University of Pune
Structure of T. E. Polymer Engineering
[2012 Course]

Term I

Code	Subject	Teaching Scheme			Examination Scheme					Total
		L	P	T	In Semester Assessment	TW	PR	OR	End Semester Exam	
					P I				P II	
309361	Mathematical Methods for Polymer Engineers	4	--	--	30	--	--	--	70	100
309362	Polymer Chemistry - I	4	4	--	30	25	--	50	70	175
309363	Polymer Materials - I	4	2	--	30	50	--	--	70	150
309364	Polymer Structure Property Relationship	4	2	--	30	--	--	50	70	150
309365	Mass Transfer and Reaction Engineering	4	--	--	30	--	--	--	70	100
309366	Employable Skill Development	--	2	--	--	--	--	50	--	50
309367	Industrial Visit	--	--	--	--	25	--	--	--	25
Total of First Term		**20**	**10**	**--**	**150**	**100**	**--**	**150**	**350**	**750**

Term II

Code	Subject	Teaching Scheme			Examination Scheme					Total
		L	P/ D	T	In Semester Assessment	TW	PR	OR	End Semester Exam	
					P III				P IV	
309368	Polymer Chemistry - II	4	2	--	30	25	50	--	70	175
309369	Polymer Materials - II	4	--	--	30	--	--	--	70	100
309370	Polymer Rheology and Processing	4	2	--	30	25	--	--	70	125
309371	Design Equipment & Machinery Element	4	2	--	30	--	--	50	70	150
309372	Instrumentation and Process Control	4	2	--	30	25	--	--	70	125
309373	Seminar and Technical Communication	--	2*	--	--	--	--	50	--	50
309374	Industrial Visit	--	--	--	--	25	--	--	--	25
309375	Industrial Training (To be evaluated in seventh term)	--	--	--	--	--	--	--	--	--
Total of Second Term		**20**	**10**	**--**	**150**	**100**	**50**	**100**	**350**	**750**

Examination Duration:
In semester: 90 min. End semester: 180 min.
L: Lecture, P: Practical, T: Tutorial, TW: Term work, PR: Practical, OR: Oral.
PI: Phase one, PII: Phase two, PIII: Phase three, PIV: Phase four.

To be conducted in a single batch

TERM: I

309361: Mathematical Methods for Polymer Engineers

Teaching Scheme:
Lectures : 4 Hours / Week

Examination Scheme:
In Semester: 30
End Semester: 70
Total: 100

Objectives:

1. To learn finite difference techniques, interpolation, numerical integration for solving Engineering problems.
2. To learn to apply numerical techniques in solving algebraic and differential equations usually encountered in polymer engineering practice.
3. To learn differential equations and boundary value problems like heat equation, wave equation.
4. To get acquainted with operations research tools and statistical techniques required in polymer engineering practice.
5. To learn statistical distributions and testing of hypothesis which occur in data distribution problems of polymer engineering.
6. Understanding tensor calculus and applications of it in polymer engineering practices.

Unit I : Numerical Methods: 08 Hrs

Calculus of finite difference, finite difference operators, Newton's, Lagrange's & Stirling's interpolation formulae, numerical differentiation and numerical integration, error analysis.

Unit II : Solutions of Equations 08 Hrs

Solution of algebraic and transcendental equations, bisection method, method of false position, Newton-Raphson method, method of successive approximation, convergence and stability criteria, solution of system of simultaneous linear equations, Gauss elimination method, Gauss Seidel Method, Jacobi's method, method of least square for curve fitting.

Unit III : Finite Difference Techniques 08 Hrs

Ordinary differential equations, initial value problems, Euler's method, modified Euler's method, Runge–Kutta method, overview of the step–size control and error estimation. Stability of algorithms, stiff ordinary differential equations and Gear's technique, boundary value problems, solutions of ordinary and partial differential equations using finite difference techniques. Overview of finite element methods, computer algorithms for the various numerical methods described above.

Unit IV : Optimization Techniques 08 Hrs

Formulation of linear programming problem, graphical procedure, Slack and Surplus variables, computational procedure of simplex method, simplex method computation, Big–M method, duality.

Unit V : Statistics & Probability **08 Hrs**

Mean & standard deviation, coefficient of variation, moments, skewness and kurtosis, correlation and regression, probability, probability distributions, binomial, normal and poisson distribution, Chi-square distribution, random sampling, estimation of parameters, testing of hypothesis, student t test, F-Test.

Unit VI : Tensors **08 Hrs**

General curvilinear co-ordinate systems, contravarient, covariant and mixed tensors, metric tensor, Christoffel symbols, covariant derivative, divergence, laplacian & curl, applications of tensors.

Text Books

1. Kreyszig E.; Engineering Mathematics; Wiley Eastern Ltd.
2. Hilderbrand F. B.; Introduction to Numerical Analysis.
3. Freund John; Probability and Statistics for Engineers; Prentice-Hall of India Pvt. Ltd.

Reference Books

1. Gupta S.K. 'Numerical methods for Engineers', New Age International Publishers [Previously Wiley Eastern Ltd.], 2nd edition 1995.
2. Jain M.K., Iyengar, S.R.K., Jain, R. K., 'Numerical methods for scientific and Engineering Computation', Wiley Eastern Ltd, 2nd edition, 1985.
3. Kreyszig F. 'Advanced Engineering Mathematics', John Wiley Eastern Ltd, 8th edition, 1999.
4. Ariken E. 'Advanced engineering methods in the physical science,' Academic press.
5. Boas M. L. 'Mathematical methods in the physical science,' J. Wiley and sons,2nd edition,1966
6. Aris R. 'Vectors, tensors and the basic equations of fluid mechanics,' Dover Publication Inc.,1962
7. Probability and statistics in Engineering William W. Hines, D. C. Montgomery, John Wiley & Sons, Inc 4th edition
8. H.A. Taha: 'Operations Research – An Introduction', Prentice-Hall of India Pvt. Ltd, 4th edition, 2003.
9. Hira-Gupta, 'Operations Research', S. Chand & Company, 3rd edition, 1993.

309362: Polymer Chemistry I

Teaching Scheme:
Lectures : 4 Hours / Week
Practical : 4 Hours / Week

Examination Scheme:
In Semester: 30
End Semester: 70
TW: 25
OR: 50
Total: 175

Objective

To provide the basic building blocks of polymer science by imparting fundamental knowledge of molecular weight, polymerization mechanism, polymer reactions and environmental awareness & polymer science.

Unit I: Fundamentals of Polymer Science and Molecular Weight — 8 Hrs

Brief revision to – basic concepts in polymer science, various polymerization mechanisms, polymerization techniques and molecular weight. Various methods of determination of MW and MWD such as ebulliometry, cryoscopy, osmometry, GPC, ultracentrifugation, light scattering, chemical methods, fractionation methods etc.

