K5

K1-Remember, K2-Understand, K3-Apply, K4-Analyse, K5- Evaluate, K6-Create

Course Articulation Matrix (CO-PO Matrix)

PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
3	3	1	3	2	-	2	-	-	-	-	3
3	3	1	3	2	-	2	-	-	-	-	3
3	3	1	3	2	-	2	-	-	-	-	3
3	3	1	3	2	-	2	-	-	-	-	3
3	3	1	3	2	-	2	-	-	-	-	3
3	3	3	3	2	2	2	2	1	2	-	3

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

Course Content

UNIT- 1

Bonding VSEPR Theory, Valence Bond Theory, Crystal-field theory, Electronic Spectra and Ligands (strong and weak field), Phosphorescence and Fluorescence, Jablonski diagram, hydrogen bonding and their effect on physical properties, Metallic bonds, Classification and Applications of Liquid crystals, Band Theory of Solids and superconductors.

Spectroscopy Basic Principles, Instrumentation and Applications of UV-Vis and IR Spectroscopy.

UNIT- 2

Chemical Kinetics Second order reactions. Determination of order, Fast and slow reaction, steady state approximation, Temperature effect, Concept of Activated Complex / Transition State: Energy of activation, Potential energy surface, Theories of reaction rate: Collision and Transition State theories interms of enzyme catalysis.
Surface Chemistry Introduction, Types of adsorption, Adsorption isotherms, BET, Applications of adsorption.

UNIT- 3

Electrochemistry Dry and fuel cells, electrochemical cell, Solar cells, Disensitized cell, Photovoltaic cell.

Nanochemistry Introduction, general methods of synthesis, classification and applications of nano materials.
Environmental Chemistry Air and Water Pollution, analysis of gaseous effluents oxides of Nitrogen, oxides of Sulphur and H_2S, chemical analysis of effluents liquid streams, BOD, COD, control of pollution, Depletion of ozone layer.

UNIT- 4

Stereochemistry Stereoisomerism of organic compounds containing one & two chiral centers. Enantiomers & Diastereomers, E-Z nomenclature, R-S configuration, Atropisomerism, and Optical isomerism in Allenes, biphenyl and Spiranes, Circular Dichroism.
Reaction Mechanism Inductive, Electromeric and Mesomeric effects. Study of reaction intermediates (Carbanion, carbocation, carbene, nitrene and benzyne). Mechanism of nucleophilic and electrophilic substitution reactions. Mechanism and application of following reactions:

a) Suzuki-Miyaura Cross coupling reaction
b) Fries and Photo-Fries Rearrangement
c) Wagner-Meerwein Rearrangement
d) Umpolung Reactions
e) Favorskii Rearrangement

UNIT- 5

Polymers: Introduction, types of polymers, Molecular mass-number and mass average molecular weight, determination of molecular mass by Osmometry, viscosity, light scattering and size exclusion chromatography, Rheological properties and uses of some common polymers. Synthetic Polymers (carbon framework, silicon framework, fluorinated polymer), Conducting and Biodegradable polymers.

Water Analysis: Introduction; Hardness of Water- cause, types, units, Disadvantages of using hard water for domestic and industrial purposes, Softening of hard water, Chemical analysis of Water- estimation of free chlorine, total alkalinity, hardness, Numerical based on determination of hardness.

Solid Waste Management: Classification, waste treatment & Disposal methods (Composting, sanitary landfilling, thermal processes, recycling and reuse).

List of Experiments:

1. Determination of alkalinity in given water sample.
   i. Sodium Carbonate & Sodium Bicarbonate
   ii. Sodium Carbonate & Sodium Hydroxide
2. Determination of temporary and permanent hardness in water sample using EDTA as standard solution.
3. Determination of Chloride content of water by Mohr's Method.
4. Determination of Chlorine content in Bleaching powder.
5. Determination of strength of supplied Ferrous Ammonium Sulphate (FAS) solution in usingexternal, internal indicators.
6. Determination of viscosity of a given liquid by Ostwald's viscometer.
7. Determination of surface tension of a given liquid by Stalagmometer.
8. pH metric titration.
9. Determination of Dissociation constant of weak acids by conductometric Titration.
10. To prepare aspirin (acetyl salicylic acid) from salicylic acid.
11. Synthesis of polyurethanes
12. Find the concentration of the given samples using UV-visible spectroscopy.

Textbooks

A Text Book of Engineering Chemistry by Shashi Chawla, Dhanpat Rai & Co., Fifth Edition, 2017.

Reference Books:

1. Organic Chemistry by I. L. Finer, *Vol-1, Ninth Edition, 2015, Pearson Publisher.*
2. Physical Chemistry by Puri, Sharma & Pathania, Vishal Publishing Co., 48th Edition, 2021, ISBN: 978-93-87015-81-4

3. Polymer Science by V. R. Gowarikar, N. V. Vishwanathan and J. Shridhar, Wiley Eastern Ltd.,New Delhi, 1987, ISBN: 978-0470203224.
4. Elementary Organic Spectroscopy by Y.R. Sharma, S. Chand, Fifth Edition, 2013, ISBN: 9788121928847.

Web links

1. https://nptel.ac.in/courses/104101121 [Prof. Debabrata Maiti, IIT Bombay]
2. https://nptel.ac.in/courses/104106119 [Prof. Harinath Chakrapani & Prof. Neeraja Dashaputre, IIT Madras]
3. https://nptel.ac.in/courses/104105084 [Prof. Debashis Ray, IIT Kharagpur]
4. https://nptel.ac.in/courses/104106129 [Prof. M. V. Sangaranarayanan, IIT Madras]

Evaluation Scheme:

S. No.	Course Type	Subject Code	Course title	Credits (L-T-P)	Sessional Marks				ESM	Total Marks
					MSE	TA	Lab	Total		
1	BSC	NCY 101/102	Engineering Chemistry	4(3-0-2)	15	20	15	50	50	100

NCS 101/102 INTRODUCTION TO COMPUTER SCIENCE AND ENGINEERING

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

Course Outcomes (COs):

To explain the fundamentals of the computer system in terms of hardware components and basics of an operating system, understanding of programming, database management systems, and working with Internet and web applications.

At the end of this course students should be able to:

CO1	Understand hardware components of computer systems such as memory system organization, and input/output devices, and be aware of software components of computer system	Understand	K1
CO2	Understand Operating systems and be able to develop basic shell scripts.	Understand, Apply	K1, K2
CO3	Develop a basic understanding of programming and get a concept of algorithmic thinking.	Apply, Analyze	K2, K3
CO4	Understand Databases, Use SQL to write queries.	Understand, Evaluate	K1, K4
CO5	Explain how the Internet works and be able to make basic static Web applications.	Understand, Create	K1, K5

K1-Understand, K2-Apply, K3-Analyse, K4-Evaluate, K5-Create

Course Articulation Matrix (CO-PO Matrix)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	-	-	-	-	-	-	-
CO2	2	1	1	-	-	-	-	-	-	-	-	-
CO3	3	3	2	3	1	-	-	1	1	1	1	1
CO4	3	2	2	3	1	-	-	-	1	-	2	1
CO5	3	2	3	1	2	1	1	2	2	2	1	2

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

Course Content

Unit - 1

Fundamentals of Computers: Introduction to Computers - Computer Definition, Characteristics of Computers, Evolution, and History of Computers, Types of Computers, Basic Organization of a Digital Computer; Classification of Digital Computer Systems: Microcomputers, Minicomputers, Mainframes, Supercomputers. Number Systems, Computer Codes – BCD, Gray Code, ASCII, and Unicode; Boolean Algebra – Boolean Operators with Truth Tables; Types of Software – System Software and Utility Software; Computer Languages - Machine Level, Assembly Level & High-Level Languages, Translator Programs – Assembler, Interpreter and Compiler; Planning a Computer Program – Data Structures, Algorithm, Flowchart and Pseudo code with Examples.

Unit-2

Operating System Fundamentals: Operating Systems: Introduction, Functions of an Operating System, Classification of Operating Systems, System programs, Application programs, Utilities, The Unix Operating System, Basic Unix commands, Microkernel Based Operating System, Booting.

Unit-3

Fundamentals of C Programming Language: Introduction to C Programming Languages, Structure of C programs, compilation and execution of C programs, Debugging Techniques, Data Types and Sizes, Declaration of variables, Modifiers, Identifiers and keywords, Symbolic constants, Storage classes (automatic, external, register and static), Enumerations, command line parameters, Macros, The C Preprocessor.

Operators: Unary operators, Arithmetic & logical operators, Bitwise operators, Assignment operators and expressions, Conditional expressions, Precedence, and order of evaluation.

Control statements: if-else, switch, break, and continue the comma operator, goto statement. Loops: for, while, do-while. Functions: built-in and user-defined, function declaration, definition and function call, and parameter passing: call by value, call by reference, recursive functions. Arrays: linear arrays, multidimensional arrays, passing arrays to functions, Arrays, and strings.

Unit-4

Introduction to Database Management Systems: Database, DBMS, Why Database -File system vs DBMS, Database applications, Database users, Introduction to SQL, Data types, Classification of SQL-DDL with constraints, DML, DCL, TCL

Unit-5

Internet Basics: Introduction, Features of the Internet, Internet application, Services of the Internet, Logical and physical addresses, Internet Service Providers, Domain Name System.

Web Basics: Introduction to web, web browsers, http/https, URL, HTML5, CSS

Text Books:

1. Kernighan B.W., Ritchie D.M., “The C Programming Language”, 2nd Edition, Prentice Hall Software, 2015
2. V. Rajaraman, “Fundamentals of Computers”, 6th Edition, PHI Learning Pvt. Ltd., 2015
3. Peter Norton’s, “Introduction to Computers”, 7th Edition, Tata McGraw Hill, 2017
4. David Riley and Kenny Hunt, “Computational Thinking for Modern Solver”, Chapman & Hall/CRC, 1st Edition, 2014

Reference:

1. J. Glenn Brook shear,” Computer Science: An Overview”, Addision-Wesley, Twelfth Edition, 2017
2. R.G. Dromey, “How to Solve it by Computer”, PHI, 1982
3. Balagurusamy E., “Fundamentals of Computers”, Second ed. 2009, McGraw Hill
4. Thareja R., “Fundamentals of Computers”, 2014, Oxford University Press.

Web link:

1. https://onlinecourses.swayam2.ac.in/cec19_cs06/preview

NTE 101/102 INTRODUCTION TO ELECTRONICS ENGINEERING

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

Course Objective

To understand the fundamentals of analog & digital electronic devices like diode, transistor, logic gates, flip-flop and to understand the working principles of common Instruments used in electronic measurement.

Course Outcomes (CO):

At the end of this course students should be able to:

CO1	To understand the basic concept of diodes, and use the diode as a circuit element for different applications.	K2,K3
CO2	To understand the working of BJT, FET and OP-amp and their application.	K2, K3, K6
CO3	To design the simple digital circuits using different logic gates.	K4, K6
CO4	To identify the errors while making electronic measurements and to understand the working of different types of transducers.	K1, K4, K5
CO5	To understand the working principle of electronic instruments and displaying it on electronic devices.	K1, K2, K4

K1- Remember, K2- Understand, K3-Apply, K4-Analyse, K5- Evaluate, K6- Create

Course Articulation Matrix (CO-PO Matrix)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	1	1	-	-	-	-	-	-	-
CO2	2	3	3	3	2	2	-	-	-	-	-	-
CO3	3	2	1	3	2	1	-	-	-	-	-	-
CO4	3	2	1	1	1	-	-	-	-	-	-	-
CO5	3	1	3	2	1	-	-	-	-	-	-	-

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

Course Content

Unit-I:

P-N Junction Diode, Depletion layer, Barrier potential, forward and reverse bias, Knee voltage, V-I Characteristics and its Equivalent Models, Avalanche and Zener Break Down, Diode Applications as Half Wave, Full Wave & Bridge Rectifier and their comparative analysis, Clippers, Clampers, Voltage Multiplier Circuit, Zener Diode and its Applications as a voltage regulator, Varactor diode.

Unit-II:

Basic theory and operation of PNP and NPN transistors, Characteristics of Common Base, Common Emitter and Common Collector configuration, DC Biasing : Fixed Bias, Emitter Bias, voltage divider

bias, Field effect transistor: JFET, Drain and Transfer characteristic, MOSFET, Introduction to Operational Amplifier and its Applications as Adder, Subtractor, Integrator, Differentiator, log antilog.

Unit-III:
Number System, Base Conversion, BCD code, Excess-3 code, Gray Code, Review of Logic Gates, Concept of Universal Gates &, Boolean laws and theorems, SOP and POS representation of Boolean functions, Minimization of Boolean functions using K map, Basic Combinational Circuits: Half Adder, Full Adder, Subtractor, Sequential Circuits: Latch, Flip-Flops, Characteristic and Excitation Table of SR, JK, D and T Flip-flop. Concept of Master Slave Flip- Flop, Shift Registers.

Unit-IV:
Functional Elements of Instruments, Classification & Characteristics, Types of Errors, Sources of Error, Dynamic Characteristics, Active and Passive Transducers: Resistive Transducers, Thermistor, Strain Gauge, Thermocouple, Differential Output Transducers, LVDT and their Characteristics.

Unit-V:
Display Devices: LCD, LED, Seven Segment Display, Alphanumeric Display, Electronic Ammeter and Voltmeter, Digital Multi-meter, Cathode Ray Oscilloscope (CRO), Digital Storage Oscilloscope (DSO)

Text Books:

1. Electronics Principles by Albert Malvino, & David Bates, 2016, Tata McGraw-Hill, Eigth Edition, ISBN- 978-0-07-337388-1
2. Electronic Devices & Circuit Theory by Boylestad, Robert & Nashelsky, 2015, Louis, Prentice Hall of India. Eleventh Edition, ISBN- 10-9332542600
3. Electronic Instrumentation and Measurements by H.S. Kalsi, 2019, Tata McGraw-Hill, Fourth Edition, ISBN-10- 9353162513
4. Digital Principles and Applications by Leach, Malvino, & Saha, 2014, Tata McGraw-Hill, 8th Edition, ISBN-10- 9789339203405

Reference Books:

1. Microelectronic Circuits by Adel Sedra, Kenneth C.(KC) Smith, Tony Chan Carusone, Vincent Gaudet, 2020, Oxford University Press, 8th Edition, ISBN-10-0190853468
2. A Course in Electrical and Electronic Measurements and Instrumentation by A K Sawhney 2021, Dhanpat Rai & sons, ISBN-10- 8177001000
3. Fundamentals of Microelectronics by Behzad Razavi, Wiley, Second Edition, ISBN-13:9781118156322

Web Links:

1. https://nptel.ac.in/courses/108101091
2. https://nptel.ac.in/courses/122106025

NCE 101/102 INTRODUCTION TO CIVIL ENGINEERING

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

Course Outcomes

At the end of this course students should be able to:

CO1	To understand the overview and scope of Civil Engineering and apply the fundamentals of Surveying
CO2	To understand the various types of Civil Engineering materials
CO3	To understand the basic concepts of water and wastewater quality, infrastructure, and also the basics of different pollution
CO4	To understand the basics of Highways, Railways and Airport Engineering
CO5	To understand the basics of various Civil Engineering structures

Course Articulation Matrix (CO-PO Matrix)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	2	-	-	-	-	-	1
CO1	2	-	-	-	-	2	-	-	-	-	-	1
CO2	2	-	-	-	-	2	3	-	-	-	-	1
CO3	2	-	-	-	-	2	3	-	-	-	-	1
CO4	2	-	-	-	-	2	3	-	-	-	-	1
CO5	2	1	1	-	-	2	1	-	-	-	-	1

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

Course Content

Unit-1: Introduction

Civil Engineering: Overview and scope of Civil Engineering, Civil Engineering landmarks, Job opportunities in Civil Engineering

Fundamentals of Surveying: Introduction, Types of Surveying - Chain, Compass, levelling and contouring, Total Station, Introduction to Remote Sensing/ GIS/ GPS

Unit-2: Civil Engineering materials

Building materials: Bricks, Stones, Cement, Aggregate, Concrete, RCC, Steel, Timber, Tiles, lime, paint.

