SAVITRIBAI PHULE PUNE UNIVERSITY, PUNE-411 007

STRUCTURE AND SYLLABUS OF

TE (Polymer Engineering)-2015 Course

(With effective from Academic Year 2017-2018)

T.E. (Polymer Engineering)-2015 Course
(w.e.f. Academic Year 2017-18)

SEMESTER-I											
Subject Code	Subject	Teaching Scheme Hrs./Week			Examination Scheme					Total Marks	Credits
		L	PR/DRG	T	In-Semester Assessment	TW	OR	PR	End Semester Exam		
309361	Numerical and Statistical Methods for Polymer Engineering	4	2	-	30	25	--	--	70	125	4
309362	Polymer Chemistry – I	3	4	--	30	--	50	--	70	150	5
309363	Polymer Materials	3	2	--	30	--	--	50	70	150	4
309364	Polymer Structure Property Relationship	4	2	--	30	--	50	--	70	150	5
309365	Mass Transfer and Reaction Engineering	3	--	1	30	25	--	--	70	125	4
309366	Employable Skill Development	--	2	--	--	50		--	--	50	1
309367	**Audit Course 3**	--	--	--	--	--	--	--	--	--	--
	Total →(30 Hrs.)	**17**	**12**	**1**	**150**	**100**	**100**	**50**	**350**	**750**	**23**

SEMESTER-II											
Subject Code	Subject	Teaching Scheme Hrs./Week			Examination Scheme					Total Marks	Credits
		L	PR/DRG	T	In-Semester Assessment	TW	OR	PR	End Semester Exam		
309368	Polymer Chemistry-II	4	2	--	30	--	--	50	70	150	4
309369	Polymer Processing Operations-I	4	2	--	30	--	50		70	150	4
309370	Polymer Rheology	3	2	1	30	--	50	--	70	150	5
309371	Design of Equipment and Machinery	3	2	--	30	25	--	--	70	125	4
309372	Process Instrumentation and Control	3	2	--	30	25	--	--	70	125	4
309373	Seminar	--	2	--	--	50	--	--	--	50	2
	Industrial Training after second term** (To be evaluated in Seventh Semester)	--	--	--	--	--	--	--	--	--	--
309374	**Audit Course 4**	--	--	--	--	--	--	--	--	--	--
	Total →(30 Hrs.)	**17**	**12**	**1**	**150**	**100**	**100**	**50**	**350**	**750**	**23**

IMPORTANT NOTES

1. **Abbreviations**

   L: Lecture, P: Practical, DRG: Drawing, T: Tutorial

   TW: Term work, PR: Practical, OR: Oral

2. ****** The students are required to undergo industrial training of *minimum 3 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.
3. In-Semester Theory examination will be conducted approximately one and half month after the commencement of each semester.
4. In-Semester Theory examination will be based on first three units from Syllabus and will be conducted by the Savitribai Phule Pune University.
5. Total time allotted for In-Semester Theory examination will be 1 hr.
6. Total time allotted for End- Semester Theory examination will be 2 hrs. 30 min.
7. **Audit Courses 3 and 4:**

- In addition to credits courses, it is recommended that there should be audit course (non-credit course). Audit course is for the purpose of self-enrichment and academic exploration. Audit course carry no academic credit.
- Selection of audit courses helps the learner to explore the subject of interest in greater details resulting in achieving objective of audit course's inclusion.
- Audit course 3 and 4 will be conducted in the first and second semester respectively.
- This is inclusive of submission of assignments based on sessions conducted by the industry professionals by way of workshop, guest sessions, internship report, mini project, industry visit report, Hands on experience on specific focused topic, IIT Mooc/EDX/NPTEL etc.
- Evaluation of audit course will be done at institute level. Method of conduction and method of assessment for audit courses is suggested.
- This should be submitted at the end of the term and successful submission should be given PP in the mark sheet and NP if not submitted or incomplete submission.
- The performance in these courses is not accounted in the calculation of the performance indices SGPA and CGPA.
- The audit course should cover twenty working hours in the term and submission should be in the form of a report submitted towards the end of term. Details are given in appropriate sections.

SEMESTER - I

T.E. (Polymer Engineering) - 2015 Course
Course Code: 309361
Course Name: Numerical and Statistical Methods for Polymer Engineering
Credits: 4

Code	Subject	Teaching Scheme (Weekly Load in hrs.)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
309361	Numerical and Statistical Methods for Polymer Engineering	4	-	2	30	70	25	--	--	**125**

PREREQUISITES

Basic courses in Mathematics and Strength of Materials

COURSE OBJECTIVES

1. Understanding of numerical methods to obtain approximate solutions for various engineering problems.
2. To work with mathematical models of polymer engineering.
3. Write an efficient code for solving numerical problems.