Unit II: Chain Polymerization — 8 Hrs

Free radical polymerization: initiators, chain transfer, inhibition and retardation; Cationic and anionic polymerization: initiators; Kinetics of free radical, cationic and anionic polymerization reactions, an overview of solid phase and gas phase polymerization.

Unit III: Step Polymerization — 8 Hrs

Polycondensation, polyaddition and ring-opening polymerization, need for stoichiometric control, gelation, crosslinking, Carother’s equation, kinetics of step polymerization, an overview of interfacial and melt polymerization technique.

Unit IV: Copolymerization — 8 Hrs

Step copolymerization: introduction, types, methods of synthesis; Chain copolymerization: introduction, types, copolymerization equation, monomer reactivity ratio, applicability of copolymerization equation, types of copolymerization behavior, sequence length distribution, Q-e scheme; Commercial applications of copolymerization.

Unit V: Polymer Modification and Degradation Reactions — 8 Hrs

An overview of various polymer modification reactions viz. hydrolysis, acidolysis, aminolysis, hydrogenation, addition and substitution, specific group reactions like hydroxyl, aldehyde, ketone, carboxyl, amino groups etc. Introduction to polymer degradation, study of polymer degradation based on various factors or agents.

Unit VI: Plastic and environment — 8 Hrs

Polymers as a replacement to traditional natural resources, energy conservation due to plastics, biodegradability, plastic waste and management of plastic waste in the environment - recycling, incineration and biodegradation. Green chemistry, new methods of production of polymers, new feedstock alternative to petroleum, alternative technologies for eco-friendly plastics, role of biopolymer and biodegradable polymers.

Practical –TW-OR
[Expt. No. 1 is compulsory, minimum 08 experiments from 2 to 14]

1. Study of various laboratory practices like material handling, handling laboratory equipments, basic laboratory techniques etc. (Compulsory assignment based on health hazards associated with various chemicals used in polymer industry their handling and first aid should be a part of the journal)
2. Comparative study of bulk and solution polymerization techniques.
3. To synthesize polymer by suspension polymerization technique.
4. To synthesize polymer by emulsion polymerization technique.
5. To synthesize polymer by interfacial polymerization technique.
6. Comparative study of kinetics of catalyzed and uncatalyzed polyestrification.
7. Casting of PMMA sheets.
8. Synthesis of cellulose acetate from cellulose.
9. Preparation of cellophane.
10. Synthesis of styrene-maleic anhydride copolymer
11. Synthesis of epoxy resin.
12. To synthesize UF / MF resin for adhesive application.

Reference books:

1. Polymer Chemistry - An Introduction, **M.P. Stevens,** Oxford University Press, [2nd edition], 1999.
2. Principles of Polymerization, **George Odian,** Wiley Interscience John Wiley and Sons, [4th edition]
3. Polymer Science, **V.R. Gowarikar,** New Age International [P] Ltd. Publisher, 1986 [1st edition]
4. Text book of Polymer Science, **F.W. Billmeyer Jr.,** Inter science Publisher John Wiley and Sons, 1962, [3rd edition].
5. Polymer Molecular Weight, **Slade, Jr.** Vol. I and II.: M. Dekker, New York ,1975.
6. Polymer Science and Technology, **Joel R. Fried**, PHI publications pvt. Ltd., New Delhi [2nd edition]
7. Interaction of Polymers with Polluted Atmospheres, Smithers Information Ltd, September 2009.

309363: Polymer Materials I

Teaching Scheme:
Lectures : 4 Hours / Week
Practical : 2 Hours / Week

Examination Scheme:
In Semester: 30
End Semester: 70
TW: 50
Total: 150

Objective

To impart the knowledge pertaining to various commercial polymeric materials to enable polymer engineers to choose appropriate materials for new and demanding applications.

Unit I: 8 Hrs

Historical of development of plastic material, market for plastics, future for plastics. Polymer Additives : Role of polymer additives, classification, examples of stabilizing additives, property modifiers, processing aids, commodity plastics, engineering plastics and high performance polymers, material selection, factors affecting material choice, material data sources.
Industrial manufacturing processes, properties, additives, compounding, processing and applications of polyethylene [LDPE, LLDPE, HDPE, UHMHDPE, EVA, crosslinked PE, chlorinated PE etc.] polypropylene and their copolymers.

Unit II: 8 Hrs

Industrial manufacturing processes, properties, additives, compounding, processing and applications of polyvinyl chloride and polyvinylidene dichloride, fluorine containing polymers [PTFE, PVDF etc.], styrene based polymers [GPPS, HIPS, ABS, SAN, expandable PS etc.] and their copolymers.

Unit III: 8 Hrs

Industrial manufacturing processes, properties, additives, compounding, processing and applications of acrylics, polyvinyl acetate, polyvinyl alcohol and cellulosics such as CA, CN, HPC, CMC, EC etc.

Unit IV: 8 Hrs

Fundamentals of rubbers – Molecular requirements for a material to function as an elastomers, basic terminologies such as raw rubber, vulcanisate, peptizers, antioxidants, accelerators, activators, carbon black reinforcement etc., various processes involved in isolation of natural rubber, physics of raw and vulcanized rubber, outline of raw rubber technology – concepts of mastication, compounding, vulcanization in brief.

Unit V: **8 Hrs**

Industrial manufacturing processes, properties, applications, compounding & processing in detail for natural rubber [NR], styrene-butadiene rubber, [SBR], butyl rubber, thermoplastic elastomers, polychloroprene rubber, nitrile rubber and IIR.

Unit VI: **8 Hrs**

Adhesives: Guidelines for good adhesion, various theories of adhesion, diffusion, electrostatics, mechanical interlocking, types of adhesives, classification, epoxy, acrylic, elastomer modified, PU based adhesives, pressure sensitive adhesives, hot melt adhesives, solvent and emulsion based adhesives. Various additives used with adhesives: solvents, fillers, plasticizers, hardeners, primers, thickening agents etc. Paint: Basic principles. Terminologies – Resins, paints, lacquers, varnish, primer, binders, solvents, pigments, additives. Various paint formulations. Architectural coating, industrial coating, automotive coatings, decorative coatings, powder-coatings, water based coatings, printing inks.