Highway materials: bitumen, concrete, Surkhi, sand, stone dust

Soil: Types of soil, classification of soil.

Unit-3: Environmental Engineering

Water and Wastewater Quality, Drinking Water Standards, Water infrastructure- Intake, Treatment plants, distribution system, and household plumbing.
Waste water infrastructure- household drainage system, sewerage system, Treatment Plant, and, disposal, effluent standards.
Introduction to Air Pollution, Air Quality Index, Air quality standards, Solid Waste Management- collection and segregation, Noise Pollution- standards

Unit-4: Transportation Engineering

Highway Engineering: Introduction, Model, elemental and functional classification of Transportation System, IRC classification of roads, Typical cross-section of pavements, Control system.
Railway Engineering: Types of rails, Components of permanent way, stations
Airport- Components of the airport
Introduction to Docks, Harbour, and Inland waterways

Unit-5: Civil Engineering Structures

Introduction to buildings: Elements- slab, beam, column, footing

Introduction to various Civil Engineering Structures- Bridges, Retaining Wall, Tanks and Reservoirs, Hydraulic Structures-Dams, Canals, Weirs, Barrage, Industrial Structures

Textbooks

1. S.S. Bhavikatti (2010). 'Basic Civil Engineering.', 1st edition, New Age International Publishers, New Delhi
2. Sateesh Gopi (2009). 'Basic Civil Engineering.', Pearson Publishers, Delhi, India
3. Punmia, B.C., Jain, A.K. and Jain, A.K. (2003). 'Basic Civil Engineering.' Laxmi Publications, New Delhi.

Reference Books

1. An Introduction to Civil Engineering by V. Okumu, CreateSpace Independent Publishing Platform.
2. Penn M. R. and Parker P. J. "Introduction to Infrastructure: An Introduction to Civil and Environmental Engineering" John Wiley & Sons 2011.

Web Resources

https://nptel.ac.in/courses/105106201

NCT 102

Introduction to Chemical Engineering and Technology

L	T	P	C
3	1	0	4

Course Objective:

The objective of the course is to impart

- Knowledge of basics concepts of microbiology and Food processing
- General introduction to Oils, fats, oleochemicals, essential oils, their sources, composition and structures. Basic concepts about paints, ingredients, functions, formulation and application of paints
- Knowledge of basic concepts of Polymer and Plastics
- Knowledge of basic concepts of chemical engineering
- Knowledge of basics of leather processing

Course Outcome

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

CO1	Understanding the basic concepts of microbiology and food processing	Understand
CO2	Understand the basic concepts about oils & paints, their ingredients and functions	Understand
CO3	Understand the basics and applications of Polymers and Plastics	Understand
CO4	Understand basics and application of chemical engineering	Understand
CO5	Understanding basics of leather processing	Understand

CO-PO Mapping

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1				1	2	1	1	2		2
CO2	3	1				1	2	1	1	2		2
CO3	3	1				1	2	1	1	2		2
CO4	3	1				1	2	1	1	2		2
CO5	3	1				1	2	1	1	2		2

Syllabus

Module 1: Introduction to Biochemical Engineering and Food Technology

Introduction to biochemical engineering. Microorganisms: Characteristics, classification, morphology, and reproduction in brief, Introduction to Food Technology: Scope of Food Technology, Overview of Food Constituents, Food Quality & Safety, Regulatory framework in India.

Module 2: Introduction to Oil and Paint

General introduction to Oils; their sources, composition, physiochemical characteristics. Fatty acids; structures nomenclature, classification and principal sources. Production and consumption pattern of various oils.

Basics concepts of paints, general ingredients & their functions. Introduction of drying oils, natural & synthetic resins, extenders & prime pigments, solvents, driers and plasticizers. General formulation of paint and basic machineries used in its manufacture. Testing and application of paint.

Module 3: Introduction to Polymer Science and Technology

Concept and definition of monomers, polymers, plastics and related chemicals, Basic properties, and types of plastic materials, Utility of plastic materials in variety of fields and their advantages over other material of construction, Global and Indian scenario of Plastic and allied industries.

Module 4: Introduction to Chemical Engineering

Introduction to Chemical Engineering, Unit Operations and Processes, Thermodynamics and Kinetics, Material and Energy Balances, Reactor Design, Piping and Instrumentation, Automation and Control, Energy Resources and Environmental Engineering, Process Safety, Operations and Troubleshooting, Career Opportunities and Challenges.

Module 5: Introduction to Leather Technology

History of Leather; Overview of Leather Sector; By-Product of Meat Industry; Biodegradable products; Hides and Skins Protein; Curing of Hide & Skins; Introduction to Leather Processing; Leather Machinery.

Suggested Readings

Module 1:

Text Books:

1. Biochemical Engineering Fundamentals by J. E. Bailey & D. F. Ollis (1987) 2nd Ed. McGraw Hill International Edition.
2. Pelczar M J, Chan E C S and Krieg N R "Microbiology, 5th Edition, " Mc Graw Hill, New York (1995)
3. Food Science By Norman N. Potter, 2012

Reference Books:

1. Food Microbiology By William C. Frazier, Dennis C. Westhoff · 2004
2. The Food Safety and Standards Act,2006
3. Food Facts and Principles By N. Shakuntala Manay & M. Shadaksharaswamy

Web Links:

1. www.fssai.gov.in
2. https://egyankosh.ac.in

Module 2:

Text Books

1. Baileys Industrial oil and fat products by Daniel Swern, Wiley Interscience publication (1979)
2. Chemistry and Technology of Oils and Fats by Prof. M. M. Chakrabarti, Allied publishers (2003)
3. Nontraditional oilseeds and oils by N. V. Bringi, Oxford and IBH Co. Pvt. Ltd. (1989)

Reference Books:

1. Fatty Acid by K. S. Markely, Inter Science publishers (1968)
2. Organic Coating Technology, Vol. I& II; byHF Payne.
3. Outlines of Paint Technology; byWMMorgan.
4. Basics of Paint Technology(Part I& II);by Malshe & Sikchi.

Web Links:

1. https://www.youtube.com/watch?v=34IADhdkvKQ
2. https://www.youtube.com/watch?v=6j8HnaZLVL8
3. https://www.youtube.com/watch?v=KTyQ-T21XgM

Module 3:

Text Books:

1. F. W. Billmeyer; Text Book of Polymer Science; Wiley; Third edition; January 2007.
2. Vasant R. Gowariker; Polymer Science; New Age International; January 2019

Reference Books:

1. Premamoy Ghosh; Polymer Science and Technology; Tata McGraw-Hill Education, New Delhi;1990.
2. R.J. Young and P.A. Lovel; Introduction to Polymers; CRC Press; London, 2011.

Web Links:

1. Introduction to Polymer Science - https://nptel.ac.in/courses/104/105/104105124/
2. Science & Technology of Polymers - https://nptel.ac.in/courses/113/105/113105028/
3. Polymer Chemistry - https://nptel.ac.in/courses/104/105/104105039/

Module 4:

Text Books:

1. Salil K Ghosal, Siddhartha Datta, "Introduction to Chemical Engineering" Tata McGraw Hill Education Private Limited, 1993.
2. Warren Lee MacCabe Smith, Peter Harriott, "Unit Operations of Chemical Engineering", 7th Edition, McGraw Hill 2005

Reference Books:

1. Maloney, James O. Perry Chemical Engineers Handbook. The McGraw-Hill Companies, Inc, 2008

Web Links:

1. https://youtu.be/WgWNQVdhE9A
2. https://www.pmu.edu/department-of-chemical-engineering/pdf/IntroductionChemicalEngineering.pdf
3. https://en.wikipedia.org/wiki/Chemical_engineering

Module 5:

Text Books:

1. Dutta. S.S., “An Introduction to the Principles of Leather Manufacture”.

Reference Books:

1. Covington T., “Tanning Chemistry: The Science of Leather”.
2. Sarkar K.T., “Theory & Practice of Leather Manufacture”.

Web Links:

1. https://youtu.be/z6QnUCc7ZCg
2. https://youtu.be/4PBRW-g01Ag
3. https://www.neratanning.com/knowledge/the-leather-making-process-step-by-step/

NWS 101 / 102 WORKSHOP PRACTICE

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

Course Objective: The objective of this course is to educate and impart basic knowledge of various hand tools and equipments and their use in different shops, day to day industrial work and domestic life. Students able to understand safety precautions in the workshop. Student acquires skills of application oriented task.

Course Outcome

At the end of the course the student should be able to :

CO 1	Study and practice on machine tools and their operations	K2
CO 2	Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry, black - smithy and welding work	K3
CO 3	Identify and apply suitable tools for machining processes including plain turning, step turning, taper turning, facing, thread cutting operations	K4
CO 4	Understand and practice welding and forging operations	K3
CO 5	Select the appropriate tools required for specific operation and the proper safety measure required to be taken while using different tools.	K2 , K3

K1 - Remember, K2 - Understand, K3 - Apply, K4 - Analyze, K5 - Evaluate, K6 – Create

Course Articulation Matrix (CO-PO Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO(	PO10	PO11	PO12
CO1	2	-	-	1	1	1	-	-	-	-	-	1
CO2	2	-	-	1	1	1	-	-	-	-	-	1
CO3	2	-	-	1	1	1	-	-	-	-	-	1
CO4	2	-	-	1	1	1	-	-	-	-	-	1
CO5	2	-	-	1	1	1	-	-	-	-	-	1

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

CO1

1. Working principle of lathe machine
2. Parts and operations on lathe machine
3. Tool geometry of single point cutting tool

CO2

1. Study and practice of different tools used in Fitting shop, Carpentry shop and Foundry shop.
2. Study and practice of different tools used in Black-smithy shop, Sheet metal shop and Welding shop.

CO3

1. Explanation and demonstration of various processes like plain turning and step turning.
2. Explanation and demonstration of various processes like taper turning and facing.
3. Explanation and demonstration of various processes like thread cutting, knurling and chamfering.

CO4

1. Classification of different welding processes with the help of flow chart.
2. Explanation and demonstration forging operations.
3. Safety precautions during actual forging and welding.

CO5

1. Selection of proper drilling tool for drilling operation.
2. Selection of proper tap for internal thread cutting operation.
3. Selection of power hacksaw blade, wood cutting cutter, snips, chisels etc.

CO6

1. Proper demonstration of safety precautions to be taken for example leather apron, leather hand gloves, welding shield etc.
2. Description of different safety tools and precautions in workshop.

Course Content

1. Carpentry Shop

Practice (I) : To prepare half lap corner joint from given pieces of mango wood.
Practice (II) : To prepare mortise and tenon joint from given pieces of mango wood.
Instructions : Description and demonstration of different tools, joints along with advanced carpentry joints, classification and definition of timber, wood seasoning, demonstration of wood working lathe and advanced power tools used in carpentry work, safety precaution during actual working.

2. Fitting and Bench working Shop

Practice (I) : To prepare male-female joint from given pieces of mild steel.
Practice (II) : To prepare practice work piece involving marking, measuring, sawing, drilling and tapping operations.
Instructions : Classification and description of different tools used in fitting shop e.g. marking and measuring tools , holding and supporting tools, striking tools

and cutting tools etc. , safety precaution during actual working.

3. Black Smithy Shop

Practice (I) : To prepare 'L' shape job from given piece of mild steel rod by hand forging.
Practice (II) : To prepare a 'Ring' from given piece of mild steel rod by hand forging.
Instructions : Description of various forging processes done in black-smithy work e.g. upsetting, drawing down, punching, bending, fullering etc, classification and description of different tools, Equipments used in black smithy shop, safety precaution during actual working.

4. Welding Shop

Practice (I) : To prepare simple butt joint and lap joint by electric arc welding from given pieces of mild steel.
Practice (II) : To prepare simple lap joint by oxy-acetylene gas welding and gas flame Cutting practice.
Instructions : Concept of welding, classification and explanation of various types of welding with the help of flow chart, description of different tools. Equipments required for arc welding and gas welding, demonstration of various types of flames in Oxy-acetylene gas welding, setting of current and selection of electrodes along with different welding joints, safety precaution during actual working.

5. Sheet Metal Shop

Practice (I) : To prepare a funnel complete with soldering from given G.I. sheet.
Practice (II) : To fabricate tray / tool box or electric panel box from given G.I. sheet.
Instructions : Classification and description of different types of tools, Equipments used in sheet metal work, different types of metals used in sheet metal shop e.g. Galvanized iron, lack iron, copper, aluminum etc., concept of development of surfaces along with different types of joints in sheet metal work, safety precaution during actual working.

6. Machine Shop

Practice (I) : To prepare a job by plain turning, facing, step turning and chamfering Operation from given mild steel rod.
Practice (II) : To prepare a job by taper turning, threading, knurling operations from given mild steel rod.
Instructions : Classification of lathe machines, different parts of lathe machine, tools and Equipments used, explanation and demonstration of various operations on lathe machine, tool geometry of single point cutting tool, cutting speed, feed and depth of cut in turning, safety precaution during actual working.

7. Foundry Shop

Practice (I) : To prepare a mould of given pattern in Green Sand
Practice (II) : To prepare a mould with two step pulley with runner and riser
Instructions : Description and use of various foundry tools, showel, flat rammer, hand rammer, strike off bars, vent wire, trowels, hand riddle etc. Types of various moulding sands, types of patterns, pattern materials, pattern allowances, safety precautions during actual working.

Text Books

1. Elements Of Workshop Technology Vol-1, by Choudhury H S K, MPP Pvt. Ltd., 2008
2. A Course in Workshop Technology Vol I by Raghuwanshi, Dhanpat Rai & sons, 2011.
3. Workshop Practice Manual by V Kapoor, Dhanpat Rai & sons, 1998
4. Workshop Technology: Manufacturing Processes by Khurmi & Gupta, S. Chand Publications, 2008

Reference books

1-Mechanical Workshop Practice, 2/E 2nd edition, Kindle Edition, K.C.John, PHI, 2010.
2-Workshop Practice , Singh Swarn, Katson Books, 2003.
3- Workshop Practice, R.K.Rajput, 2016.
4- Workshop Practice, B.L.Juneja, Cengage Learning Publishers, 2015.