COURSE OUTCOMES

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

1. use various approximation techniques for solving mathematical problem.
2. transform the problem to system of equations and able to solve for unknown variables.
3. solve ODE and PDE using finite difference techniques.
4. apply the optimization technique for solving engineering problems.
5. interpret real-world problems into probability models.
6. solve mathematical problems involving tensors.

COURSE CONTENTS

Unit I: Numerical Methods (L 08)

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

Unit II: Solutions of Equations (L 08)

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 (L 08)

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.

Unit IV: Optimization Techniques (L 08)

Formulation of Linear Programming Problem, Graphical procedure, Slack and Surplus variables, Simplex method computation, Big–M method, Duality.

Unit V: Statistics and Probability (L 08)

Mean and standard deviation, Coefficient of variation, Moments, Skewness and Kurtosis, Correlation and Regression, Probability, Probability Distributions, Binomial, Poisson and Normal distribution, Chi-square distribution, random sampling, estimation of parameters, testing of hypothesis: t-distribution, F-Test.

Unit VI: Tensors (L 08)

General Curvilinear co-ordinate systems, Contravarient, Covariant and Mixed tensors, Metric tensor, Christoffel symbols, Covariant derivative, Divergence, Laplacian and Curl, Applications of tensors.

Books:

1. Kreyszig E., Advanced Engineering Mathematics, 9th edition, Wiley, 2006.
2. Jain M. K., Iyengar S. R. K. and Jain R. K., Numerical methods for scientific and Engineering Computation, New Age International Publishers, 6th edition, 2012.
3. Gerald Curtis F. and Wheatley Patrick O., Applied Numerical Analysis, Pearson, 7th edition, 2004.

4. Gupta S. K., Numerical methods for Engineers, New age International Publishers, 2nd edition, 1995.
5. Aris R., Vectors, tensors and the basic equations of fluid mechanics, Dover Books, 1990.
6. Johnson Richard Arnold, Miller Irwin and Freund John E., Probability and Statistics for Engineers, Prentice Hall, 8th edition, 2011.

Suggested List of Laboratory Assignments/Experiments: (Any 8 from the following list)

Solve Pre-formulated Mathematical Models for Polymer Engineering Operations using C, C++ or Mathematical Software Packages.

1. Interpolation by using Newton's forward difference formula.
2. Evaluate the integration by using Simpson's and Trapezoidal rule.
3. Determine the solution of equation by using method of bisection.
4. Solve algebraic equations by using Newton-Raphson method.
5. Determine the solution for system of equations by Gauss Seidel method.
6. To fit a straight line $y = mx + C$ by using method of least squares.
7. Solve the differential equation of 1st order by using Runge-Kutta of fourth order method.
8. Solve the ordinary differential equations by using finite difference method.
9. Solve the algebraic equation by using method of successive approximation
10. To find functional value for f(x) at some given point using Lagrange's Interpolation.
11. Write a finite element code for analyzing one dimensional bar.
12. Compute the coefficient of variation.

Term Work:

The evaluation of students should be based on submitted certified journal and performance in the laboratory sessions.

T.E. (Polymer Engineering) - 2015 Course
Course Code: 309362
Course Name: Polymer Chemistry-I
Credits: 5

Code	Subject	Teaching Scheme (Weekly Load in hrs.)			Examination Scheme (Marks)					
					Theory		TW	PR	OR	Total
		Lect.	Tut.	Pract.	In Sem.	End Sem.				
309362	Polymer Chemistry-I	3	-	4	30	70	-	--	50	150

PREREQUISITES

Courses in Engineering Chemistry

COURSE OBJECTIVES

1. To provide basic building blocks of polymer science by imparting fundamental knowledge.
2. To provide in-depth knowledge of molecular weight, polymerization mechanism, polymer reactions.
3. To create environmental awareness and concern.