Practical -TW
[Minimum 08 experiments, students should identify minimum 12 materials from expt. no. 1-4]

1.	Identification of	1]	Polyolefin [LD, HD, PP]
		2]	Polyamides [Nylon 6, 66]
		3]	Polyacetals
2.	Identification of	1]	Cellulose acetate
		2]	Phenol formaldehyde
		3]	PET, PBT
3.	Identification of	1]	Acrylics
		2]	PC
		3]	PS
4.	Identification of	1]	PVC
		2]	Different types of elastomers
		3]	Polyester resin
		4]	Epoxy resin

5. Determination of carbon black content.
6. Determination of filler content.
7. Determination of heat deflection temperature of plastics materials
8. Determination of vicat softening temperature
9. Determination of thermal conductivity
10. Determination of dielectric strength / break down voltage of plastics.
11. Determination of flexural strength, flexural modulus of plastics.
12. Determination of curing time of resin.

Reference Books:

1. Plastic Materials, **J.A. Brydson**, Heinemenn / Elsevier Publisher, [7thedition],2005
2. Manufacture of Plastics, **S.W. Mayo**, Reinhold Publishing Corporation, Chapman & Hall, Ltd. London, 1964.

3. Fundamentals Principles of Polymeric Materials, **S.L. Rosen**, John Wiley Publisher, [2nd edition], 1993.
4. Plastics Engineering Handbook, **J. Fredos,** Van Nostrand Reinhold, New york, [2nd-3rd edition] 1976.
5. Plastics Materials Handbook **A.S.Athalye**, Multi Tech Publisher Mumbai, [3rd edition],1995
6. Handbook of Plastics Materials and Technology, **I. Rubin**, Wiley Inter. Sc. Publisher.
7. Science and Technology of Rubbers, J. E. Mark, B. Ermas, F. R. Eirich, Academic Press 1994.
8 Paints and Surface coatings, Lambourne (new), second edition, Woodhead Publication House, 2004

309364: Polymer Structure & Property Relationship

Teaching Scheme:	**Examination Scheme:**
Lectures : 4 Hours / Week	In Semester: 30
Practical : 2 Hours / Week	End Semester: 70
	OR: 50
	Total: 150

Objective

To make the students aware of relation between structure, properties and application of different polymers so as to equip them with the ability of prediction of properties based on structure and hence material selection, substitution of economical and best performing polymer for particular application.

Unit I: Submolecular Structure **8 Hrs**

Chemical composition and types of bonds in the structure. Influence forces and molecular flexibility. Chemical composition of polymer molecules and its effect on properties like mechanical, chemical, thermal, electrical, optical etc. Monomeric ingredients required in final polymer composition & their effect on properties & applications. Types of additives and its role on end properties.

Unit II: Molecular Structure **8 Hrs**

Molecular size and shape and its effect on processability and various other properties such as mechanical, chemical, thermal, electrical, optical etc. MW & MWD and its effect on various properties mentioned above. Conversion methods from low to high MW during various processing techniques. Structure and morphology developed during processing techniques like injection, blow molding, rotational molding etc.

Unit III: Molecular Flexibility **8 Hrs**

Molecular Flexibility and freedom of rotation of bonds and thus effect on properties like Tg, Tm, crystallinity etc. Structural restriction to rotation and thus effect of properties- mechanical, electrical, optical etc. Effect of copolymer and blends on polymer properties. Intermolecular order first and second order transition, super cooled state, fringed micelle theory, spherulitic growth and its effect on various properties. Effect of chemical groups on adhesive properties.

Unit IV: Intermolecular Structure **8 Hrs**

Intermolecular order, amorphous and crystalline state. Study of spherulites, factors leading to crystallinity & its effect on various properties like processing, mechanical, thermal etc., Thermodynamic and kinetic factors affecting rate of crystallization. Orientation & relation between crystallization & orientation. Effect of orientation on various polymer properties like mechanical, chemical, thermal, electrical, optical etc. Relation between Tm and Tg and their significance.

Unit V: Intermolecular Bonding **8 Hrs**

Intermolecular bonding forces like London Dispersion Forces [LDF], induced & permanent dipole. Effect of these forces on structure and properties like solubility, melting, CED, permeability etc. Ionic bonding, cross linking, polarity and their effect on polymer properties like mechanical, chemical, thermal, electrical, optical etc..

Unit VI: Supermolecular Structure **8 Hrs**

Multiple phases & macrostructure, temporary heterogenity for processing, chemical micro heterogenity, complex multi component: total macro structures. Structure property relation in advance polymeric material: Polymer-clay nano composites, polymer composites with carbon nano tubes, synergism in polymer hybrid composites, gas barrier properties, dendrimers and hyperbranched polymers and their blends.

Practical – OR

List of experiments: [Minimum 08]

(Minimum 04 performing experiments must be given to the students along with study experiments.)

1. To study DSC, its working and applications along with interpretation of few spectra for various polymer systems.
2. To study TGA, its working and applications along with interpretation of few case studies from thermo gram of polymer.
3. To study FTIR spectroscopy working & application and to understand the identification chart to identify polymer from the spectra obtained. Also to study various other parameters of polymer system, like blends, co-polymers, additives, etc.
4. To study NMR, its working and applications along with interpretation of few spectra for various polymer systems.
5. To study working of GPC to find MW, MWD, polydisperity, etc.
6. To study X-ray diffraction, its working and application along with interpretation of the d-spacing from the spectra obtained & thus have morphology understood.
7. To find out the swelling of rubber in various solvents and thus find out its degree of crosslinking, etc.
8. To find out the permeability of LDPE film towards various solvents and to study the importance of barrier properties and factors affecting them.
9. To study and find out the % of vinyl acetate in EVA.
10. To study the relationship between MFI and VA content in EVA.
11. To study the importance of scanning electron microscope for studying the morphology of polymer system.
12. To develop and study the growth of spherulites.
13. To establish the relation between molecular weight and properties of polymer.

Reference Books:

1. Polymer Structure, Properties and Applications, **Rudolph.D. Deanin,** Plastics World, Cahners Publication, 1972.
2. Introduction to Polymer Crystallization, **Allan Sharples,** St. Martin’s Press, N.Y., 1966.

3. Macromolecular Physics, **Berhard Wunderlich**, Academic Press, N.Y.
4. Properties and Structure of Polymers, **A.V. Tobolsky, John Wiley & Sons,** N. Y., 1960.
5. Structure and Properties of Polymers, **H.V. Boenig,** J.Wiley & Sons, N.Y., 1973.
6. Text book of Polymer Science, **Fred W. Billmeyer Jr.,** Inter science Publisher John Wiley and Sons, [3rd edition] ,1962.
7. Polymer Chemistry & Physics of Modern Materials, **J.M.G. Cowie,** Chapman & Hall [2nd edition].
8. Introduction to physical polymer science, **L.H. Sperling ,**Wiley Interscience [3rd edition]. 2001
9. Physical Chemistry of Polymers, **A. Tager**, MIR Publishers [Moscow],1978.