Link:

1- https://sjce.ac.in/wp-content/uploads/2018/04/Workshop-Laboratory-Manual.pdf
2- https://nptel.ac.in/courses/112107219

Evaluation Scheme

Course Title	Credit (L:T:P)	Sessional Marks				ESM	Total Marks
		MSE	T A	Lab	Total		
Workshop Practice	2(0-0-4)	--	20	30	50	50	100

Year II, Semester III

BMA 251 ENGINEERING MATHEMATICS–II

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

OBJECTIVE: The objective of this course is to educate the students about:

- Ordinary differential equations and their applications as mathematical models.
- Series solutions of ordinary differential equations and special functions.
- Laplace transform, Fourier series, differential equations and boundary value problems.

Course Outcome

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

CO1	Solve first and higher order ordinary differential equations.	Apply, Analyze Evaluate,
CO2	Find series solutions of ordinary differential equations and learnBessel's and Legendre's function and its applications.	Apply, Analyze Evaluate,
CO3	Solve IVPS and BVPS using Laplace Transform.	Apply, Analyze Evaluate,
CO4	Find Fourier series expansion of given function and solve partial differential equations.	Apply, Analyze Evaluate,
CO5	Solve boundary value problems using variable separable method etc.	Apply, Analyze Evaluate,

Course Articulation Matrix (CO-PO Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	1	2	-	-	1	-	1	-	3
CO2	3	3	2	1	2	-	-	1	-	1	-	3
CO3	3	3	2	1	2	-	-	1	-	1	-	3
CO4	3	3	2	1	2	-	-	1	-	1	-	3
CO5	3	3	2	1	2	-	-	1	-	1	-	3
Average	3	3	2	1	2	-	-	1	-	1	-	3

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

Detailed Syllabus:

Unit- I: Ordinary Differential Equations

First order ordinary differential equations, Existence and uniqueness of solutions of initial value problems, Solution of higher order linear differential equation with constant coefficients, Solution of second order differential equations by changing dependent and independent variables, Cauchy-Euler equations, Methods of diagonalization, undetermined coefficients and variation of parameters: Nonlinear equations, Linear and nonlinear models, Initial value and boundary value problems, Systems of equations. Application of differential equations as mathematical models, Models from population dynamics, Newton's Law of cooling, electric circuit, Oscillation of spring.

Unit-II: Series Solutions of Ordinary Differential Equations & Special Functions

Ordinary and singular points of an equation, Power series solutions, Frobenius method, Bessel's and Legendre's equations and their series solutions, Properties of Legendre's polynomials and Bessel's functions, Generating functions, Fourier- Bessel series and Fourier-Legendre series expansions, sturm- Liouville Problem and related theorems.

Unit-III: Laplace Transform:

Laplace transform, Existence conditions and ROC, Inverse Laplace transform, Operational properties, Convolution, Unit step function, Dirac-Delta function, Periodic functions, Applications to solve IVP and BVP: Linear ordinary differential equations, Transfer function and control system analysis.

Unit-IV: Fourier Series and Partial Differential Equations:

Orthogonal functions, Fourier series, existence conditions, Fourier series of even and odd functions, convergence of Fourier series, Fourier half range series, Harmonic analysis, Complex Fourier series and frequency spectrum. Development of partial differential equations and Solutions, Solution of first order partial differential equations, Solutions of linear higher order partial differential equations with constant coefficients.

Unit-V: Boundary-Value Problems:

Classification of second order partial differential equations, Derivation of heat and wave equations, solutions in rectangular coordinates by separation variable method, solution of Laplace equation, D'Alemberts solution of wave equation, Non-homogeneous equations and boundary conditions, Orthogonal series expansions, Fourier series in two dimensions, Boundary value problems in polar, cylindrical and spherical coordinate systems and their solutions.

Books Recommended:

1. E.A. Coddington, An Introduction to Ordinary Differential Equations, Practice Hall, 1995.
2. I.N. Sneddon, Elements of Partial Differential equations, McGraw-Hill 1957.
3. Dennis G, Zill & Michael R. Cullen; Advanced Engineering Mathematics, Jones & Bartlett Publishers. 2nd Edition.
4. R.K. Jain & S.R.K. Iyengar; Advanced Engineering Mathematics, Narosa Publishing House, 2002.
5. Erwin Kreyszig; Advaced Engineering Mathematics, John Wiley & Sons 8th Edition.

Course Code: NCT 201

FLUID MECHANICS & MECHANICAL OPERATIONS

L	T	P	C
3	0	2	4

Course Objectives: The objective of this course is to impart

- Knowledge of various fluid properties and their measurement devices.
- Knowledge of different types flow and flow behavior during flow of fluid through pipes.
- Knowledge of mass, energy and momentum balance in the system for interdisciplinary applications
- Knowledge of mechanical operations used in understanding fluid mechanics.

CO1	Understand the concept of viscosity and other fluid properties and their measurement.	Understand
CO2	Design the fluid flow systems by applying integral balances.	Design, Apply
CO3	Apply differential balance on fluid flow to formulate and solve the problems related to fluid flow.	Analyze, Apply, Evaluate
CO4	Apply the concept of agitation and mixing of liquids to solve problems related to particulate flow	Apply, Evaluate
CO5	Understand the principle involved in various mechanical operations.	Understand, Apply
CO6	Conduct various experiments to apply the concepts of fluid mechanics and mechanical operations.	Analyze, Understand, Apply, Evaluate

CO-PO Mapping

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	**3**	**2**	**-**	**-**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**2**		
CO2	**3**	**2**	**3**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**2**		
CO3	**3**	**3**	**3**	**2**	**1**	**-**		**-**	**-**	**-**	**-**	**2**		
CO4	**3**	**3**	**3**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**2**		
CO5	**3**	**3**	**3**	**1**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**2**		
CO6	**3**	**3**	**2**	**2**	**1**	**-**	**-**	**1**	**3**	**3**	**3**	**3**		
Average	3	2.7	2.8	1.6	1	0	0	1	3	3	3	2.2		

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

Syllabus

Module I (6 hours)

Definition of a fluid; Continuum hypothesis; 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 (6 hours)

Macroscopic Balances: derivation of integral balances for mass, energy and momentum; Derivation of engineering Bernoulli equation with losses, Application of macroscopic balances. Flow measurement: Orifice meter, venturimeter, Pitot tube, and Rota meter, Hydrodyanmics in environmental systems.

Module III (6 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.

Module IV (6 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. Application of fluidized systems for environmental remediation.

Module V (6 hours)
Properties and handling of Particulate solids. Classification of size reduction equipment: Crushers, Grinders, Ultra-fine grinders, Cutting machines and related Problems. Size reduction – Rittingers Law, Kicks law, Bonds crushing law, Work index, Problems. Different types of screening equipment in industries, Screen efficiency. 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. Basic idea of transportation equipment's.

List of experiments

1. To determine coefficient of discharge of an venturimeter
2. To determine coefficient of discharge of an orifice meter.
3. To determine the minor losses in pipe fittings
4. To verify the Bernoulli's Theorem
5. To find critical Reynolds number for a Pipe flow,
6. To calculate reduction ratio in Jaw crusher
7. To calculate reduction ratio in crushing roll
8. To calculate critical speed of Ball mill
9. To perform differential and cumulative screen analysis

Text book:

1. Dr. R. K. Bansal, Fluid mechanics and hydraulic machines, Lakshmi Publication, Tenth edition, 2019
2. McCabe, Smith and Harriott, Unit Operations of Chemical Engineering: McGraw Hill, 7th Edition 2017
3. K. Swain, H. Patra, G. K. Roy, Mechanical operations, Mc Graw Hill, 2017

Reference:

1. Chhabra, R. P., and V. Shankar, eds. Coulson and Richardson's Chemical Engineering: Volume 1A: Fluid Flow: Fundamentals and Applications. Butterworth-Heinemann, 2017.
2. Gupta, Vijay and S. K. Gupta, "Fluid Mechanics and its Applications", Wiley Eastern, New Delhi, 2015

Web Links:
https://nptel.ac.in/courses/103102211
https://archive.nptel.ac.in/courses/103/104/103104043/

NPL 201 INTRODUCTION TO POLYMER CHEMISTRY (ITPC)

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

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

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

Course Outcome

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

CO1	Understand the fundamentals types and properties of polymers.	Understand
CO2	Understand and apply the chain growth polymerization and its kinetics.	Apply
CO3	Understand and apply the step growth polymerization, its kinetics, mechanism and crosslinking.	Apply
CO4	Analyze molecular weight and molecular weight distribution of polymers, copolymers, etc.	Analyze
CO5	Understand and analyze co-polymerization usefulness and its types	Analyze

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus

Module-I: Basics of Polymer formation

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

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

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

Module-IV: Molecular Weight and its Control
Concept of Molecular weight of polymers, factors affecting molecular weight and molecular weight distribution, polydispersity. Chain transfer reactions, retarders, inhibitors, effect of temperature on polymerization

Module-V: Copolymerization and other Reactions
Copolymerization reactions and its utility. Kinetics of copolymerization, copolymerization behavior and types of copolymers. Significance & Global Impact of copolymerization on Plastic Industry

Text books:

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

Reference Books:

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

Web Links:

1. https://archive.nptel.ac.in/courses/104/105/104105124/
2. https://nitsri.ac.in/Department/Chemical%20Engineering/M3__Polymer_Technology.pdf

NPL 203 POLYMERIZATION ENGINEERING – I (PE-I)

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

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

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

Course Outcome

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

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

Course Articulation Matrix (CO-PO Matrix)

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 "-"*

Detailed Syllabus

Module-I: Industrial Polymerization

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

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

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

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

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

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

List of Experiments:

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

Text books:

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

Reference books:

1. J. Scheries& W. Kaminsky, “Metallocene based Polymers ", Wiley, 2000.
2. F. J. Davis, “Polymer Chemistry: A Practical Approach (The Practical Approach in Chemistry Series)”,1st Edition, Oxford University Press, 2004
3. O. Olabisi,“Handbook of Thermoplastics”, 2nd Edition, 2016.

Web Links:

1. https://archive.nptel.ac.in/courses/103/107/103107206/

Course Code: NPL 205

CHEMICAL PROCESS CALCULATION

L	T	P	C
3	0	0	3

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.	Remember, Understand, Apply
CO2	Select appropriate basis and conduct degree of freedom analysis for 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.	Analyze, Evaluate
CO4	Perform process calculations utilizing psychometric charts and steam tables.	Understand, Apply,Evaluate
CO5	Design of steady state continuous flow systems and unsteady state systems by applying simultaneous material and energy balance calculations	Design, Apply, Evaluate

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	3	2	1	-	-	-	-	-	-	-	2		
CO2	3	3	3	2	-	-	-	-	-	-	-	2		
CO3	3	3	3	3	2	2	-	-	-	-	-	2		
CO4	3	3	2	2	1	-	-	-	-	-	-	2		
CO5	3	3	2	1	-	-	-	-	-	-	-	2		
Avg	3	3	2.4	1.8	1.5	2	0	0	0	0	0	2		

Syllabus

Module 1 (6 hours)

Dimensions, system of units and their conversions, Mass and volume relations, Basic stoichiometric principles, limiting and excess reactants, Degree of completion, Conversion, Ideal gas law, Dalton’s Law,

Module 2 (6 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 (6 hours)

Material balance without chemical reactions and its application to unit operations like distillation, absorption etc.

Module 4 (6 hours)

Materialbalance with chemical reaction Recycle, bypass and purging. Yield and selectivity.

Module 5 (6 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.

Text books

1. Hougen, O.A., Watson, K.M and Ragatz, R.A., "Chemical Process Principles Part-I", John Wiley and Asia Publishing, 2nd edition 2005.
2. Himmelblau, D.M., "Basic Principles and Calculations in Chemical Engineering", Prentice Hall Inc., seventh edition, 2003
3. Felder, R.M. & Rousseau, R.W. "Elementary Principles of Chemical Processes ", JohnWiley, 4th edition, 2016.

Reference Books

1. Venkataramani, V., Anantharaman, N., Begum, K. M. MeeraSheriffa, "Process Calculations", Prentice Hall of India, Second Edition, 2011.
2. Sikdar, D. C., "Chemical Process Calculations", Prentice Hall of India, 2013.

Web Links:

https://archive.nptel.ac.in/courses/102/106/102106069/

NHS 201/202 ECONOMICS AND MANAGEMENT

Course: B. Tech.	**Branch:** All branches	**Semester:** 3rd & 4th
Sessional Marks:	50	**Credit:** 3
End Semester Exam:	50	**LTP:** 3 0 0

UNIT I: Introduction to Economics:

Overview: production possibility curve, choices-what, how and for whom, micro- and macroeconomics, inflation, unemployment, GDP and business cycle; demand and supply, elasticity ofdemand, consumer surplus and its applications,

UNIT II: Production, Cost and Market:

Production function, Cost Function, Types of Market: Perfect Competition, Monopoly, Oligopoly

UNIT III: Fundamentals of Management:

Development of Management Thoughts, Objectives, Functions of Management

UNIT IV: Functional Areas of Management-I

Human Resource Management: HRP, Recruitment and Selection, Performance Appraisal; MarketingManagement: Functions, Strategies

UNIT V: Functional Areas of Management-II

Finance Management: Objectives, Functions; Operations Management: Concepts, Functions,Inventory Management

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Text Books:

1. **Koutsoyiannis, A**., 'Modern Microeconomics', English Language Book Society, Macmillan.
2. **Joseph, L Massod,** "Essential of Management", Prentice Hall, India.
3. **S. P. Robbins,** "Management"**,** Prentice Hall, India

Additional Reference Books:

1. **Armstrong, Michel**, "A Handbook of Management Techniques", Kogan Page Limited
2. **Samuelson, Paul A** , 'Economics', 5th edition, McGraw Hill New York.
3. **Henderson, J M and Quadnt, R E** , 'Microeconomic Theory: A Mathematical Approach.', TataMacGraw Hill, New Delhi,2003

Course Outcome (COs)

1. Understand essential economic principles for solving economic problems with suitable policy alternatives.
2. Apply the knowledge of production, cost and market functions

3. Understand and apply basic functions of management
4. Develop and apply the understanding of people and marketing
5. Develop and apply the understanding of finance and operations

CO-PO Mapping

Co/PO	PO 1	PO 2	PO3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
CO1	0	0	0	0	0	0	2	1	0	0	0	2
CO2	0	0	0	0	0	0	2	1	0	0	0	2
CO3	0	0	0	0	0	0	2	1	2	2	1	2
CO4	0	0	0	0	0	0	2	1	2	2	2	2
CO5	0	0	0	0	0	0	2	1	2	2	3	2

NPL 207 POLYMER CHEMISTRY LAB (PC 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

Course Articulation Matrix (CO-PO Matrix)

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

List of Experiments

Sl No.	**List of Experiments**
1	Determination of refractive index of organic compounds, monomers, solvents, etc.
2	Purification of monomers and determining the yield and refractive index of the purified monomer
3	Purification of solvent by washing and determination of yield
4	Determination of percentage purity of initiators, viz. benzoyl per oxide, AIBN, etc.
5	Determination of percentage purity of potassium persulphate
6	Determination of percentage purity of phenol
7	Determination of percentage purity of formaldehyde
8	Determination of density of given polymer granules
9	Determination of specific gravity of given moulded sample of plastic
10	Identification of known and unknown polymer (unprocessed and processed) samples

Year II, Semester IV

NCY 202 MODERN ANALYTICAL TECHNIQUES

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

OBJECTIVE:

The objective of this course is to make the students aware of the modern instrumental techniques, the principles underlying them and their applications in the characterization of materials.