COURSE OUTCOMES

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

1. apply the fundamentals for polymer synthesis and manufacture
2. demonstrate understanding of polymer synthesis mechanisms and various reactions
3. demonstrate understanding of polymer degradation mechanisms
4. develop sensitivity towards environment in terms of plastics waste management and recycling

COURSE CONTENTS

Unit I: Fundamentals of Polymer Science and Molecular Weight (L 06)

Brief revision ofbasic concepts related to Polymer Science. Polymerization techniques - Interfacial polymerization, Melt polycondensation, Gas phase polymerization, Plasma polymerization.Various methods of determination of molecular weight and molecular weight distribution such as Ebulliometry, Cryoscopy, Osmometry, Viscometry, Gel permeation chromatography, Ultracentrifugation, Light-scattering, Chemical methods, Fractionation methods, etc.

Unit II:Chain Polymerization (L 06)

Free radical chain polymerization - Polymerizability of monomers. Types of initiators used in radical chain polymerization. Chain transfer reactions, inhibition, retardation; Ceiling temperature; Kinetics of polymerization reaction.Ionic chain polymerization - Cationic and anionic polymerization.Types of initiators.Kinetics of cationic and anionic polymerization reactions.

Unit III:Step Polymerization (L 06)

Introduction, Reactivity of functional groups, equivalence and nonequivalence of functional groups. Need for stoichiometric control. Gelation, Crosslinking, Carother's equation.Kinetics of step polymerization. Crosslinking technology, polyesters, unsaturated polyesters and alkyds.Ring-opening polymerization.

Unit IV:Copolymerization (L 06)

Chain copolymerization - Introduction, Types, Copolymerization equation, Monomer reactivity ratio, Applicability of copolymerization equation, Types of copolymerization behavior, Q-e scheme. Step copolymerization - Introduction, Types, Methods of synthesis. Commercial applications of copolymerization.

Unit V:Polymer Reactions (L 06)

An overview of various polymer modification reactions such as Hydrolysis, Acidolysis, Aminolysis, Hydrogenation, Addition and Substitution.Specific group reactions like Hydroxyl, Aldehyde, Ketone, Carboxyl, Amino groups, etc.Cyclization reactions, Cross-linking reactions, Vulcanization, Cure reactions.

Unit VI: Polymer Degradation and Waste Management (L 06)

Introduction to polymer degradation, Types of degradation, Study of factors or agents causing degradation such as Thermal degradation, Mechanical degradation, Degradation by Ultrasonic Waves, Photo-degradation, Degradation by High Energy Radiations, Oxidative degradation andAntioxidants, Hydrolytic degradation, Biodegradation, Recycling, Incineration, Pyrolysis.Plastic waste management.

Books:

1. Stevens M.P.,Polymer Chemistry - An Introduction, 2nd edition, Oxford University Press, 1999.
2. Odian G.,Principles of Polymerization, 4thedition ,Wiley India

3. Gowariker V.R., Viswanathan N.V. and Sreedhar Jayadev, Polymer Science, 1st edition, New Age International Publishers Pvt. Ltd., New Delhi, 2008
4. Mustafa Nabil, Plastics Waste Management: Disposal, Recycling and Reuse, Marcel Dekker Inc., New York, 1993.
5. Fried Joel R., Polymer Science and Technology, 2nd edition, PHI Publications Pvt. Ltd., New Delhi
6. Albertsson A. and Huang S.J.,Degradable polymers, recycling and plastics waste management, Marcel Dekker, Inc., 1995.

Suggested List of Laboratory experiments (Any 08 experiments from the following list):

1. Study of various laboratory practices like material handling, handling of laboratory equipments, basic laboratory techniques, etc.
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 un-catalyzed polyesterification reactions.
7. Casting of PMMA sheets.
8. Synthesis of styrene-maleic anhydride copolymer.
9. Synthesis of epoxy resin.
10. To synthesize UF / MF resin for adhesive application.

Oral Examination:

Evaluation of student should be based on the performance of student during examination along with understanding of the experiments and theoretical knowledge acquired during laboratory sessions.

T.E. (Polymer Engineering) - 2015 Course
Course Code: 309363
Course Name: Polymer Materials
Credits: 4

Code	Subject	Teaching Scheme (Weekly Load in hrs.)			Examination Scheme (Marks)					
					Theory		TW	PR	OR	Total
		Lect.	Tut.	Pract.	In Sem.	End Sem.				
309363	Polymer Materials	3	-	2	30	70	-	50	-	150

PREREQUISITES

Applied Science, Courses in Engineering Chemistry, Engineering Materials and Solid Mechanics.