309365: Mass Transfer & Reaction Engineering

Teaching Scheme:
Lectures : 4 Hours / Week

Examination Scheme:
In Semester: 30
End Semester: 70
Total: 100

Objectives:

1. To provide theoretical understanding of various inter-phase mass transfer operations such as diffusion, vapor-liquid, liquid-liquid and gas-liquid systems, humidification and drying.
2. To understand basic principles of chemical reactor design for homogeneous reactions.

Unit I: Diffusion **8 Hrs**

Introduction to mass transfer: Various industrially important mass transfer operations, their classification, choices of separation methods, methods of conducting mass transfer operation design principle, molecular diffusion in fluids, steady state diffusion under stagnant and laminar flow conditions, diffusivity of gases and liquid, diffusion in solids and its application, mass transfer coefficient, Eddy diffusion, two film theory, surface renewal theory and penetration theory, mass, heat and momentum analogies.

Unit II: Absorption and Distillation **8 Hrs**

Raoults Law & Henry's law, equipment for gas liquid operations, absorption equilibrium, ideal non-ideal solution, modified Raoult's law, selection of solvent for absorption, design concept of absorption. Distillation - Introduction, relative volatility, types of distillations, concepts designs and operation for distillation.

Unit III: Humidification and Drying **8 Hrs**

Basic concepts of humidification and psychrometric chart construction, humidification and dehumidification operations, design calculation, cooling tower principle and operation, types of equipment, design calculation, theory and mechanism of drying, drying characteristics of material, batch and continuous drying, calculation for continuous drying, drying equipment, design and performances of various drying equipments.

Unit IV: Fundamental of Reaction Kinetics **8 Hrs**

Chemical reactions: Rate of chemical reactions, variable affecting the reaction rate, order of reaction, reaction rate constant, elementary and non-elementary reaction mechanism, Arrhenius equation, collision theory, predictability of reaction rate, kinetics of homogeneous chemical reactions, rate equations for simple and complex reactions.

Unit V: Ideal Reactor **8 Hrs**

Interpretation of reactor data in constant volume and variable volume batch reactions, integral and differential method of interpretation of batch reactor, classification of chemical reactor, interpretation of reactor data in flow reactions, reactor design for homogeneous, isothermal operations, batch, semi batch, plug flow and continuous stirred tank reactor, concepts of space time, space velocity and residence time in flow reactors.

Unit VI: Chemical Reactor Systems **8 Hrs**

Comparison of single reactors like batch, plug flow and CSTR for first and second order reactions, multiple reactors system, and plug flow reactions in series and for parallel equal sized constant stirred tank reactor's [CSTR's] in series, introduction to polymer reactors.

Reference Books:

1. Unit operations in Chemical Engineering, **McCabe, Smith & Peter Harriot** McGraw Hill, 7^{th} edition 1993.
2. Mass Transfer Operations, **Treybal** McGraw Hill, 3^{rd}edition, 1980.
3. Chemical Engineering vol. 1 to 2, **Richardson Coulson,** Pergamon Press,4^{th} edition,1990
4. Chemical Reaction Engineering, **O. Levenspiel, John Wiley 3^{rd} edition, 2007**
5. Chemical Reaction Engineering, **Ians Netcalfe,** Oxford University Press, 1997.
6. Chemical Reaction & Chemical Reactor, **George W. Roberts,** John Wiley & Son, Inc. 2008.
7. Element of Chemical Reaction Engineering, **Scott Fogler,** Prentice Hall, 3^{rd}edition, 1999
8. Mass Transfer Fundamental, **Anthony L. Hines,** Prentice Hall, 1985.
9. Mass Transfer Operation, **Treybal R.E.,** McGraw Hill, 3^{rd} edition. 1980
10. Chemical Engineering vol. I & II, **Richardson Coulson**, Pergamon Press, 1977.
11. Chemical Reaction Engineering, **O. Levenspiel,** John Willey, 2007, [3^{rd} edition].

309366: Employable Skill Development

Teaching Scheme:
Practical : 2 Hours / Week

Examination Scheme:
OR: 50
Total: 50

Employable Skill Development:

The basic purpose of introducing Employable Skill Development to the students is to make them proficient in the chosen area of their interest from amongst the following choices so as to equip them with basic entrepreneurship skills.

The student can choose any one skill from the following -

1. Manufacturing of various usable articles of FRP Composite.
2. Through training on any one processing equipment such as blow, extrusion, compression, injection molding etc.
3. Mold and die design.
4. Mold and die manufacture / fabrication.
5. Hands on training on any industrially important software.

The students will maintain the record of above in the form of Journal.

Based on the practical training the students are required to work on a mini-project. A mini-project can be a small task assigned to the students in a group of **maximum five** students per group. At the end of the term the students are required to submit a **'mini project report'** (about 25 pages) based on the selected 'skill'. The mini project shall contain

1. The detailed statement of project problem,
2. Literature review, market survey
3. Experimental work or product design or process design
4. Results/conclusion and
5. Plant costing relevant to his selected 'skill'
6. References.

Students will submit a neatly typed and bound mini-project report at the end of the term for the purpose of term work assessment. They will be evaluated on the basis of their work and oral examination by the examiner.

The college is expected to have interactions with industry, industrial experts and conduct industrial visits to reinforce this course. The students are expected to be trained through 100% practical sessions.

(Note: The institute may request for any new 'skill' in conformity with the demand in market/industry to be added to the syllabus through concerned BoS. The new skill can be added to the syllabus only after prior sanction from the BoS and faculty as per the standard procedure.)

309367: Industrial Visit

Teaching Scheme:

Examination Scheme:
TW: 25
Total: 25

It is **mandatory** that the students along with a mentor/teacher visit a large scale Polymer Industry (manufacturing, processing, equipment industry etc.) minimum once during **every semester** (i. e. minimum two visits during an academic year).

The students are required to submit industrial visit report in spiral bound form and soft copy within 15 days of visit to the department.

The students will be evaluated based on the report submitted, knowledge acquired during the industrial visit at the end of the semester under the head TW for 25 marks.

(Note: As the industrial visit is mandatory the term is not to be granted if any student fails to attend industrial visit.)

TERM: II

309368: Polymer Chemistry II

Teaching Scheme:
Lectures : 4 Hours / Week
Practical : 2 Hours / Week

Examination Scheme:
In Semester: 30
End Semester: 70
TW: 25
Practical: 50
Total: 175

Objective Chemistry orientation structure, reaction conditions, reaction routes

To impart advance knowledge about synthesis, polymerization mechanism, high performance polymers and biodegradable polymers of present day relevance to the industry. A sound understanding of this would keep students updated about the frontier areas of research and development.