Course outcome

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

CO1	Interpret Raman and IR–Spectra for characterization ofmaterials.	Understand, Apply, Analyze
CO2	Interpret NMR, Mass and ESR–Spectra forcharacterization of materials.	Understand, Apply, Analyze
CO3	To analyze the conductivity to determine the concentration of solution and i-E characteristics of the samples.	Understand, Apply
CO4	Analytical separation carried out by Chromatography in a multi-component system.	Remember, Apply, Analyze
CO5	Elucidation of the Thermal Stability of different molecules and their Characterization on the basis oftheir thermal stability and Glass Transition Temperatureof Polymers. Determine the specific heat, heat ofreaction, Melting point & boiling point. Check the purity of drugs, crystallization and fusion of polymeric materials.	Understd, Apply, Evaluate, Create
CO6	To develop experimental skills to perform, monitor and manipulate the reactions.	Understand, Evaluate, Analyze

Course Articulation Matrix (CO-PO Matrix)

Chemistry												
BCY252	PO 1	PO 2	PO3	PO 4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO12
CO1	3	3	2	3	2	-	1	-	-	-	-	3
CO2	3	3	2	3	2	-	1	-	-	-	-	3
CO3	3	3	2	3	2	-	1	-	-	-	-	3
CO4	3	3	2	3	2	-	1	-	-	-	-	3
CO5	3	3	2	3	2	-	1	-	-	-	-	3
CO6	3	3	3	3	2	2	2	2	1	2	-	3
Average	3	3	2.17	3	2	0.33	1.17	0.33	0.17	0.33	-	3

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

SYLLABUS

Module I

(i) ***Infrared Spectroscopy*****:** Principle, mechanics of measurements, Selection rules, fundamental vibration modes, Factors influencing the band position and intensities, some characteristic frequencies and co-relation of IR spectra with molecular structures (applications), effect of Hydrogen Bonding on vibrational frequencies. (Lectures: 5-6)

(ii) ***Raman Spectroscopy*****:** Introduction theory of Raman Spectroscopy, Mechanism of Raman and Rayleigh scattering, Rule of Mutual Exclusion, correlation with the molecular structure, difference between Raman and IR spectra, Resonance Raman effect, Application of Raman Spectroscopy.

(Lecture 2-3)

(iii) ***Inductively coupled plasma-*** Introduction, Principle and applications of ICP-AES or OES.

(Lectures: 2-3)

Module II

(i) ***Nuclear Magnetic Resonance Spectroscopy*****:** Introduction, basic principles, mechanics of measurements, chemical shift, band multiplets, spin-spin splitting, shielding and deshielding effect, spin-spin coupling and coupling constant (J), some characteristics of NMR positions, Application in elucidation of molecular structure, , Elementary idea of NOE, DEPT NMR, C^{13} NMR, P^{31}NMR, F^{19}NMR.

(Lectures: 4-5)

(ii) ***Mass Spectroscopy*****:** Introduction, basic principles, instrumentation, fragmentation patterns, nitrogen rule, Mc Lafferty Rearrangement, interpretation of mass spectra and applications.

(Lectures: 3-4)

(iii) ***ESR* (*Electron Spin Resonance*) -** Basic Principles, Instrumentation and Applications.

(Lectures: 2-3)

Module III

(i) ***Potentiometry and Conductometry*****:** General principles, reference and indicator electrodes,potentiometric and conductometric titrations.

(Lectures: 3-4)

***Polarography*:** Basic principle, dropping mercury electrode (DME), half wave potential, polarographic currents and applications.

(Lectures: 3-4)

Module IV

(i) ***Chromatographic methods***: Introduction to chromatographic methods: Paper, TLC, Column and Gas chromatography, Principles, Instrumentation, GC column, Detectors and stationary phases and applications, Hyphenated techniques (GC-MS). (Lectures: 4-5)

Liquid Chromatography LC/HPLC, Column efficiency in LC, Detectors, Instrumentation, Partition/Adsorption/Ion Exchange Chromatography and applications.
(Lectures: 4-5)

Module V

(i) ***Thermal Methods of Analysis*:** Thermogravimetric analysis, differential thermal analysis and differential scanning calorimetry and applications. (Lectures: 4-5)
(ii)*Electron Microscopy:* Introduction and Applications of Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM). (Lectures: 2-3)
(iii) ***X-ray methods:*** Introduction and applications of XRD. (Lectures: 2-3)

CHEMISTRY LAB

List of Experiments:

1. Estimation of vitamin C in commercial soft drink / Glucon D.
2. Determine the strength of oxalic acid conductometrically using sodium hydroxide solution.
3. Separation of amino acids by thin layer chromatography.
4. Determination of R_f value of Methyl Orange and Phenolphthalein using paper/ thin layerchromatography.
5. Separation of metal ions by paper chromatography.
6. Determine the adsorption isotherm of oxalic acid/acetic acid on activated charcoal andverify the Freundlich adsorption isotherm.
7. Determine the rate constant (K) of hydrolysis of ethyl acetate catalyzed by HCl.
8. Synthesis of p-nitro acetanilide from acetanilide and find its percentage yield.
9. Determine the viscosity and percentage composition of the given liquid using Ostwald'sviscometer.
10. Determine the strength of given glucose solution by titration against Fehling's solution.
11. Determination of dissociation constant k for a weak acid using conductometry.
12. Separation of mixtures using column chromatography.
13. Estimation of Phosphoric acid from coca cola.
14. Preparation of picric acid (2,4,6-trinitrophenol) from phenol.

Reference Books:

1. Instrumental Analysis by Douglas A. Skoog, F. James Holler & Stanley R. Crouch.
2. Instrumental Methods Analysis, by B. K. Sharma.
3. Text book of Quantitative Inorganic Analysis, A. I. Vogel.
4. Elementary Organic Spectroscopy by Y.R. Sharma.
5. Engineering Chemistry by Shashi Chawla

Evaluation Scheme:

S. No.	Course Type	Subject Code	Course title	Credits	L T P	Sessional Marks				ESM	Total Marks
						MSE	TA	Lab	Total		
1	BSC	BCY 252	Modern Analytical Techniques	4	3 0 3	15	20	15	50	50	100

COMPUTER ORIENTED NUMERICAL METHODS
(Semester-IV: II B.Tech, BE, CHE, FT, LT, OT, PT, PL)

Course Code: BMA 204 **L-T-P-C: 3-0-2-4**

OBJECTIVE: The objective of this course is to provide conceptual understanding of:

- Various numerical methods for solving linear and nonlinear equations.
- Various numerical techniques of interpolation, integration and differentiation with their applications.
- Various numerical methods to solve IVPS and BVPS.

Course Outcome

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

CO1	Find roots of nonlinear equations and solve systems of algebraic equations.	Apply, Evaluate
CO2	Use interpolation techniques and to find numerical differentiation/ integration of data, function.	Apply, Evaluate
CO3	Use numerical methods for finding solutions of ordinary differential equations, simultaneous and higher order equations.	Apply, Evaluate
CO4	Learn numerical methods for finding solution of initial and boundary value problems, partial differential equations.	Apply, Evaluate
CO5	Learn basic concepts of some Finite element methods.	Apply, Evaluate

Course Articulation Matrix (CO-PO Matrix)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	1	1	1	-	-	-	-	3
CO2	3	2	3	3	1	1	1	-	-	-	-	3
CO3	3	2	3	3	1	1	1	-	-	-	-	2
CO4	3	2	3	3	1	1	1	-	-	-	-	3
CO5	3	2	3	3	1	1	1	-	-	-	-	3
Average	3	2	3	3	1	1	1	-	-	-	-	3

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

Detailed Syllabus:

UNIT I: <u>Nonlinear Equations and Simultaneous Linear Equations:</u>

Roots of nonlinear equation, Methods of solution, Order of convergence of iterative methods,

Simple roots: Bisection, False position, secant, Newton-Raphson, Chebyshev, Iteration and multi point iteration methods, Multiple roots: Newton-Raphson and Chebyshev, Complex roots: Newton-Raphson and Muller's method, a system of nonlinear equations: Newton-Raphson and Iteration methods, Polynomial equations: Bairstow's method, convergence analysis of above methods.

Linear systems: Introduction, Direct methods, Operation count, Pivoting, III conditioned linear systems & condition number, Iteration methods: Jacobi, Gauss-Seidel, SOR methods, convergence conditions. Special system of equations: Thomas algorithm. Eigen value problems: Given's and Power methods.

UNIT II: Interpolation, Differentiation and Integration:

Curve fitting: Polynomial interpolation, error, Existence and Uniqueness, Truncation error bounds, difference operators, Newton forward and backward difference interpolations, Lagrange, Newton divided difference and Iterated interpolations, stirling and Bessel's interpolations, Spline interpolation, Least squares and Chebyshev approximations. Numerical Differentiation: Methods based on interpolation, Error analysis. Numerical Integration: Methods based on interpolations (Trapezoidal, Simpson's 1/3, simpson's 3/8 rule), Gauss quadrature methods, Romberg integration, Error bounds and estimates.

UNIT III: Numerical Solution of Ordinary Differential Equations:

Initial-value problems, Single step methods: Taylor's, Picard's, Euler's, Modified Euler's method and Runge-Kutta method (fourth Order), Error estimates, Multi-step methods: Adam's-Bashforth and Milne's methods, convergence and stability analysis, Simultaneous and Higher order equations: RK Fourth order method.

UNIT IV: Initial & Boundary Value Problems and Iterative Solvers:

BVP: Shooting method and Finite difference methods for Ordinary Differential Equations, Solution of Partial differential equation; solution of Laplace, Poisson equations: Standard 5-point and diagonal 5- point formulae, Jacobi method, Gauss Seidel method (Liebmann's iterative method) Relaxation method. Solution of heat equation: Crank – Nicolson method, Solution of wave equation.

UNIT V: Finite Element Method:

Basic concepts, variational formulation and functional, base functions, approximations weighted residual methods: Ritz method, Galerkin method, Least squares method, collocation method, Finite element and solution of simple problems and time dependent problems.

Book Recommended:

1. M.K.Jain, S.R.K. Iyengar & R.K.Jain, Numerical methods for Scientific and Engineering Computation, N age International Publication.
2. S.S Sastry, Intoductory Methods of Numerical Analysis, Eastern Economy Edition.
3. S. Rajasekaran, Numerical Method in Science and Engineering, Wheeler Publishing House.
4. B.S. Grewal, Numerical Method in Engineering & Science, Khanna Publishers.

NPL 202 PROCESSING OF POLYMERS –I (PP-I)

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

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

- To understand the fundamentals of polymer processing
- To learn the fundamentals of extrusion processes of thermoplastics.
- To learn the basic principle of compounding of thermoplastics
- To learn the fundamentals of calendaring process.
- To learn processing of plastics on different machines and prepare simple plastic articles.

Course Outcome

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

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

Course Articulation Matrix (CO-PO Matrix)

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

Detailed Syllabus

Module-I: Introduction to Polymer Processing

Principles and concept of Processing of polymers; introduction to different plastic processing techniques Criteria for selection of process for plastics; Factors determining efficiency of plastic

processing: molecular weight, viscosity and rheology, Difference in approach for thermoplastic and thermoset processing. Sustainability of these processes

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

Module-III: Extrusion Processes for plastic products
Plastic Product formed by extrusion process, Basic principle, equipment used, and process détails for plastic extrusion lines for production of Blown film, pipe, tubing, sheet, wire and cable coating, etc.; Utility of these products in urban développement. Extrusion Casting process for films and lamination; Process variables, die design and defects observed in each of the extrusion product. Reactive extrusion: basic principles, equipment used and applications.

Module-IV: Compounding of Polymers
Importance and concept of compounding of polymers; compounding additives viz. fillers, plasticizers, colorants, stabilizers, blowing agents, flame-retardants, antioxidants, lubricants, processing aids, etc. sustainability and effects on environment of variety of additives for plastics Mixing, blending and compounding techniques and equipments. Pelletization, Reactive compounding, Global technical development in compounding additives and compounding technology for plastics. Finishing of Plastics

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

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

Text Books:

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

4. R. Jacobi; London, GB ILIFFE Books Ltd. 1963.
5. Polymer Mixing and Extrusion Technology, by Nicholas Cheremisinoff; First Published1987;eBook Published 25 October 2017; CRC Press, Available on Taylor and Francis eBooks.
6. Additives for Plastics; J. Stepek and H Daoust; Springer New York; 1983.

Reference books:

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

Web links:

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

Course Code: NPL 204
CHEMICAL ENGINEERING THERMODYNAMICS

L	T	P	C
3	1	0	4

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:

CO1	Understand the basic laws of thermodynamics and the terminology associated with engineering thermodynamics.	Understand, Analysis
CO2	Apply the laws of thermodynamics to evaluate the work and energy required/produced in different thermodynamic processes	Apply, Evaluate
CO3	Apply the knowledge of phase equilibria in two-component and multi-component systems.	Apply, Evaluate
CO4	Analyze the thermodynamic properties of substances in gas or liquid state of ideal and real mixture	Understand, Analysis
CO5	Understand intermolecular potential and excess property behaviour of multi-component systems	Understand, Analysis

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	-	-	1	-	-	1	-	1
CO2	3	1	1	1	-	-	3	-	-	1	-	1
CO3	3	3	2	2	-	-	-	-	-	1	-	1
CO4	3	3	3	2	-	-	1	-	-	1	-	1
CO5	3	2	2	3	-	-	1	-	-	1	-	1
Avg.	3	2.2	1.8	1.8	-	-	1.5	0	0	1	0	1

Syllabus

Module 1 (8 hours)

Basic Concepts: Scope of thermodynamics, System & Surroundings, Properties, phase, zeroth law of thermodynamics, Temperature, Equilibrium, Reversible & Irreversible process, Work, Heat, Energy;
First Law of Thermodynamics: Joule's Experiment, Internal energy, Enthalpy, Heat capacities, Application of first law to closed & open systems; Volumetric properties of pure fluids: PVT behaviour of pure substances, Phase rule; Virial equation of state and its application: ideal gas and cubic equation of state.

Module 2 (6 hours)
Second Law of Thermodynamics: Limitations of First law of thermodynamics, second law of Thermodynamics, Kelvin–Planck statement & Clausius Statement, Heat engine and thermal efficiency, Heat pump, Refrigerator, COP, Carnot's cycle, Carnot theorems; Entropy: Clausius theorem & Clausius inequality, Principle of entropy, Entropy changes of an ideal gases, Entropy generation, Entropy balance for open systems, ideal work, and lost work, Sustainability in chemical process industry.

Module 3 (6 hours)
Thermodynamic Properties of Fluids: Residual properties, Two phase systems: Clapeyron equation, Estimation of thermodynamic properties by using graphs and tables;
Vapor-Liquid Equilibria: Nature of equilibrium, phase rule, VLE qualitative behaviour, Simple Models for VLE, VLE by Modified Raoult's law

Module 4 (6 hours)
Solution thermodynamics Theory: Fundamental property relation, Chemical potential and phase equilibria, Partial properties, Ideal gas mixture model, Fugacity, and fugacity coefficient for pure species and in solution, Ideal solution model and excess properties.