COURSE OBJECTIVES

1. To impart the knowledge pertaining to various commercial polymeric materials to enable students to choose appropriate materials for new and demanding applications.
2. To make the student aware of material selection, material data correlation with application, factors affecting material choice, properties, applications and substituting new material.
3. To impart the knowledge pertaining to fundamentals of rubbers and surface coatings

COURSE OUTCOMES*:*

After completing the course the students will be able to demonstrate

1. understanding of various aspects related to industrial manufacturing techniques, basic polymer properties, processing and their applications.
2. the ability to select appropriate materials for new and demanding applications.
3. understanding the role of various additives in formulation of rubber and plastics.

COURSE CONTENTS

Unit- I : Polymers containing Carbon and Hydrogen (L 06)

Industrial manufacturing processes, properties, additives, compounding, processing and applications of - Polyethylene (Low density polyethylene, High density polyethylene, Linear Low density polyethylene, Ultra high molecular weight high density polyethylene, Ethylene vinyl acetate, cross-linkedpolyethylene, chlorinated polyethylene, etc.); Polypropylene and its copolymers; Styrenics.

Unit – II: Polymers containing Carbon, Hydrogen and Oxygen (L 06)

Industrial manufacturing processes, properties, additives, compounding, processing and applications of - Acrylics; Polyacetals; Polyvinyl alcohol and Polyvinyl acetate; Polycarbonate.

Unit – III :Polymers containing Carbon, Hydrogen and Oxygen (L 06)

Industrial manufacturing processes, properties, additives, compounding, processing and applications of - Polyethylene terepthalate, Polybutyleneterepthalate, Copolyesters; Cellulosics.

Unit – IV :Polymers containing Carbon and/or Hydrogen,Halogens, Sulphur (L 06)

Industrial manufacturing processes, properties, additives, compounding, processing and applications of - Polyvinylchloride, Polyvinylidene chloride; Polytetrafluoroethylene, Polyvinylidene fluoride, Polychlorotrifluoroethylene; Polyphenylene sulphide, Polysulphones.

Unit – V :Polymers containing Carbon, Hydrogen and/or Nitrogen, Oxygen (L 06)

Industrial manufacturing processes, properties, additives, compounding, processing and applications of – Polyamides; Polyimides; Polyacrylonitrile; styrenics (ABS, SAN)

Unit – VI: Fundamentals of Elastomers and Surface Coatings (L06)

Fundamentals of rubbers – Molecular requirements for a material to function as elastomers,Brief introduction to various elastomeric materials, Theory of rubber elasticity.Outline of raw rubber technology – Concepts of mastication, compounding, vulcanization in brief.Adhesives - Terminologies used, Guidelines for good adhesion, Theories of adhesion, Types of adhesives.Paints – Fundamentals, Terminologies used, Various ingredients used in formulation of paints.

Books:

1. Brydson J., Plastics Materials, 7th Edition, Elsevier, 2005
2. Kirk and Othmer, Encyclopedia of Chemical Technology, Volume 17, 4thedition, John Wiley and Sons, 1996
3. Mayo S.W., Manufacture of Plastics, Reinhold Publishing Corporation, Chapman & Hall Ltd., London, 1964
4. Blow C.M., Rubber Technology and Manufacture , 2nd edition, Butterworth-Heinmann, 1982
5. Mark H.F., Bikales N.M., Overberger C.G.and Menges G., Encyclopedia of Polymer Science and Engineering,John Wiley and Sons, Chichester, 1985

Suggested List of Laboratory experiments (Any 08 experiments from the following list):

1. Identification of Polymers containing C&H
2. Identification of Polymers containing C, H&O
3. Identification of Polymers containing C,H,N&O
4. Identification of Polymers containing C,H & Halogens
5. Identification of Elastomer
6. Determination of curing time of resins
7. Determination of filler content
8. Determination of density & melting point
9. Determination of K-value of PVC
10. Determination of percentage purity of plasticizer
11. Determination of vinyl acetate content in EVA

Practical Examination:

Evaluation of student should be based on the performance of student during examination along with understanding of the experiments and theoretical knowledge acquired during laboratory sessions.