Unit 1: Polymer Solutions **8 Hrs**

Polymer dissolution process, thermodynamics, Flory-Huggins theory, effect of: molecular weight, crystalline and amorphous polymers on dissolution; Size and shape of macromolecule in solution, viscosity of dilute and concentrated polymer solutions.

Unit 2: Advanced Polymerization Mechanisms **8 Hrs**

Metathesis polymerization, NMP, ATRP, RAFT, electrochemical polymerizations, click polymerization, phase transfer polymerization, group transfer polymerization, plasma polymerization.

Unit 3: Stereochemistry of Polymerization **8 Hrs**

Introduction, Types of isomerism in polymers, properties of stereo regular polymers, forces of stereo regulation in alkene polymerization, mechanism of coordination polymerization, Ziegler – Natta polymerization, Metallocene catalyst.

Unit 4: Chemistry of Thermosetting Polymers **8 Hrs**

Chemistry, synthesis and cross-linking of polyester, polyamides, polycarbonate, phenolics, amino, epoxy, polyurethane and silicones polymers.

Unit 5: Chemistry of High Performance Polymers **8 Hrs**

Requirements of high performance polymers, chemistry & synthesis of - aromatic polyethers, polyketones, polysulfones, polyetherketones, polyetheretherketones, polysulfides, polyimides, polyetherimides, polyamideimides, polesterimides, PBI, PBO, PBT, PQs etc.

Unit 6: Green Polymers **8 Hrs**

Green polymers, isolation, synthesis, structure, PHA, PHB, PHV, PHH, PLA, PBS, PCL etc., mechanism of breakdown, evaluation of biodegradability, advantages and applications.

Practical – PR

(Minimum eight)

1. Determination of % chlorine/ K-value/ plasticizer absorption test of PVC.
2. Determination of epoxy value and epoxy equivalent.
3. Determination of acid value and gel time of unsaturated polyester resin.
4. Determination of molecular weight of PEG resin by end group analysis technique.
5. To determine molecular weight of above polymer by viscometry technique.
6. To find out strength of formalin solution
7. To find out saponification value of oil samples
8. To determine functionality of given monomer / chemical compound.
9. Modification of polyvinyl acetate to polvinyl alcohol.
10. Preparation of cellophane film from cellulose.
11. To determine purity of given plasticizer.
12. To determine purity of adipic acid.
13. Determination of melting point and density of polymers.
14. Biodegradation of polymer.
15. Click / frontal polymerization.

References books:

1. Polymer Chemistry - An Introduction, Oxford University Press: M.P. Stevens
2. Principles of Polymerization, Wiley Eastern: George Odian
3. Polymer Science, New age international (P) Ltd. Publishers: V.R. Gowarikar
4. Text book of Polymer Science, Wiley Eastern: F.W. Billmeyer Jr.
5. Polymer Molecular Weight – Vol. I and II: Slade Jr.
6. Handbook of Biodegradable Polymers**,** Edited by Catia Bastioli, Rapra Technology Limited

309369: Polymer Materials II

Teaching Scheme:
Lectures: 4 Hours / Week

Examination Scheme:
In Semester: 30
End Semester: 70
Total: 100

Objective:
To make the student aware of material selection, material data correlation with application, factors affecting material choice, properties, applications and substituting new material

Unit I: **8 Hrs**

Industrial manufacturing processes, additives, formulations, compounding, processing, properties and applications of phenolic resins, amino resins and silicone resins

Unit II: **8 Hrs**

Industrial manufacturing processes, additives, formulations, compounding, processing, properties and applications of saturated polyester resins, unsaturated polyester resins and alkyds and vinyl ester resins

Unit III: **8 Hrs**

Industrial manufacturing processes, additives, formulations, compounding, processing, properties and applications of epoxy resins and polyurethane resins

Unit IV: **8 Hrs**

Industrial manufacturing processes, additives, formulations, compounding, processing, properties and applications of polyacetals, polyamides and polyimides

Unit V: **8 Hrs**

Industrial manufacturing processes, additives, formulations, compounding, processing, properties and applications of polyphenyleneoxide, polyphenylenesulfide, polysulphone, polyetherketone and polyetheretherketone.

Unit VI: **8 Hrs**

Recent trends in polymer science: Manufacturing and applications of - Polymer membranes science and technology, Biomedical engineering, polymers in drug delivery, Conducting polymers, Nano-composites, Liquid crystalline polymers, Biodegradable polymers,

Assignments: *A few assignments based on the selected commodity, engineering and high performance polymers should be given to the students so as to cover the above important aspects of polymer materials.*

References Books:

1. Plastics Materials, **J. Brydson**, Heinemen / Elsevier, [7th edition], 2005
2. Handbook of Thermoset Plastics, **S.H. Goodman** [ED] Noyes Publisher, [2nd edition], 1986.
3. Organic Polymer Chemistry, **K. J. Saunders,** Chapman & Hall, 1988.
4. Encyclopedia of Chemical Technology, Volume 17, **Kirk & Othmer**, John Wiley & Sons, [4th edition], 1996.

309370 Polymer Rheology and Processing

Teaching Scheme:	**Examination Scheme:**
Lectures: 4 Hours / Week	In Semester: 30
Practical: 2 Hours / Week	End Semester: 70
	TW: 25
	Total: 125

Objective:
The subject prepares the student for understanding of various polymer processing operations from rheological and processing equipment point of view. The subject deals with basic processes like extrusion, injection, compression molding, transfer molding, various specialized injection molding processes, rheology and melt flow analysis. The students will be able to understand polymer melt flow behavior and to bring out co-relation between polymer rheology and polymer processing

Unit I: 8 Hrs

Polymer rheology and viscoelasticity, Relationship between polymer rheology and polymer processing, types of fluids, fluid elasticity of polymeric liquids, shear thinning behavior. Fundamental principles of polymer rheology: flow fields, tensors, stress and material functions, basic equations of fluid mechanics. Continuum theories for the viscoelasticity of flexible homogeneous polymer liquids: different types of constitutive equations for viscoelastic fluids.

Unit II: 8 Hrs

Molecular theories for the viscoelasticity of flexible homogeneous polymeric liquids, static properties of macromolecules and stochastic processes in the motion of polymeric chains, molecular theory for viscoelasticity of dilute polymer solutions, molecular theory for viscoelasticity of concentrated polymer solutions and entangled polymer melts. Stress relaxation and modulus, mechanical models, glass-transition and theories of glass transition.