Module 5 (4 hours)
Solution thermodynamics Application: Liquid phase properties from VLE data, Models for the excess Gibbs energy, Property changes of mixing.

Text Books

1. J.M. Smith and H.C. Van Ness, Introduction to Chemical Engineering Thermodynamics, McGraw Hill International Ltd,7th Edition, 2009.
2. Y.V.C. Rao, Chemical Engineering Thermodynamics, Universities Press (India) Ltd. Hyderabad.
3. K.V. Narayanan, Chemical Engineering Thermodynamics, Prentice Hall. 2007

Reference Books

B.G. Kyle, Chemical and Process Thermodynamics, Prentice Hall. 1999 Çengel, Y.A., Boles, M.A., Kanoğlu, M., Thermodynamics: An Engineering Approach, McGraw-Hill Education, New York.

Web Links:

https://archive.nptel.ac.in/courses/103/106/103106070/

https://archive.nptel.ac.in/courses/103/101/103101004/

Course Code: NPL 206

HEAT TRANSFER OPERATIONS

L	T	P	C
3	0	0	3

Course Objective: To understand the fundamentals of heat transfer mechanisms in solids and fluids through different modes and their applications in various heat transfer equipment such as heat exchangers and evaporators etc in process industries.

Course outcomes:

CO 1.	Understand different modes of heat transfer and solving steady and unsteady heat conduction problems	Understand Analyze, Evaluate
CO 2.	Apply calculation of heat transfer by free and force convection	Apply, Analyze, Evaluate
CO 3.	Apply mechanism of radiation of heat transfer in systems used in different processing operations including solar radiation	Apply, Evaluate
CO 4.	Understand phase-change phenomena of boiling and condensation	Understand, Analyze, Evaluate
CO 5.	Design of heat exchangers and its various types and applications	Design

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	3	2	1	-	-	-	-	-	-	-	2		
CO2	3	3	3	2	-	-	-	-	-	-	-	2		
CO3	3	3	3	3	2			-	-	-	-	2		
CO4	3	3	2	2	1	-	-	-	-	-	-	2		
CO5	3	3	2	2	-	-	-	-	-	-	-	2		
Avg	3	3	2.4	2	1.5	0	0	0	0	0	0	2		

Syllabus:

Module 1 (6 hours)

Introduction to heat transfer and general concepts of heat transfer by conduction, convection and radiation, Types of Insulating materials ,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 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.

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 vapors, film wise and drop wise condensation, heat 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, 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.

Text Books:

1. B. K. Dutta, Heat transfer: principles and applications. PHI Learning Pvt. Ltd., 2000.
2. C.P. Gupta, R. Prakash, Engineering Heat Transfer, Nem Chand & Bros., 2012.
3. D. Q. Kern. Process heat transfer, New York: McGraw-Hill, 1950

Reference books

1. J.P. Holman, Heat transfer. McGraw Hill Higher Education; 2010.
2. Y. A., Cengel and A. J. Ghajar, Heat and Mass Transfer Fundamentals and Applications, McGraw Hill, 5th edition, 2016.

Web Links

https://archive.nptel.ac.in/courses/103/105/103105140/

https://archive.nptel.ac.in/courses/103/101/103101137/

NPL 208 POLYMERIZATION ENGINEERING–II (PE-II)

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

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 high performance thermoset resins and their applications.
- To understand synthesis, manufacturing process, properties and applications of specialty plastics.
- 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

Course Articulation Matrix (CO-PO Matrix)

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**3**	**3**
CO1	3	2	1			3	1	1		1		3	3	3
CO2	3	2	1			3	1	1		1		3	3	3
CO3	3	2	1			3	1	1	1	1		3	3	3
CO4	3	2	1	1		3	1	1		1		3	3	3
CO5	3	2	1	1	1	3	2	1	1	1	1	3	3	3
Total	**3**	2	**1**	**3**	**1**	**3**	**1.4**	**1**	**1**	**1**	**1**	**3**	**3**	**3**

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

Detailed Syllabus

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

Module-II: Engineering Thermoplastics-II
Monomers, chemistry of synthesis, manufacturing process, properties and applications of polyamides: Nylon6, Nylon 66, Nylon 11 and aromatic polyamide, polyesters: PET, PBT, fluorine-containing polymers Polytetraflouroethylene, Polyvinylidine flouride, Polychlorofluoroethylene, etc. effect of these polymers on environment sustainability. Global and local manufacturers of these polymers

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

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

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

Text Books:

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

Reference books:

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

Web links:

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

NPL 210 POLYMERIZATION ENGINEERING LAB (PE LAB)

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

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

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

Course Outcome

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

Course Articulation Matrix (CO-PO Matrix)

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

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

List of Experiments

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

Year III, Semester V

NPL 301 PROCESSING OF POLYMERS- II (PP-II)

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

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

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

Course Outcome

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

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.	Understand and 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 and casting	Understand
CO6	Apply different parameters related to processing machines for formation of plastic products.	Apply

Course Articulation Matrix (CO-PO Matrix)

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**3**	**3**
CO1	3	3	1	1	1	3	1	1	1	1		2	3	3
CO2	3		1	1		3	1	1	1	1		2	3	3
CO3	3	3	1	1		3	2	1	1	1		2	3	3
CO4	3	3				3	1	1	1	1		2	3	3
CO5	3	3				3	1	1	1	2		3	3	3
CO6	3	3	3	3	1	3	2	1	3	2	1	3	3	3
Total	**3**	**3**	**1.5**	**1.5**	**1**	**3**	**1.3**	**1**	**1.3**	**1.3**	**1**	**2.3**	**3**	**3**

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

Detailed Syllabus

Module-I: Injection Molding of Thermoplastics

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

Module-II: Molding Processes for Thermoset polymers

Concept of Injection molding of thermoset polymers and process details. General concept of compression and transfer molding process; hydraulic press and their capacity; process parameters; advantages and disadvantages of these processes; description of various types of transfer molding processes and their utility in processing of thermosetting materials. Advances in compression and transfer molding process: global and Indian scenario.

Module-III: Thermoforming Process

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

Module-IV: Molding Process for hollow products

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

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

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

Module-V: In-situ Reaction Molding process

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

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

Module VI: Laboratory Experiments

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

6. Preparation of an article by Compression Molding Machine.

Text books:

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

Refernce books:

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

Web links:

1. https://elearn.nptel.ac.in/shop/nptel/processing-of-polymers-and-polymer-composites/
2. https://web.ics.purdue.edu/~kviswana/polymerProc_Dec29.pdf
3. https://nptel.ac.in/courses/112107221

NPL 303 PLASTIC MOULD DESIGN AND DIES (PMDD)

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

OBJECTIVE: The objective of this course is **t**o 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.	Understand
CO2	Understand and apply design features for plastic product shape.	Understand
CO3	Understand and apply design concepts for structure of injection molds.	Apply
CO4	Understand concepts and apply design in structure of compression & in structure of extrusion dies.	Apply
CO5	Understand and apply concepts Computer Aided Design to Mold design	Apply

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus

Module-I: Plastic product design criteria

Design of polymeric products, design criteria based upon product functions and geometry, material selection by property assessment, 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 cavity, multi cavity: two and three plate mould, semi- automatic and automatic moulds, Types of injection moulds, their applications, detailed structure and working. Globally available mold bases

Module-IV: Design Concept of other Mold types
Design concepts for compression molds and transfer molds. Extrusion 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.

Text books:
1. R. D. Beck, “Plastic Product Design:”,2nd edition, New York : Van Nostrand Reinhold Co. 1980.
2. R.G.W. Pye, ‘Injection mould Design”, East-West Press Pvt., 2000.
3. J. H. Dubois & W. I. Pribble, "Plastic Mould Engg.", Van Nostrand Reinhold, New York, 1965.
4. M. V. Joshi, "Dies for Plastic Extrusion",1984.

Reference books:

1. Rosato & Rosato, "Injection Moulding", 3rd edition, Kluwer Academic Publishers, 2000.
2. D. H Morton-Jones & John W-Ellis “Polymer product design materials and processing”, vol. 25, 1987.
3. M. Edward, “plastics product design part B”, 1st edition, CRC press, 1983.
4. R. H. Bebb, “Plastics Mould Design, Compression and Transfer Moulds", vol. 1, 2006.
5. N.S. Rao., “Design data for plastics engineers”, Hanser/Gardner Publications Inc. 2017.

Weblinks:

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

NPL 305 POLYMER RHEOLOGY AND TESTING (PRT)

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

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	Understand the correlation between Linear viscoelasticity with mechanical models and apply these models to interpret the flow behavior of polymer melts	Understand and Apply
CO3	Understand the concept of viscometry and rheometry and apply the knowledge in handling viscometer and rheometer to measure rheological properties.	Understand and Apply
CO4	Understand the concept of testing standard and specification and apply these to test the plastics materials for its mechanical, electrical, optical, and thermal properties.	Understand and Apply
CO5	Apply characterization techniques viz. FTIR, NMR, TGA & DSC to elucidate the properties of polymers.	Apply

Course Articulation Matrix (CO-PO Matrix)

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**3**	**3**
CO1	3	1	1	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	3	3
Total	**3**	**2.4**	**2.4**	**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 "-"*

Detailed Syllabus

Module -I: Fundamentals of Polymer Rheology

Introduction to polymer rheology, importance of rheology on polymer processing techniques such as extrusion, injection molding, etc., Concept of stress and strain, shear stress, shear rate, Ideal elastic solid and viscous fluid, Hook's Law, Newton's Law, Newtonian and non-Newtonian fluids, dependence of various rheological parameters on viscosity of polymer melts and solutions, time independent and time- dependent fluids, constitutive equations.

Module-II: Mechanical Models and Polymer Rheology
Concept of Linear viscoelasticity, Mechanical models, discussion of models for flow and deformation in polymers and treatment of measurable rheological properties. Global scenario of different rheometers.

Module – III: Measurement of viscosity and Rheometers
Concept of viscometry and rheometry, Poiceuille and Couette flow, Rheometric analysis of these flows, Viscometers and Rheometers to measure rheological properties. Use of Viscometer and rheometer in Indian Polymer industries and research organization.

Module-IV: Testing of Polymer Properties
Concept of Testing of polymer materials, Standard test methods, Testing of polymer properties viz. thermal, optical, electrical, and mechanical properties as per standard specifications, viz. BIS, ASTM, ISO, etc. and its importance, correlation of these tests with actual performance. Application of these test methods in local polymer industries. Concept of global quality assurance method.

Module-V: Characterization of Polymers
Introduction to polymer characterization methods, Characterization of polymer properties by different characterization techniques such as FTIR, NMR, DSC, TGA, SEM.

Text books:

1. J.D.Ferry," Visco-elastic properties of polymers", Wiley,1980.
2. R.B. Brown, “Handbook of Plastics Test Method ",CRCPress,1999.
3. V. Shah & Brown, “Handbook of Plastic Testing Technology", Wiley- Blackwell,1998.
4. W. Christopher & Macosko,“Rheology, Principles, measurements and Applications",Wiley-VCH,1994.
5. A.B. Mathur, & I.S. Bhardwaj “Testing and evalution of Plastics”, 2003.
6. Haslam “identification and analysis of plastics”, vol. 13, 1974.

Reference books:

1. J. Fergusonand, Z.Kemblowski,“Applied fluid rheology",Springer Netherlands,1991.
2. J. M. Dealy, Kurt F. Wissburn,“Melt Rheology & its Role in Plastics processing theory & applications", Springer Netherlands, 1998.
3. J. A. Brydson, "Flow Properties of Polymer Melts", CBLS,1970.
4. V. shah “Plastics testing technology hand book”,2nd edition, Publisher Wiley–Blackwell**,** 1998.
5. G.C. lves, J.A. Mead & M.M. Riley “Hand book Plastics test methods”, vol. 4, 1972.
6. ASTM, ISO, IS Standards

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

Course Code: NPL 307

MASS TRANSFER OPERATIONS

L	T	P	C
3	0	0	3

Course Objectives: The Mass Transfer Operations course aims to provide students with an understanding of the principles, processes, and equipment involved in mass transfer operations. Upon completion of the course, students should be able to:

1. Understand the fundamental principles of mass transfer, including diffusion, convection, and mass transfer coefficients.
2. Analyze mass transfer processes in various unit operations such as distillation, absorption, extraction, and drying.
3. Design and optimize mass transfer equipment such as packed and trayed columns, liquid-liquid extraction units, and drying equipment.
4. Apply mathematical models and simulations to predict and optimize mass transfer processes, including heat and mass transfer coefficients, mass transfer rates, and system performance.

Course outcomes:

CO 1	Understand the basic principles and laws of mass transfer, Calculation of rate of mass transfer	Understand & Evaluate
CO 2	Analyze the mass transfer concepts and apply them for Absorption and Distillation processes to evaluate different process parameters	Analyze, Apply & Evaluate
CO 3	Analyze the mass transfer concepts and apply them for LLE and SLE processes to evaluate different process parameters	Analyze, Apply & Evaluate
CO 4	Analyze the mass transfer concepts and apply them for Humidification and Drying processes to evaluate different process parameters	Analyze, Apply & Evaluate
CO 5	Analyze the mass transfer concepts and apply them for Adsoption, Membrane separation and Crystallization processes to evaluate different process parameters	Analyze, Apply & Evaluate

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

Avg	3	2.4	2.2	1.8	2.7	0	0	0	0	1	0	1		

Syllabus

Module I (6 hours)

Concept of Mass Transfer, Diffusion: Steady-state molecular diffusion: Fick's law of diffusion; Equimolar counter diffusion; Stagnant film diffusion, Diffusion coefficients: Film theory; Penetration theory; surface-renewal theory; film-penetration theory, Two-film theory. Concept of interphase /mass transfer, Analogies in mass transfer.

Module II (6 hours)

Absorption and Stripping: Gas-liquid equilibrium, Henry's law, Selection of solvent,calculation of number of stages and Equipments used in Absorption and Stripping

Distillation: Equilibrium diagrams for ideal and non-ideal solutions; Relative volatility, Flash Distillation-Differential distillation, McCabe Thiele method, for determining number of stages & Equipments for Distillation

Module III (6 hours)

Liquid-Liquid Extraction(LLE): Applications; Ternary liquid-liquid equilibria; Triangular graphical representation; solution of single and multistage operation. Solid-Liquid Extraction: Applications; Solid-liquid equilibrium; Equipments used for single stage and multistage continuous operations in LLE & Leaching

Module IV (6 hours)

Humidification and Dehumidification: Vapor pressure temperature curve and Fundamental concepts Drying: Solid-gas equilibrium, Definitions of moisture contents, Different modes of drying operations, Rate and mechanism of batch drying, Time of drying, Classification of Cooling Towers and Dryers

Module V (6 hours)

Adsorption: Concept and application of adsorption, Nature of adsorbents; Adsorption isotherms and adsorption hysteresis; Number of Stages and Equipment used in adsorption. Introduction to membrane separation processes, Introduction to Carbon Capture Technology, Crystallization: Concept and laws; Supersaturation, Nucleation & Crystal growth; Types of crystallization; Equipments used for crystallization.

Text Books

1. R.E. Treybal, "Mass Transfer Operations", 3rd ed. New York: McGraw-Hill, 2017.

2. B. K. Dutta, "Principles of Mass Transfer and Separation Processes", 8th Printing, PHI Learning Private Limited, 2015

3. W. L. McCabe, J. C. Smith, P. Harriott, "Unit Operations of Chemical Engineering", McGraw-Hill, VII International edition, 2005.

Reference Books

1. T. K., Sherwood, R. L. Pigford, and C.R. Wilke, "Mass Transfer" McGraw Hill, 1975.
2. C.J. Geankoplis, "Transport Processes and Separation Process Principles", 4th ed., PHI Learning Private Limited, New Delhi, 2012.
3. J.D. Seader, and E.J., Henley, "Separation Process Principles", 2nd ed., Wiley India Pvt. Ltd., New Delhi, 2013.
4. S. Foust, "Principles of Unit Operations", 2nd Ed., Wiley, 1980.
5. P.C., Wankat "Separation Process Engineering", Prentice Hall, III edition, 2011.

Web-Links

https://archive.nptel.ac.in/courses/103/103/103103145/
https://archive.nptel.ac.in/courses/103/103/103103154/

Course Code: NPL 309

CHEMICAL REACTION ENGINEERING

L	T	P	C
3	0	0	3

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	To develop an understanding of the basic concepts involved in using reaction rate equations and kinetic constants	Understand, Apply
CO 2	To Perform derivations of rate equations for non-elementary reactions both in homogenous and in heterogeneous reacting systems	Apply
CO 3	To understand the role of temperature and concentration in the rate equation	Understand
CO 4	To Perform constant volume batch reactor calculations	Apply
CO 5	To 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		
CO2	3	3	3	1	-	-	-	-	-	1	-	1		
CO3	3	3	3	2	-	-	-	-	-	1	-	2		
CO4	3	3	1	-	2	-	-	-	-	1	-	2		
CO5	3	3	2	2	2	-	-	-	-	1	-	2		
Avg.	3	2.8	2.4	1.7	2	0	0	0	0	1	0	1.6		

Syllabus

Module I (6 hours)

Rate of Reaction, Elementary and non-elementary homogeneous reactions, Molecularity and order of reaction, Introduction of Arrhenius, collision, and transition theories. Integral and differential methods for analyzing kinetic data, interpretation of constant volume reactor, zero, first, and second, half-life period, irreversible reaction in series, auto catalytic reaction, reversible reactions.

Module II (6 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 (6 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, recycle reactor, autocatalytic reactions.

Module IV (6 hours)

Introduction to multiple reactions, yield, selectivity, qualitative discussion about product distribution, optimum temperature progression. Introduction of heterogeneous catalyst preparation and kinetics. kinetics of enzyme reactions (Michaelis-Menten and Monod models).

Module V (6 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.

Text Book:

1. Levenspiel, O., “Chemical Reaction Engineering”, 3rd edition, John Wiley 2006.

Reference Books

1. H. Scott Folger, “Elements of Chemical Reaction Engineering” 6th Edition, Prentice Hall, 2021.
2. J. M. Smith., “Chemical Engineering Kinetics”, 3rd Edition, McGraw-Hill chemical engineering series, 1981.

Web Links

https://archive.nptel.ac.in/courses/103/103/103103153/

https://archive.nptel.ac.in/courses/103/101/103101141/

NPL 311 POLYMER TESTING LAB (PT Lab)

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

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

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

Course Outcome

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

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

Course Articulation Matrix (CO-PO Matrix)

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

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

List of Experiments:

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

NHS 351/352 ENTREPRENEURSHIP

Course: B. Tech.	**Branch:** All	**Year / Semester:** 3RD Year/ 3RD Sem. / 4TH Sem.
Sessional Marks:	50	**Credit:** 2
End Semester Exam:	50	**LTP:** 2 0 0

UNIT I Entrepreneurship:

Entrepreneur and manager, Growth of entrepreneurship in India, Government's policy actions towardsentrepreneurial motivation, entrepreneurship development programmes.

UNIT II Business Enterprises and Ownership Structure:

Small scale, medium scale and large scale enterprises, role of small enterprises in economicdevelopment; proprietorship, partnership, companies and co-operatives firms: their formation,

UNIT III Project Management:

Identification and selection of projects; project report: contents and formulation, project evaluation,method

UNIT IV Project Financing and Working Capital Management:

Cost of Project, Capital Structure Planning, Sources of long term financing, Working CapitalManagement

UNIT V Institutional Support and Policies:

Institutional support towards the development of entrepreneurship in India: technical consultancyorganizations (TCOs), government policies for small scale enterprises.

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Text Books:

1. **Khanka, S S**. 'Entrepreneurial Development', S Chand & Company Ltd. New Delhi
2. **Desai, Vasant**, ' Project Management and Entrepreneurship', Himalayan Publishing House, Mumbai, 2002.

Additional Reference Books

1. **Gupta and Srinivasan**, 'Entrepreneurial Development', S Chand & Sons, New Delhi.
2. **Ram Chandran**, 'Entrepreneurial Development', Tata McGraw Hill, New Delhi
3. **Saini, J. S**. 'Entrepreneurial Development Programmes and Practices', Deep & Deep Publications (P), Ltd
4. **Holt, Davis, '**Entrepreneurship : New Venture Creations, PHI

Course Outcomes (COs)

1. Develop understanding of basics of entrepreneurship.
2. Apply the beginner's concept, ownership and various forms
3. Identify opportunities using identification; project conceptualisation, formulation & evaluation.
4. Learn , apply and evaluate the project financing and working capital management
5. Evaluate the role of Institution support and policy framework of Government for entrepreneurship development in India.

CO-PO Mapping

Co/PO	PO 1	PO 2	PO3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
CO1	0	0	0	0	0	0	1	1	0	0	1	2
CO2	0	0	0	0	0	0	1	1	0	0	2	2
CO3	0	0	0	0	0	0	1	1	0	0	3	2
CO4	0	0	0	0	0	0	1	1	0	0	3	2
CO5	0	0	0	0	0	0	1	1	0	0	3	2

Year III, Semester VI

Course Code: NPL 302

INSTRUMENTATION & PROCESS CONTROL

L	T	P	C
3	0	2	4

Course Objective: Objective is to introduce the fundamentals of process control, controllers, stability and frequency response along with different process instruments used in chemical industries. The course will teach the students, how to obtain dynamic response of closed loop systems, stability analysis in transient and frequency domains. The course will also introduce about the instruments used for measurement of temperature, pressure, flow, level, viscosity.

CO1	Introduction to process control and controllers along with open and closed loop systems	Understand, Apply
CO2	Transient response of simple control systems	Apply, Evaluate, analyze
CO3	Concept of stability and frequency response, control system design by frequency response	Analyze, Evaluate, Design
CO4	Understand the principles involved in measurements. knowledge on different measurement methods employed in industrial process units	Understand, Apply, Evaluate, analyze
CO5	Application of different measurement devices in Chemical allied industries	Apply, evaluate , analyze
CO6	Conduct various experiments to apply the concepts of fluid mechanics and unit operations.	Apply, Evaluate , analyze

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

Syllabus

Module 1 (6 hours)

Introduction to Process control systems, Use of Laplace & Inverse Laplace Transformation in study of Process Dynamics & Control. Dynamic Modeling of a Process, Dynamic behavior of First order system. First order systems in series, Second and higher order systems for various kind of inputs, Linearization of nonlinear systems, Transportation & Transfer Lag.

Module 2 (6 hours)

Classification of control systems, Regulator & Servo control, Feed Forward & Feed backward control, Negative & Positive Feedback Control, Controllers & Final control Elements, Reduction of Block & Signal Flow Diagrams, P, PI, PD and PID controller, Response of control system with these controllers

Module 3 (6 hours)

Concept of stability, Stability Criterion, Routh test for stability, Introduction to frequency response, Introduction to control system design by frequency response (Bode Plot, Zeigler Nichols controller settings), Introduction to Controller Tuning.

Module 4 (6 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 (6 hours)

Flow measurement instruments, Concentration Measuring Instruments, Level measurement; float types- hydrostatic types, thermal effect types, electrical methods and solid level measurement. Pressure Measurement: Manometers, measurement of vacuum.

List of Experiment

1. To calibrate and study the response of bimetallic thermometer.

2. To study the response of a liquid level tank system.

3. To calibrate the P/I converter.

4. To calibrate the given manometer for level measurement.

5. To study and calibrate diaphragm control valve.

7. To study the response of first order system in series using two tank liquid level system (Non-interacting system) to step input.

8. To study the response of first order system in series using two tank liquid level system (interacting system).

9. To calibrate a thermocouple using a glass bulb thermometer.

10. To assess the accuracy of a pressure gauge with a dead weight gauge tester.

Text Books

1. Coughnour and Koppel, "Process Systems Analysis and Control", McGraw-Hill, New York, 3rd Edition, 2017.

2. George Stephanopolous, "Chemical Process Control ", Prentice-Hall of India Pvt-Ltd., New Delhi, 2015.

3 Eckman, D.P., “Industrial Instrumentation”, Wiley Eastern Ltd., New York, 1990

Reference Books:

1. Singh, S. K. , “Industrial Instrumentation and Control” , Prentice Hall of India, 2016

Web Links:

https://archive.nptel.ac.in/courses/103/105/103105064/

https://archive.nptel.ac.in/courses/103/105/103105130/

NPL 304 STRUCTURE AND PROPERTIES RELATIONSHIP OF POLYMERS (SPRP)

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

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

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

Course Outcome

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

CO1	Understand the basic concept of polymer structure-property relationship.	Understand
CO2	Apply mathematical equations to interpret the concept of molecular weight averages and apply different techniques to measure molecular weight of polymers. Understand the concept of heterogeneity in polymers and it's effect on polymer properties.	Understand and Apply
CO3	Understand the concept of polymer crystallinity and its role to analyzepolymer properties.	Understand and Analyze
CO4	Apply mathematical equations to analyze polymer solution properties.	Apply and Analyze
CO5	Understand and apply the concept of flexibility to interpret the glass transition temperature and apply the concept of glass transition temperature to analyze polymer properties	Understand, Apply and Analyze

Course Articulation Matrix (CO-PO Matrix)

Cos	P					O			s				PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**1 0**	**1 1**	**1 2**	**3**	**3**
CO1	3	2				3	3					3	3	3
CO2	3	3		2		3		1				3	3	3
CO3	3	3		2		3		1	2			3	3	3
CO4	3	3	3	2		3			2	1	1	3	3	3
CO5	3	3	3	2		3			2			3	3	3
Total	**3**	**2 . 8**	**3**	**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 "-"*

Detailed Syllabus

Module-I: General Structural Features of Polymers
Basic structures in polymers, structure-property relationship. Classification of polymers. Effect of chemical composition and types of bonds in structure of polymer and their effect on polymer properties, Role of intermolecular forces in polymer properties.

Module-II: Molecular weight averages and Molecular mass heterogeneity
Concept of average molecular weight in polymers, mathematical equations of molecular weight averages and the calculation of average molecular weight of polymer. Importance of average molecular weight in polymer processing. Determination of molecular weight averages by various techniques such as end-group analysis, light scattering, etc. Concept of polydispersity and molecular weight distribution and it's role on polymer properties. GPC technique to measure different types of molecular weight averages.

Module -III: Polymer Crystallinity and its measurement
Concept of degree of crystallinity and crystallizability, Concept of crystalline and amorphous regions in polymer structure, Various models of crystalline and amorphous zones, Effect of crystallinity on polymer properties. Theory of polymer crystallization. Polymer single crystal, dimensions of polymer chain, X-ray diffraction (XRD) and differential scanning calorimetric (DSC) techniques to measure degree of crystallinity.

Module-IV: Polymer-in-solution
Concept of polymer solution, Polymer-solvent interaction, good and poor solvents, intrinsic viscosity and Mark-Houwink equation, concept of fractionation process, different types of fractionation techniques to draw molecular weight distribution curve.

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 polymer properties. Degradation behavior of polymer and it's effect on polymer properties.

Text books:

1.F. W. Billmeyer, John Wiley & Sons, "Text Book of Polymer Science", 2009.
2.A. T. Tobolsky,"Properties and structure of polymers",Wiley,NewYork,1960.
3.C. E. Carrshar, Marcel Dakker, "Polymer Chemistry", 2003.
4.M. P. Stevens, "Polymer Chemistry–An Introduction", Oxford University Press, 1990.
5.G. O. Shonaike and S.G.Advani, "Advanced Polymeric Materials: Structure property relationship", CRC Press, 2000.
6.S. Man, R.E., and R.J. Bishop, "Metals and Materials", Butterworth-Heinemann, Oxford University Press, (1995).
7.W. Smith, "Principles of Materials Science and Engineering", McGraw Hill, 1990.
8.P. Ghosh, "Polymer Science and Technology", 2nd edition, Tata McGraw Hill, 2021.

Reference books:

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

Web Links:

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

NPL 306 RUBBER TECHNOLOGY (RT)

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

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

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

Course Outcome

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

CO1	Understand the characteristic features of rubbers, utility of compounding and formulations of rubber 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 chemistry of synthesis, manufacturing process, properties and applications thermoplastic elastomers.	Understand
CO5	Analyze utility of processing methods for rubber product manufacturing; quality and testing of properties of various rubbers.	Analyze

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus

Module-I: Rubber Material Characteristics and Compounding

Definition of rubber materials and rubber elasticity; Characteristic structural features of rubbers. Components of rubber compound and their effects on vulcanizate properties; compounding equipments. Preparation, characteristic features and applications of Carbon black and nonblack fillers

and their effect on rubber properties. Mechanism of reinforcement; Bound rubber, Mastication of rubbers.

Module-II: Natural rubber

History of natural rubbers, Agriculture of Natural rubber tree plantation, Latex tapping, Properties and applications of natural rubber; Dry rubber production; technically specified rubber, specifications of different Indian Grades and global grades available and their utility, mechanism of sulphur and non sulphur vulcanization systems; various vulcanization techniques. Effect of state of cure and cure system on properties of rubbers, crosslink density and swelling characteristic of natural rubber

Module-III: Synthetic Rubbers

Different monomers used in synthetic rubbers, Manufacturing processes, properties and application of general purpose synthetic rubbers viz. styrene-butadiene rubbers, Nitrile rubber, butyl rubber, polychloroprene rubber, Fuorocarbon rubbers, Hypalan rubber, silicon rubber, etc. Global, Indian and local development in synthetic rubbers

Module-IV: Thermoplastic Elastomers

Concept of thermoplastic elastomers: basic structure and morphology classification, preparation, properties and applications of thermoplastic elastomers Manufacturing processes, properties and application of EVA, polyurethane elastomers, EPDM rubber, thermoplastic elastomers based on blends/ copolymers of EPDM rubber, EVA , polyurethane, polyesters, styrene and ionomers.

Module-V: Industrial fabrication of Rubber Products and quality control

Industrial fabrication of rubber products such as Transmission V-belts, Hoses, Tires, Rubber Tubing and Sheets, manufacturing of products from latex like gloves, foams, coated fabric, balloons. Quality control and Testing methods for determination of properties of vulcanized rubbers.