Unit III: 8 Hrs

Melt flow analysis, experimental methods for measurement of rheological properties of polymeric fluids, cone and plate rheometry, capillary and slit rheometry, elongational rheometry. Rheological behavior of polymeric materials: Rheology of flexible homopolymers, rheology of miscible and miscible polymer blends, rheology of composite materials. *Problems based on above three units.*

Unit IV: 8 Hrs

Extrusion process: Fundamentals, analysis of flow through extruder, drag flow, pressure flow, solids conveying, melting mechanism, power consumption in metering zone, output and power requirements in a single screw extruder, extruder design, extruder drives: screw design, construction and operation. Extrusion process and plants for various profiles, dies, downstream equipment and auxiliary units for extrusion lines, processing parameters and product quality, quality control and trouble shooting.

Unit V: 8 Hrs

Injection molding process, stages involved PVT diagram and injection molding, cycle processing parameters and their effect on product quality, close loop and open loop machines, trouble shooting in injection molding, Specialized molding processes**:** Gas assisted, two color pattern making, two color-two component molding machine and process, injection molding of thermosets, DMC, elastomers, low pressure injection molding, injection–compression molding, RIM. Co-extrusion of sheet and films, profiles, tubing and other products, extrusion of cellular / foamed plastic products, equipment for foamed product, process control, specialized products and processes.

Unit VI 8 Hrs

Compression molding: Basic principle and molding cycle, effect of bulk factors on molding cycle, defects & remedies, molding of thermoplastics, thermosets, DMC and SMC, analysis of compression molding; flow rate, compaction force for molding.
Transfer molding: Basic principle and molding cycle, types, process parameters and their effect on product quality, defects & remedies, transfer molding of thermosets and DMC, clamping tonnage calculations,

Practical – TW
List of experiments (Rheology) [Minimum 04]

1. To study different types of fluids with examples.
2. To find M.F.I of different polymers using melt flow indexer.
3. Study of cone and plate viscometer.
4. Study of torque rheometer.
5. Study of Brook field's viscometer.
6. Study of oscillating disc viscometers for rheological characterization of elastomers.

List of experiments (Processing) [Minimum 04]

1. Study and working of compression and transfer molding of PF.
2. Study of transfer molding technique.
3. Study and working of blown film plant.
4. To study the effect on film properties by varying haul – off speed, temperature, blow ratio, screw speed, cooling etc.
5. Study of Gas-Assisted injection molding.
6. To plot screw and die characteristics and to study the effect of variation of process parameters on screw & die characteristics.
7. Study of dip coating and slush molding.
8. Study of injection molding of thermosets
9. Study of injection molding of DMC.
10. Study of compression and transfer molding of DMC.
11. Study of injection molding of thermoplastics.
12. Study of vented screw barrel systems.
13. Study of grooved barrel systems

Reference Books:

1. Fundamentals of Polymer Processing, **Stanley Middleman,** McGraw-Hill, 1977.
2. Plastics Extrusion Technology Handbook, **James F. Carley,** Industrial Press Inc. 1989.
3. Plastics Engineering, **J. Crawford,**. Butterworth –Heinemann, [3rd edition], 2006
4. Polymer Extrusion, **Chris Rauwendaul,** Hanser Publication, Munich, 1987.
5. Polymer Processing, **Mcklevy J**., John Wiley, New York, 1962.
6. Applied Rheology in Polymer Processing, **B.R. Gupta**, Asian Book Pvt. Ltd, [1st edition] 2005.
7. Rheology and Processing of Polymeric Materials: Volume 1: Polymer Rheology, Chang Dae Han, Oxford University Press.
8. Plastic Engineering Handbook of the society of the Plastics Industry, **Fredos J.** Van Nostrand Reinhold, N.Y. [4th edition].
9. Extrusion of Plastics, **Fisher,** Newnes - Butterworth, [3rd edition], 1976.
10. Engineering Principles of Plasticizing Extrusion, **Tadmor, Klein**, Krieger Publishing Company, 1978
11. Polymer Science & Technology **Premamony Ghosh,** Tata McGraw Hill Publication, [2nd edition,].1990.
12. Polymer Melt Rheology, **F.N. Cogswell,** John Wiley and Sons, 1981, [1st edition].
13. Melt Rheology and its Role in Plastic Processing Theory and Applications, **Kurt F. Wissburn, Van Nostrand, Reinhold, John M. Dealy,** Chapman & Hall,1995.
14. Introduction to Polymer Viscoelasticity & Rheology, John .J**.** Aklonis, [2nd edition].
15. Principles of Polymer Processing, **John Wiley N.Y**. Tadmor Z. Gogos C.G.,A Wiley – Interscience Publication,1979
16. Injection Moulding Handbook, **Rosato and Rosato,** CBS Publishers & Distributors, 1987 [1st edition].
17. Injection Moulding Theory & Practice, **Irvin I. Rubin,** John Wiley .
18. Injection Moulding Materials, **E. Whelan,** Applied Science Publishers,1982
19. Polymer Mixing Technology, **George Matthews,** Applied Science Publishers, London,1982
20. Thermosetting Plastics Practical Moulding Technology, **J.F. Monk** George Godwin Ltd, 1981.
21. Blow Moulding Handbook, **Ronald Rosato & Dominick Rosato**, Hanser Publication, 1989.
22. Fundamentals of Polymer Processing**, Stanley Middleman,** McGraw Hill Education, 1977**.**
23. Plastics Engineering, **J. Crawford,** Butterworth –Heinemann, [3rd edition], 2006
24. Design Formulas for Plastic Engineers, **Natti. S. Rao**, Hanser Publishers, 1999.

309364 Design of Equipment and Machine Elements

Teaching Scheme:
Lectures: 4 Hours / Week
Drawing: 2 Hours / Week

Examination Scheme:
In Semester: 30
End Semester: 70
Oral: 50
Total: 150

Objective

To impart practical and theoretical knowledge of machine and process equipment design so as to enable students to understand machines used in the polymer industry.

Unit I: 8 Hrs

Fundamentals of Design: Methodology, steps in design, Mohr Circle, selection of materials and material standards, BIS standard, theories of failures for biaxial stress system, factor of safety, stress concentration. Types of keys, design of key. Couplings and their types, design of muff coupling, compression coupling, flange coupling, flexible coupling.

Unit II: 8 Hrs

Design of shafts subjected to twisting moment, bending moment, combined twisting & bending moment, fluctuating loads, torsional rigidity. Flat belt, material, types of flat belt drive, slip of belt, creep of belt, length of open belt drive, length of cross belt drive, power transmitted by a belt, ratio of driving tensions for flat belt drive, centrifugal tension maximum tension in a belt, initial tension in belt.

Unit III: 8 Hrs

Classification of bearings, design of bush and journal bearings, types and design of thrust bearing. Types of gears, cone and pulley arrangement, sliding gear arrangement, sliding key mechanism, Norton gear box, clutched systems, common ratio and number of spindle speed steps.

Unit IV: 8 Hrs

Pumps and Valves: Positive displacement pumps used in processing machines, like vane, gear, axial etc. Directional control valves, flow control valves, Pressure control valves, relief valves etc.

Unit V: 8 Hrs

Introduction to digital and proportional hydraulics, Hydraulic Drives: Drives for clamping mechanism in injection molding machine – toggle type, conventional hydraulic, hydro mechanical and electric.

Unit VI: **8 Hrs**

Design of pressure vessels: design of shell, head, flanges, nozzles, design of reaction vessel [kettles], jackets and coils for heating and cooling.

Drawing –OR

List of Drawings:

Three assignments based on the following topics.

(I) Reaction vessel design.

(II) Study of basic hydraulic circuits.

1. Unloading circuit.
2. Regenerative circuit.
3. Sequencing circuit.
4. Counter balance circuit.
5. Breaking circuit.
6. Feed circuit
   a. Meter in-flow control
   b. Meter out-flow control
   c. Bleed off-flow control
7. Rapid advance to feed circuits
   a. Using meter-out circuit.
   b. Using meter-in circuit.
8. Open circuit for reversible hydrostatic drive.
9. Reversible closed circuit.

(III) Basic conventional hydraulic circuits in injection molding machine:
1. Clamping 2. Plasticizing 3. Injection

Oral Exam:

Evaluation should be done based on the performance and understanding of the student of above drawings and relevant theoretical knowledge acquired by the student.

Reference Books:

1. Fundamentals of Machine Component Design, **Robert C. Juvinall,** Kurt M. Marshek, August 2005.
2. Injection Molding, Theory and Practice, **Irvin Rubin,** John Wiley & Sons Publication, New York, 1972.
3. Process Equipment Design, **M.V.Joshi,** Macmillan Publication, 1984.
4. Elements of Machine Design, **Pandya & Shah**, Charoter Book Stall, 2006.
5. A text book of Machine Design, **R.S. Kurmi and J.K. Gupta**, S Chand Publication, 2009.
6. Industrial Hydraulics Manual, **Vickers**, 2004. [3rd edition].
7. Design of Machine Elements, **V.B. Bhandari**, Tata McGraw Hill Publication co. ltd., New Delhi.
8. Machine Tool Engineering, **G.R. Nagpal,** Khnna Publication, 2004.
9. Process Equipment Design, **B.C. Bhattacharya,** CBS Publication.

309368: Instrumentation and Process Control

Teaching Scheme:
Lectures: 4 Hours / Week
Practical: 2 Hours / Week

Examination Scheme:
In Semester: 30
End Semester: 70
TW: 25
Total: 125

Objective

Sensor network and computerized control system have become indispensable part of process industry. This course intends to impart basis understanding of instrumentation systems used in polymer industry and different control strategies needed to optimize process plants.

Unit 1: Measurement Fundamentals 8 Hrs

Introduction to process instrumentation, Functional elements of instruments, static and dynamic characteristics of measuring instruments, transducer elements (types and classification). Intermediate elements (Instrument amplifiers, compensators, differential and integrator elements), signal conditioners (signal generation and processing), filtering and signal analysis, data acquisition and conversion (ADC, DAC), digital signal transmission and processing (serial communication, telemetry), Indicating and recording elements, input-output (I/O) devices and displays, calibration of instruments.

Unit 2: Temperature, Pressure, and Strain Measuring Instruments 8 Hrs

Temperature measurement: Temperature measuring instruments: Introduction, classification, temperature scales (units), mechanical temperature sensors (filled- system thermometers, expansion thermometers), electrical temperature sensors (RTD, thermistors, thermocouples), radiation sensors (optical and radiation), solid-state sensors, quartz sensors, calibration of thermometers (comparison and fixed point methods). Pressure measuring instruments: Introduction, classification, low, medium, and high pressure measuring instruments, pressure scales (units), manometers, elastic element pressure gauges (using bourdon tube, diaphragms, capsule, and bellows), transduction/ electrical sensors (based on variable capacitance, resistance, and inductance/reluctance-LVDT), force- balance transducers, solid-state devices, thin-film transducers, digital transducers, piezoelectric transducers, vibrating element sensors, pressure multiplexer, calibration of pressure sensors using dead- weight tester.
Strain measuring instruments: Mechanical, optical, and electrical strain gauges.

Unit 3: Level, Flow, Density, and Viscosity Measuring Instruments 8 Hrs

Level measuring instruments: Introduction, classification, direct methods (point contact methods, sight or gauge glass methods, buoyancy methods using floats and displacers), indirect methods (hydrostatic pressure methods, capacitance methods, radiation methods, ultrasonic methods, weighing method, sonic methods), solid level measurement.
Flow measuring instruments: Introduction, classification (rate of flow and total flow meters), pressure head- type flow meters (orifice plate, venturi tube, flow nozzle, pitot tube), variable-area flow meters (rotameters), electromagnetic, mechanical (positive displacement and turbine- type), anemometer, ultrasonic- type, vortex- flow type, thermal- type, laser anemometers ,mass flow meters.

Viscosity Measurements of polymer solutions and polymer melt, and density measurements systems.

Unit 4: Dynamic behavior of processes (Process Dynamics) 8 Hrs

Introduction to process dynamics (P.D.), mathematical tools for process control (Laplace transform, complex numbers), ideal forcing functions (step, ramp, pulse, impulse, sinusoidal), transfer function and state-space models, poles and zeros of transfer function and their effect on dynamic response, studying dynamic behavior of linear time invariant (LTI) systems (pure gain, pure capacitive, first- order, second-order systems, dead- time systems), dynamic behavior of inverse response systems.

Unit 5: Feedback Control Systems 8 Hrs

Classification of process variables (controlled variable (CV), manipulated variables (MV), disturbance or load variables (DV), block diagram of feedback control system, derivation of closed- loop transfer function for servo and regulator operations, classical feedback controllers -ON-OFF, P, PI, PD, PID (control equation/ law/ algorithm, tuning parameters, open-loop response characteristics along with effect of tuning parameters), simple control performance measures (rise time, overshoot, decay ratio, offset), closed loop response characteristics of first- and second- order processes with classical controllers, Stability Analysis.

Unit 6: Control of Polymer Processing Systems 8 Hrs

Introduction to polymer processes (injection molding, blow molding, melt spinning, batch polymerization), Control of continuous and batch polymerization processes.
Advanced Process Control Systems: Introduction to Advanced process control systems, Feed forward, cascade, ratio control with different applications, Introduction to digital control systems, Programmable Logic Control (PLC), Supervisory control and data acquisition systems (SCADA). Distributed control systems (DCS).