Text Books:

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

Reference Books:

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

Web link:

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

NPL 308 POLYMER COMPOSITE (PC)

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

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

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

Course Outcome:

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

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

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus

Module-I: Introduction to polymer composites

Introduction to basic components of a polymer composite, Concept of matrix and reinforcement, Principles of composite reinforcement, Concepts of interfacial bonding, Prediction of composite

properties using rule of mixing.

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

Module-III: Matrices for Polymer composites
General characteristics of thermoplastic and thermoset matrices in polymer composites and their global and local need in packaging, construction, transportation, aerospace, etc.

Module-IV: Production Techniques -I
Fabrication of polymer composites using hand-layup, vacuum bag moulding, filament winding and pultrusion

Module-V: Production Techniques -II
Concept of Prepegs, hybrid and sandwich type composites, fabrication of polymer composites using Sheet moulding and dough moulding and resin transfer moldings. Characterization of polymer composites.

Text Books:

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

Reference Books:

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

Weblink:

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

NPL 310 POLYMER CHARACTERIZATION LAB (PCH Lab)

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

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

- To understand and apply modern characterization techniques such as UV-vis, DSC, TGA, etc. for the evaluation of properties of polymers.
- Apply laboratory techniques for determination of glass transition temperature, crystallinity, degradation temperature.

Course Outcome

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

CO1	To understand and apply modern characterization techniques such as UV-vis, DSC, TGA, etc. for the evaluation of properties of polymers.	Understand and Apply
CO2	To understand and apply the microwave process for the synthesis of polyacrylamide	Understand and Apply
CO3	Understand and Apply laboratory techniques for determination of viscosity by melt rheometer.	Understand and Apply

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

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

Laboratory Experiments

List of Experiments:

Sl. No.	**Details of Experiments**
1	Determination of glass transition temperature by using Differential Scanning Calorimeter (DSC)
2	Determination of crystallinity by using Differential Scanning Calorimeter (DSC)
3	Determination of Degradation Temperature of polymers by using Thermo Gravimetric Analyzer (TGA)
4	Determination of the presence of U.V. Stabilizer in polycarbonate sample by UV-VIS Spectrophotometer

5	Determination of the percentage transmittance of given sample by UV-VIS Spectrophotometer
6	Recording of spectra for given chemical in U.V. band visible range using UV-VIS Spectrophotometer
7	Study of wear and friction of the given plastic/composite materials sample using wear and friction monitor
8	Dispersion of two liquid or solid-liquid sample using Ultrasonicator
9	Determination of melt viscosity by melt rheometer

Program Elective- I (PEC-I)

Course Code: NPL 322
Process Equipment Design

L T P C
3 0 0 3

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

Course Outcomes:

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

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	-	3	-	-	1	1	-	2
CO2	3	3	3	2	3	3	-	-	1	-	-	2
CO3	3	3	3	2	3	1	-	-	1	-	-	3
CO4	3	3	3	2	3	1	-	-	1	-	-	3
CO5	3	3	3	2	3	1	-	-	1	-	-	3
Avg	3	2.8	2.8	1.8	3	1.8	0	0	1	1	0	2.6

Syllabus

Module-I:

Introduction to Equipment Design Introduction: Classification of engineering materials, engineering properties of Ferrous metals, Non ferrous metals, alloys & Ceramic materials Structure-Property relationship in materials. Deformation of Materials Fracture: Elastic deformation, Plastic

deformation, Creep. Corrosion And Prevention: Direct Corrosion, electro-chemical corrosion, Galvanic cells, High temperature corrosion, Passivity, factor influencing corrosion rate, Control and of corrosion-modification of corrosive environment, Inhibitors, Cathodic protection, protective coatings. Corrosion charts, Metal forming & Metal joining techniques – Different types

Module-II:

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

Module-III

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

Module-IV

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

Module-V

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

Text Books

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

Reference Books

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

Web Links:

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

Course Code: NPL 324

PROCESS MODELING AND SIMULATION

L	T	P	C
3	0	0	3

Course Objective:

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

Course Outcomes:

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	3	3	3	2	-	-	1	-	1	1	2		
CO2	3	3	3	3	3	-	-	1	-	1	1	2		
CO3	3	3	3	2	3	-	-	1	-	1	1	2		
CO4	3	3	3	2	2	-	-	1	-	1	1	2		
CO5	3	3	3	3	3	-	-	1	-	1	2	3		
Avg	3	3	3	2.6	2.6	-	-	1	-	1	1.2	2.2		

Syllabus

Module I (6 hours)

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

Module II (6 hours)

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

Module III (6 hours)

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

Module IV (6 hours)

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

Module V (6 hours)

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

Text Books

[1] A. K. Jana, “Chemical Process Modelling and Computer Simulation”, PHI, 2011.

[2] Asghar Hussain, “Chemical Process Simulation”, Wiley Eastern Ltd., New Delhi, 1986.

[3] M.M. Denn, “Process Modelling”, Wiley, New York, 1990.

Reference Books

[1] C.D. Holland, “Fundamentals of Modelling Separation Processes”, Prentice Hall, (1975)

[2] D. F. Rudd and C. C. Watson, “Strategy of Process Engineering”, Wiley international, 1971

[3] W.L., Luyben “Process Modeling, Simulation, and Control for Chemical Engineering”, Mc Graw Hill.

Web Links

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

Course Code: NPL 326

Process Optimization

L	T	P	C
3	0	0	3

Course Objective

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

Course Outcomes:

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

Table: Correlation of POs, PSOs v/s COs

PO/CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	3	1	2	2	1	-	-	1	3	-	-	2	
CO2	3	3	3	3	2	-	-	1	3	-	-	2	
CO3	3	3	3	3	3	-	-	1	3	-	-	2	
CO4	2	3	3	1	3	-	-	1	2	-	-	2	
CO5	2	3	3	1	2	-	-	1	1	-	-	3	
Average	2.6	2.6	2.8	2	2.2	-	-	1	2.4	-	-	2.2	

Syllabus

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

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

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

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

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

Text Books

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

2. S. S. Rao, Engineering Optimization Theory and Practice, Fifth Edition, John Wiley & Sons, Inc., 2019
3. G.S. Beveridge and R.S. Schechter, "Optimization theory and practice", Mc Graw Hill, Newyork, 1970.

Reference book:

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

Web Links

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

OEC-I

OPL 302 INTRODUCTION TO POLYMER SCIENCE (IPS)

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

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 andkinetics.	Understand
CO3	Understand and apply various production processes of commodityplastics	Apply
CO4	Understand chemistry and apply production of common formaldehydebased thermoset.	Apply
CO5	Understand and apply different plastic processing techniques, Indianmarkets of Plastics.	Apply

Course Articulation Matrix (CO-PO Matrix)

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

Detailed Syllabus

Module -I: Introduction to Polymers/Plastics

Polymeric Materials and their macro molecular nature (e.g. Plastics, rubber, fibers), concept of

polymerstructure, classification of polymers.

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

Module -III: Thermoplastic resins
Chemistry and manufacturing process of some important thermoplastic polymers such aspolyethylene, 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: Polymers modifications
Polymeric copolymers and their industrial applications, introduction to polymer blends and applications.Scope of polymeric materials industries in India, various areas of applications for plastics.

Text Books:

1. F. W. J. Billmeyer, "Text Book of Polymer Science", John Wiley& Sons,1984.
2. P. Tooley, "High polymers (His Chemistry in industry)",Publisher: J. Murray, 1971.
3. P.J.Flory,"PrincipleofPolymerChemistry",CornellUniversityPress,NY,1953.
4. Hans. R. Kricheldorf, "Handbook of Polymer Synthesis, Part A & B", John Wiley & Sons, 1991.
5.Seymour& Caraher, Marcel Decker, "Polymer Chemistry", CRC Press,2003.

Reference Books:

1. G. Odeon, "Principles of Polymerization", John Wiley & Sons,2004.
2. R. J. Young & P. A. Livell, "Introduction to Polymers", Ch.& Hall,London,1981.

Web Links:

1. https://archive.nptel.ac.in/courses/104/105/104105124/
2. https://www.youtube.com/watch?v=ACPDEy3evqE

Year IV, Semester VII
Program Elective –II (PEC-II)

NPL 421 PLASTIC PACKAGING (PP)

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

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

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

Course Outcome

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

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

Course Articulation Matrix (CO-PO Matrix)

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

Detailed Syllabus

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

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

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

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

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

Textbook:

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

Reference Books:

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

Web links:

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

NPL 423 POLYMER ADHESIVES (PA)

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

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

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

Course Outcome:

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

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

Course Articulation Matrix (CO-PO Matrix)

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

Detailed Syllabus

Module – I: Introduction and adhesion theories

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

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

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

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

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

Textbooks:

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

Reference Books:

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

Web links:

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

NPL 425 PLASTIC PRODUCT TECHNOLOGY (PPT)

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

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

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

Course Outcome

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

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

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus

Module-I: Plastic product design criteria

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

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

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

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

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

Text books:

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

Reference Books:

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

Web Links:

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

PEC-III

NPL 441 FIBRE AND FILM TECHNOLOGY (FFT)

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

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

- To understand the basics of fibre technology.
- To understand various techniques plastic waste reduction and conversion of plastic waste into value added products.
- To understand the policies and regulations of plastic waste management
- To understand the recycling and biodegradation of plastics.

Course Outcome

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

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

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus

Module-I: Basic Concepts of Fibre Technology

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

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

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

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

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

Text Books:

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

Reference Books:

1. B. L. Deopura, R. Alagirusamy, N. Gupta and M. Joshi, “Fibrous Materials : Polyesters and Polyamides”,Woodhead Publishing Ltd and CRC Press, 2008.
2. F. Fourne,“Synthetic Fibres, Machines and Equipment, Manufacture, Properties”, Hanser Publishers, 1999.

3. B. P. Corbman,"Textiles : fibre to fabric", McGraw Hill, 1983.

Web Links:

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

NPL 443 POLYMER COATING TECHNOLOGY (PCT)

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

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

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

Course Outcome:

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

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

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus

Module-I: Elements of surface coatings

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

Module-II: Pigments and Pigmentation
Types of Pigment and pigmentation. Dispersion techniques, role of wetting agents, driers, solvent and plasticizers in coatings.

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

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

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

Textbook:

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

Reference Books:

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

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

NPL 445 POLYMER FOAMS (PF)

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

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

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

Course Outcome

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

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

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus

Module-I: Introduction to Polymer Foams

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

Module-II: Foaming Technologies

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

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

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

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

Textbook:

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

Reference Books:

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

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

PEC-IV

NPL 461 HIGH PERFORMANCE POLYMER MATERIALS (HPPM)

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

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

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

Course Outcome

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

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

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus

Module-I: Role of Polymers for High-tech areas
Chemistry and synthesis of polymers for high tech applications, properties of high performance polymers and advanced polymeric composites for specific application like aerospace, telecommunications, microelectronics, insulations, optical fibre cables, biomedical, defense, etc. and their future prospective.

Module-II: High performance polymers – I
Chemistry, preparation, properties and applications of high temperature resistant polymers like polyetherether ketone (PEEK), polyetherimide, polyarylether ketone, superior PTFE, polyoxymethylene (POM), polyphenylenesulphide**,** polysulphones, polyphenyleneoxide.

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

Module-IV: High performance polymers – III
Self-reinforced polymer composite. High energy absorbing polymer. Super absorbent polymers. Polymers for biomedical applications. Conducting polymers-properties and applications. Self-healing polymers. Self-reinforced polymer composite. High energy absorbing polymer.

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

Text Books:

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

Reference Books:

1. H. G. Elias, “Macromolecules Synthesis”, vol. 2, Materials and Technology by, Wiley-VCH, 1984.
2. J. J. Meister, “Polymer modification” , Taylor Francis, 2014.

3. G. Erhstein, “Polymeric Materials”, Hanser Gardner, 2001.

Web Links:

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

NPL 463 POLYMER NANOCOMPOSITES (PNC)

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

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

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

Course Outcome

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

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

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus

Module-I: Basics concept to Nanoscience and nanotechnology

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

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

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

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

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

Textbook:

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

Reference Books:

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

NPL 465 POLYMER BLENDS (PB)

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

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

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

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

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

Course Articulation Matrix (CO-PO Matrix)

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

Detailed Syllabus

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

Module – II: Miscibility/ Immiscibility of polymers
Concept of miscibility; Classification of polymer blends, Miscible Blends and Immiscible Blends

- characteristics of Miscible and Immiscible Blends; Phase Equilibria, Huggins - Flory Theory; Factors Affecting Miscibility of Polymer Blends

Module – III: Blending process

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

Module – IV: Properties and application of polymer blends

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

Module – V: Characterization of polymer blends

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

Textbook:

1. L.A.Utracki,"Polymerblendsandalloys",HanserPublishers,NewYork,1979
2. L.M.Robeson,"Polymerblends"Hanserpublications,USA,2007
3. M.J.Folkes,P.S.Hope,"Polymerblendsandalloys",Springer,London,2012

Reference Books:

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

Web Links:

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

NPL 481 INDUSTRIAL TRAINING (IT)

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

Course Articulation Matrix (CO-PO Matrix)

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

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

OPL 401 BASICS OF POLYMER PROCESSING (BPP)

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

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

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

Course Outcome:

CO1	Understand fundamentals of polymer processing and their effect on processing	Understand
CO2	Understand details of plastic extrusion and its application in manufacture ofvarious products	Understand and Apply
CO3	Understand details of plastic injection moulding process and their application in article making	Understand and Apply
CO4	Understand the concept of moulding of thermosets and its application	Understand and Apply
CO5	Understand and apply the knowledge of different plastic processing methods	Understand and Apply

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus

Module-I: Basics of Polymer Processing

Fundamentals of Polymer Processing such as melt viscosity, melt flow index and it's effect on processing, molecular weight distribution. Thermal properties of polymers such as Glass transition temperature, melting temperature range, degradation.

Module-II: Extrusion Process

Plastic extrusion process details, important types such as blown film, sheets, profiles, wire coating and pipe productions. Screw characteristic curves effect of Plastics on.

Module-III: Injection Molding

Plastic Injection molding process fundamentals, types of madines and suitable products, molding cycle, Machine parameters and mold.

Module-VI: Compression Molding

Molding of thermosets, differences between molding of thermoplastics and thermosets, types and processing parameters, transfer molding.

Module-V: Other Plastic Processing Processes

Blow molding, Rotational molding, Stretch Blow molding etc, Selection of Molding Processes.

Textbook:

1. Grief, L. Allen, "Plastics Extrusion Technolgy", Hassell Street Press, 2021, Hawthorne, U.S.A.
2. Chan I. Chung, "Extrusion of Polymers Theory & Practice", Hanser Publishers, Munich Hanser Publications, Cincinnati, 2019.
3. J. Frados, "Plastic Engg. Hand Book of SPI", 1st Edition, Wiley, John & Sons Incorporated, 1976.
4. H.R. Jacobi, "Screw extrusion of Plastics", London, GB ILIFFE Books Ltd.,1963.

Reference Books and Suggested Readings :

1. Charles A. Harper and Edward M. Petrie; "Plastic Materials and Processes: a concise encyclopedia", John Wiley & Sons, 2003.
2. N. Cheremisinoff; "Polymer Mixing and Extrusion Technology", CRC Press, 2017.
3. C. Rauwendaal, Polymer Extrusion 5E; Hanser Publications, Cincinnati; Munich, 2014
4. G. Pritchard; "Plastics Additives: An A-Z reference", Springer Dordrecht, 1998.
5. J. Stepek and H Daoust, "Additives for Plastics" Springer, New York, 1983.
6. M. Chanda; "Plastics Technology Handbook" Fifth Edition; CRC Press Taylor & Francis Group NY, 2018.

Web links:

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

NPL 491 MINOR PROJECT

L- T- P- C 0- 0- 1- 2 - 6

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

Course Articulation Matrix (CO-PO Matrix)

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

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

NPL 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

Course Articulation Matrix (CO-PO Matrix)

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

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

Year IV, Semester VIII
PEC-V

NPL 422 PLASTIC WASTE MANAGEMENT (PWM)

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

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

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

Course Outcome

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

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus

Module-I: Introduction to Plastic Waste Management

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

Module-II: Plastic Waste Management

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

Module-III: Global Policies and Regulations

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

Module-IV: Recycling Technology

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

Module-V: Biodegradable Polymers

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

Text Books:

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

Reference books:

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

Web links:

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

NPL 424 CHARACTERIZATION OF POLYMERS (COP)

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

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

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

Course Outcome

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

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus:

Module-I: Determination of Molecular Weight

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

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

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

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

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

Textbook:

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

Reference Books and Suggested Readings:

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

Web Links:

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

NPL 426 SPECIALTY POLYMERS (SP)

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

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

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

Course Outcome

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

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

Course Articulation Matrix (CO-PO Matrix)

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		3						3	3	3
CO3	3	2				3		1				3	3	3
CO4	3	2				3		1				3	3	3
CO5	3	2	2			3	1			1	1	3	3	3
Total	**3**	**2**				**3**	**1**	**1**		**1**	**1**	**3**	**3**	**3**

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

Detailed Syllabus:

Module-I: High Temperature Resistant

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

Module-II: Conducting Polymers

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

Module-III: Ionic polymers

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

Module-IV: High performance polymers

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

Module-VI: Polymer Colloids

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

Textbook:

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

Reference Books and Suggested Readings :

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

Web Links:

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

OPL 402 TESTING OF POLYMERS (TOP)

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

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

- To understand the concept of testing, testing standards and identification of plastics
- To understand the mechanical properties of polymers
- To understand the thermal properties of polymers
- To understand the electrical and optical properties of polymers
- To understand the permeability and flow properties of polymers

Course Outcome

CO1	Understand the concept of testing, standard & specifications and identification of plastics by simple methods	Understand
CO2	Apply various processes and techniques used in determining the mechanicalproperties of plastic materials	Apply
CO3	Apply various processes and techniques used in determining thermal properties of polymers and plastics	Apply
CO4	Apply various processes and techniques used in determining electrical and permeability properties of polymers and plastics	Apply
CO5	Apply various processes and techniques used in determining optical and flow properties of polymers and plastics	Apply

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus

Module-I: Testing Standards and Identification of Polymers and Plastics
Importance of testing, Standard and specifications- National and International standards-BIS, ASTM, ISO,BS, etc. Identification of plastics by simple methods e.g., Visual inspection, density, effects of heat, combustion and solvents, analysis with common solvents, elemental analysis.

Module-II: Mechanical Properties of Polymers
Tensile strength, hardness, compressive strength, flexural strength, impact strength, dynamic stress − strain properties, toughness, brittle and ductile nature of materials , friction and wear test, abrasion resistance test, burst strength, peel strength.

Module-III: Thermal Properties of Polymers
Specific heat and thermal conductivity, melting point, glass transition temperature, thermal yield tests, heat deflection temperature, vicat softening temperature, brittleness temperature, ignition properties of plastics, coefficient of thermal expansion, shrinkage, thermal ageing and flammability.

Module-IV: Electrical and Permeability Properties of Polymers
Insulation resistance, power factor, permittivity, dielectric strength, tracking resistance, arc resistance and antistatic test. Water absorption, soluble and insoluble matter, chemical resistance, environmental stress cracking resistance, gas permeability, water vapour permeability and weathering.

Module-V: Optical and Flow Properties of Polymers
Luminous transmittance, haze, gloss, refractive index, colour measurement, optical microscopy. Melt flow index, melt viscosity, relationship of melt flow index on processing behaviour and properties. Quality control. Concept of Six Sigma.

Text Books:

1. W. S. Allen and P. N. Baker, "Hand Book of Plastics Technology, Volume 2, Identification, Testing & Recycling of Plastics", CBS Publishers and distributors, New Delhi (2004).
2. R. P. Brown (Ed.), "Hand Book of Polymer Testing", Marcel Dekker, Inc, New York, (1999).
3. V. Shah, "Hand Book of Plastics Testing Technology", John Wiley and Sons, SPE Monograph(1984).
4. T. Blythe and D. Bloor, "Electrical Properties of Polymers", Second Edition, Cambridge University Press, Cambridge (2005).
5. G. H. Meeten (Ed.), "Optical Properties of Polymers", Elsevier Applied Science, London (1986).

Reference Books:

1. R. Brown (Ed.), "Hand Book of Polymer Testing", Rapra Yechnology Ltd., United

Kingdom (2002).
2. P. F. Brown (Ed), “Hand Book of Plastics Test Methods”, Longman Scientific and Technical, Harlow (1988).
3. L. W. McKeen, “Permeability Properties of Plastics and Elastomers”, 4th Edition, Elsevier, New York (2016).
4. J. A. Brydson, “Flow Properties of Polymer Melts”, Godwin, 1981.
5. J. M. Ward and J. Sweeney, “Mechanical Properties of Solid Polymers”, 3rd Edition, Wiley (2012).
6. ASTM, ISO, IS standards

NPL 492 PROJECT

L-T-P-C: 0-0-24-16

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

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

Course Outcome

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

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

Course Articulation Matrix (CO-PO Matrix)

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

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

Courses for Minor Degree

Plastic Processing Technology

Year II, Semester III
NPL 201 INTRODUCTION TO POLYMER CHEMISTRY (ITPC)

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

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

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

Course Outcome

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

CO1	Understand the fundamentals types and properties of polymers.	Understand
CO2	Understand and apply the chain growth polymerization and its kinetics.	Apply
CO3	Understand and apply the step growth polymerization, its kinetics, mechanism and crosslinking.	Apply
CO4	Analyze molecular weight and molecular weight distribution of polymers, copolymers, etc.	Analyze
CO5	Understand and analyze co-polymerization usefulness and its types	Analyze

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus

Module-I: Basics of Polymer formation

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

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

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

Module-IV: Molecular Weight and its Control
Concept of Molecular weight of polymers, factors affecting molecular weight and molecular weight distribution, polydispersity. Chain transfer reactions, retarders, inhibitors, effect of temperature on polymerization

Module-V: Copolymerization and other Reactions
Copolymerization reactions and its utility. Kinetics of copolymerization, copolymerization behavior and types of copolymers. Significance & Global Impact of copolymerization on Plastic Industry

Text books:

11. F. W. Billmeyer, "Text Book of Polymer Science ", John. Wiley & Sons, 1990.
12. V. R. Gowariker, "Polymer Science", New Age International, 1986.
13. P. Ghosh, “Polymer Science and Technology ", Tata McGraw-Hill Education, 1990.
14. G. Odian, “Principles of Polymerization ", Wiley, 1981.
15. P. J. Flory, “Principles of Polymer Chemistry ", Cornell University Press, 1953.
16. R. W. Lenz, “Organic Chemistry of Synthetic High Polymers ", John Wiley & Sons Inc, 1967.
17. D. Margerison, “An Introduction to Polymer Chemistry ", Pergamon, 1967.
18. A. Ravve, “Principles of Polymer Chemistry”, Springer New York, 2012.
19. J. A. Brydson, “Plastics Material”, 7th edition, Butterworth-Heinemann, 1999.
20. J. R. Fried, “Polymer Science & Technology”, 3rd edition, Prentice Hall, 2014.

Reference Books:

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

Web Links:

1. https://archive.nptel.ac.in/courses/104/105/104105124/
2. https://nitsri.ac.in/Department/Chemical%20Engineering/M3__Polymer_Technology.pdf

Year II, Semester IV

NPL 202 PROCESSING OF POLYMERS –I (PP-I)

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

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

- To understand the fundamentals of polymer processing
- To learn the fundamentals of extrusion processes of thermoplastics.
- To learn the basic principle of compounding of thermoplastics
- To learn the fundamentals of calendaring process.
- To learn processing of plastics on different machines and prepare simple plastic articles.

Course Outcome

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

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

Course Articulation Matrix (CO-PO Matrix)

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

Detailed Syllabus

Module-I: Introduction to Polymer Processing

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

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

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

Module-III: Extrusion Processes for plastic products

Plastic Product formed by extrusion process, Basic principle, equipment used, and process détails for plastic extrusion lines for production of Blown film, pipe, tubing, sheet, wire and cable coating, etc.; Utility of these products in urban développement. Extrusion Casting process for films and lamination; Process variables, die design and defects observed in each of the extrusion product. Reactive extrusion: basic principles, equipment used and applications.

Module-IV: Compounding of Polymers

Importance and concept of compounding of polymers; compounding additives viz. fillers, plasticizers, colorants, stabilizers, blowing agents, flame-retardants, antioxidants, lubricants, processing aids, etc. sustainability and effects on environment of variety of additives for plastics Mixing, blending and compounding techniques and equipments. Pelletization, Reactive compounding, Global technical development in compounding additives and compounding technology for plastics. Finishing of Plastics

Module-V: Calendaring of plastics

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

Module VI: Laboratory Experiments

6. Preparation of plastic film on Blown Film Extrusion;
7. Preparation of HDPE plastic pipe on Extrusion;
8. Compounding of PVC on Two Roll Mill;
9. Preparation of sheet by Hydraulic press;

10. Preparation of Fiber reinforced plastic sheet by using glass fiber mat and unsaturated polyester resin

Text Books:

7. Plastics Extrusion Technology, by Grief, Allen L; published by Hassell Street Press, 2021,Hawthorne, U.S.A.
8. Extrusion of Polymers Theory & Practice, Chan I. Chung; Hanser Publishers, Munich Hanser Publications, Cincinnati, 2019.
9. Screw extrusion of Plastics, by H
10. R. Jacobi; London, GB ILIFFE Books Ltd. 1963.
11. Polymer Mixing and Extrusion Technology, by Nicholas Cheremisinoff; First Published1987;eBook Published 25 October 2017; CRC Press, Available on Taylor and Francis eBooks.
12. Additives for Plastics; J. Stepek and H Daoust; Springer New York; 1983.

Reference books:

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

Web links:

4. https://www.twi-global.com/technical-knowledge/faqs/plastic-extrusion
5. https://www.extrusion-info.com
6. https://www.iqsdirectory.com/articles/plastic-extrusion.html

Year III, Semester V

NPL 301 PROCESSING OF POLYMERS- II (PP-II)

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

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

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

Course Outcome

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

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.	Understand and 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 and casting	Understand
CO6	Apply different parameters related to processing machines for formation of plastic products.	Apply

Course Articulation Matrix (CO-PO Matrix)

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**3**	**3**
CO1	3	3	1	1	1	3	1	1	1	1		2	3	3
CO2	3		1	1		3	1	1	1	1		2	3	3
CO3	3	3	1	1		3	2	1	1	1		2	3	3
CO4	3	3				3	1	1	1	1		2	3	3
CO5	3	3				3	1	1	1	2		3	3	3
CO6	3	3	3	3	1	3	2	1	3	2	1	3	3	3
Total	**3**	**3**	**1.5**	**1.5**	**1**	**3**	**1.3**	**1**	**1.3**	**1.3**	**1**	**2.3**	**3**	**3**

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

Detailed Syllabus

Module-I: Injection Molding of Thermoplastics

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

Module-II: Molding Processes for Thermoset polymers

Concept of Injection molding of thermoset polymers and process details. General concept of compression and transfer molding process; hydraulic press and their capacity; process parameters; advantages and disadvantages of these processes; description of various types of transfer molding processes and their utility in processing of thermosetting materials. Advances in compression and transfer molding process: global and Indian scenario.

Module-III: Thermoforming Process

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

Module-IV: Molding Process for hollow products

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

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

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

Module-V: In-situ Reaction Molding process

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

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

Module VI: Laboratory Experiments

7. Preparation of simple Dumble shape test specimen on Semi-Automatic Injection Molding Machine.
8. Preparation of simple Bar/Disc shape test specimen on Hand Injection Molding Machine.
9. Preparation of simple article on Blow Molding Machine.
10. Preparation of PET Bottle on Stretch Blow Moulding Machine.
11. Preparation of an article by Rotational Molding Machine.

12. Preparation of an article by Compression Molding Machine.

Text books:

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

Refernce books:

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

Web links:

4. https://elearn.nptel.ac.in/shop/nptel/processing-of-polymers-and-polymer-composites/
5. https://web.ics.purdue.edu/~kviswana/polymerProc_Dec29.pdf
6. https://nptel.ac.in/courses/112107221

NPL 303 PLASTIC MOULD DESIGN AND DIES (PMDD)

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

OBJECTIVE: The objective of this course is **t**o 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.	Understand
CO2	Understand and apply design features for plastic product shape.	Understand
CO3	Understand and apply design concepts for structure of injection molds.	Apply
CO4	Understand concepts and apply design in structure of compression & in structure of extrusion dies.	Apply
CO5	Understand and apply concepts Computer Aided Design to Mold design	Apply

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus

Module-I: Plastic product design criteria

Design of polymeric products, design criteria based upon product functions and geometry, material selection by property assessment, 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 cavity, multi cavity: two and three plate mould, semi- automatic and automatic moulds, Types of injection moulds, their applications, detailed structure and working. Globally available mold bases

Module-IV: Design Concept of other Mold types
Design concepts for compression molds and transfer molds. Extrusion 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.

Text books:
1. R. D. Beck, "Plastic Product Design:",2nd edition, New York : Van Nostrand Reinhold Co. 1980.
2. R.G.W. Pye, 'Injection mould Design", East-West Press Pvt., 2000.
3. J. H. Dubois & W. I. Pribble, "Plastic Mould Engg.", Van Nostrand Reinhold, New York, 1965.
4. M. V. Joshi, "Dies for Plastic Extrusion",1984.

Reference books:

6. Rosato & Rosato, "Injection Moulding", 3rd edition, Kluwer Academic Publishers, 2000.
7. D. H Morton-Jones & John W-Ellis "Polymer product design materials and processing", vol. 25, 1987.
8. M. Edward, "plastics product design part B", 1st edition, CRC press, 1983.
9. R. H. Bebb, "Plastics Mould Design, Compression and Transfer Moulds", vol. 1, 2006.
10. N.S. Rao., "Design data for plastics engineers", Hanser/Gardner Publications Inc. 2017.

Weblinks:

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

NPL 405 PLASTIC PRODUCT TECHNOLOGY (PPT)

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

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

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

Course Outcome

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

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

Course Articulation Matrix (CO-PO Matrix)

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

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

Detailed Syllabus

Module-I: Plastic product design criteria

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

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

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

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

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

Text books:

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

Reference Books:

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

Web Links:

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