Tutorials:
Minimum 3 tutorials to be conducted based on any of the following points:

- Explain a basic measurement system.
- Describe the various types of signals and their conversion.
- Explain the principles of a selection of signal processors and conditioners.
- Explain in some details the principles Analogue/Digital processing.
- Explain the principles of a range of signal receivers.
- Basics of Laplace Transform.
- Use of Partial fractions to solve responses.
- Derive the mathematical models for basic systems.
- Explain and define the standards input forcing functions.
- Explain and define the standards models and transfer functions for First and second order system.
- Explain and calculate the response of Standard First and Second Order system.
- Explain the link between Open and Closed loop Control System.
- Explain different Control Mode actions and Control Tuning.
- Explain the analysis of Stability.
- Explain Advance Process Control importance in Polymer Field.

Reference books:

1. Instrument Engineers' Handbook (Process Measurement)- Bella G. Liptak, Elsevier
2. Instrument Engineers' Handbook (Process Control)- Bella G. Liptak, Elsevier
3. Instrumentation devices and systems- Rangan, Sharma, Mani, Tata McGraw Hill Publishing Co. Ltd.
4. Process Control- Bequette, PHI publications
5. Chemical process control- Stephanopoulos, PHI publications.
6. "Process Instrumentation and Control" A. P. Kulkarni, Nirali Publications
7. Process Dynamics and Control- Seborg, Edgar, Mellichamp- John Wiley and sons Inc. Industrial instrumentation, Eckman D.P. Wiley Eastern, [16th edition],1991.
8. Process systems analysis and control, Coughanowr Donald R., McGraw Hill, [2nd edition], 1991.
9. Chemical process control: An introduction to theory and practice, Stephnopoulos George, Prentice – Hall India, 2002.
10. Process control: Designing processes and control systems for dynamic performance, Marlin T., McGraw – Hill, [2nd edition] 2004.
11. Principles of industrial instrumentation, Patranabis D., Tata McGraw Hill, New Delhi, [2nd edition], 2004.
12. Instrumentation measurement and analysis, Nakra, B.C., Choudhary K.K., Tata McGraw Hill, New Delhi, [2nd edition], 2004.
13. Process control instrumentation technology, Johnson C.D., Pearson Prentice–Hall International, [4th edition], 1996.
14. Process / industrial instruments and control handbook, Considine D.M., McGraw – Hill, [1st edition] , 2006
15. Process analyzer technology, Clevett J.G., Wiley, New York 1986.
16. Industrial Control and instrumentation, Bolton W., University Press, [1st edition], 1991.
17. Handbook of Plastics Test Method, Handbook of Plastic Testing Technology, R.P. Brown, A. Wiley - Inter science Publication, 1981.

309371: Seminar and Technical Communication

Teaching Scheme:
*Practical : 2 Hours / Week

Examination Scheme:
OR: 50
Total: 50

The students (as individual activity) should choose seminar topic from the broad area of Polymer Science and Engineering. The topic should be of current commercial or research interest and should preferably be the advanced area of application. The topic should be relevant to the curriculum.

It is expected that the student should collect the information from journals, internet and reference books in consultation with his/her teacher / mentor, have rounds of discussion with him/her. The report submitted should reveal the students assimilation of the collected information. Mere compilation of information from the internet and any other resources is discouraged.

Format of the Seminar report should be as follows:

1. The report should Seminar should be based on an in depth study of any topic related to Polymer Engineering and Science. Be neatly typed on one side on A-4 size white paper. The typing shall be with normal spacing (1 or 1.5) and margins (1 in. from all sides) of the paper.
2. The report should be submitted with front and back cover of card paper neatly cut and bound or spirally together with the text.
3. Front cover: This shall have the following details.
    a. Title of the seminar report.
    b. The name of the candidate with roll number examination seat number at the middle.
    c. Name of the guide below the candidate’s details.
    d. The name of the institute and year of submission on separate lines at the bottom.
4. Seminar approval sheet.
5. The format of the text of the seminar reports:

    The report shall be presented in the form of a technical paper. The introduction should be followed by literature survey. The report of analytical or experimental work done, if any, should then follow.

    The discussion and conclusions shall form the last part of the text. They should be followed by nomenclature and symbols used followed by acknowledgement. The bibliography should be at the end. References should be written in the standard format. The total number of typed pages, excluding cover shall be about 25 to 30 only. All the pages should be numbered. This includes figures and diagrams.

    Two copies of the seminar report shall be submitted to the college. The candidate shall present the seminar before the examiners. The total duration of presentation and after-discussion should be about 30 minutes. [25 min + 5 min]. Audience can ask questions only if the examiner permits. Such questions will not have any bearing on marks].

The assessment for the subject shall be based on

1. Report submitted.
2. Presentation.
3. Discussion.

To be conducted in a single batch.

309367: Industrial Visit

Teaching Scheme:

Examination Scheme:
TW: 25
Total: 25

It is **mandatory** that the students along with a mentor/teacher visit a large scale Polymer Industry (manufacturing, processing, equipment industry etc.) minimum once during **every semester** (i. e. minimum two visits during an academic year).

The students are required to submit industrial visit report in spiral bound form and soft copy within 15 days of visit to the department.

The students will be evaluated based on the report submitted, knowledge acquired during the industrial visit at the end of the semester under the head TW for 25 marks.

(Note: As the industrial visit is mandatory the term is not to be granted if any student fails to attend industrial visit.)

309354 : INDUSTRIAL TRAINING

Teaching Scheme:	Examination Scheme:
3-4 Weeks of training in industry.	To be evaluated in seventh semester

The students are required to undergo exhaustive Industrial Training of minimum three to four weeks immediately after the completion of sixth semester and before the commencement of seventh semester in an industry of repute in the field of polymer engineering. The relevant industry is to be finalized in consultation with the head of concerned department before the end of sixth semester.

During the training period the students are expected to undergo rigorous exposure of the industry, its working style, various departments and their working, hands on experience on the various equipments available with the industry. Student should maintain a log book mentioning day to day activity he / she has carried out during the training period.

Students are required to submit neatly typed and bound training report after joining the college. The report should include information about working of the industry as also specific information of the work done by the student in the industry. The students are also required to attach the Original Certificate issued by the competent authority from the industry where he / she has undergone training mentioning the successful completion of the training.

The industrial report is to be submitted within first 15 days of commencement of the seventh term in bound format and soft copy. The department will conduct industrial report presentation session for every student under the head ‘Term work’ under Industrial Training evaluation by the external examiner. Evaluation of Industrial training by students will carried out after Semester VI based on -

i) Knowledge acquired by him during the industrial training
ii) His/her performance in presentation
iii) Report
iv) Discussions