T.E. (Polymer Engineering) - 2015 Course
Course Code: 309364
Course Name: Polymer Structure Property Relationship
Credits: 5

Code	Subject	Teaching Scheme (Weekly Load in hrs.)			Examination Scheme (Marks)					
					Theory		TW	PR	OR	Total
		Lect.	Tut.	Pract.	In Sem.	End Sem.				
309364	Polymer Structure Property Relationship	4	-	2	30	70	-	--	50	**150**

PREREQUISITES

Courses in Applied Sciences and Engineering Chemistry, Engineering Material and Solid Mechanics

COURSE OBJECTIVES

1. To understand the effect of submolecular level chemical structure (types of elements and bonds present in polymer chain) on polymer properties
2. To understand the effect of molecular level chemical (intermolecular bonds) and physical structure (size, shape, chain flexibility, morphology) on polymer properties.
3. To understand correlation between structure and properties, thereby, requirements for processing techniques as well as applications

COURSE OUTCOMES

After completing the course the students should be able to

1. Predict properties based on structure, thereby, selection of appropriate polymeric material for particular application.
2. apply effect of various morphological parameters like crystallization, orientation, spherulitic growth on structure and thus polymer properties.
3. tailor-make a polymer material as per the desired end properties of product.
4. choose the right processing technique along with the required processing parameters

COURSE CONTENT

Unit- I : Sub-molecular Structure (L 08)

Various Elements and Types of Bonds present in the polymer molecule, and their effect on properties such as Mechanical, Chemical, Thermal, Electrical, Optical, etc. Effect of various Monomeric ingredients (including additives) present in polymer composition on the properties and applications.

Unit- II :Molecular Structure (L 08)

Concept of Molecular size and shape (Molecular weight and its distribution), and their effect on as well as various properties such as processability, mechanical, chemical, thermal, electrical, optical, etc. Methods for converting low to high molecular weight during various processing techniques. Structure and morphology developed during various processing techniques such as injection, blow molding, rotational molding, etc.

Unit- III :Molecular Flexibility (L 08)

Molecular Flexibility and Freedom of Rotation of Bonds.Its effect on properties like Tg, Tm, crystallinity, etc. Effect of structural restriction on rotation,thereby, on properties such as mechanical, electrical, optical, etc.Effect of copolymer and blends on polymer properties. First and second order transition, super cooled state.Fringed micelle theory, Spherulitic growth and its effect on various properties.

Unit- IV :Intermolecular Structure (L 08)

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

Unit- V :Intermolecular Bonding (L 08)

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

Unit- VI :Super-molecular Structure (L 06)

Multiple phases and macrostructure. Temporary heterogeneity for processing, chemical microheterogeneity, complex multicomponent: total macro structures. Structure property relation in advance polymeric material: Polymer-clay nanocomposites; polymer composites with carbon nanotubes; synergism in polymer hybrid composites, gas barrier properties; dendrimers and hyperbranched polymers and their blends.

Books:

1. Deanin RudolphD., Polymer Structure, Properties and Applications, Plastics World and Cahners Publication, 1972
2. Sharples Allan, Introduction to Polymer Crystallization, St. Martin's Press, N.Y., 1966.
3. Tobolsky A.V., Properties and Structure of Polymers,John Wiley and Sons**,** N. Y., 1960.
4. Billmeyer Jr. and Fred W.,Textbook of Polymer Science, 3rdedition,Inter science Publisher, John Wiley and Sons, 1984.
5. Sperling L.H., Introduction to Physical Polymer Science, 3rdedition, Wiley Interscience, 2001

Suggested List of Laboratory experiments (Any 08 experiments from the following list):

1. To study Differential Scanning Calorimetry (DSC) –fundamentals, working principle, instrumentation, and applications alongwith interpretation of scans for various polymer systems.
2. To study Thermogravimetric Analysis (TGA) and Differential Thermogravimetry (DTG) – fundamentals, working principle, instrumentation and applications alongwith interpretation of thermograms with case studies.
3. To study Fourier Transform Infra-redSpectroscopy (FTIR) –fundamentals, working principle, calibration and application; identifying polymer from the spectra using identification chart.
4. To study working of Gel Permeation Chromatography (GPC) –working principle, instrumentation, universal calibration curve alongwith finding out molecular weight, molecular weight distribution using GPC data for few polymers
5. To study X-ray diffraction (XRD) – fundamentals, working principle and application alongwith interpretation of the d-spacing as well as understanding morphology of polymer system from diffraction pattern
6. To find swelling of rubbers in various solvents, and thus, find out degree of cross-linking.
7. To study the importance of barrier properties and factors affecting them. To find out permeability of polymerfilm towards various solvents.

8. To study microscopic techniques used for characterization of polymers.
9. To develop and study the growth of spherulites.
10. To study effect of orientation on mechanical properties.

Oral Examination:

Evaluation of student should be based on the performance of student during examination alongwith understanding of the experiments and theoretical knowledge acquired during laboratory sessions.

T.E. (Polymer Engineering) - 2015 Course
Course Code: 309365
Course Name: Mass Transfer and Reaction Engineering
Credits: 4

Code	Subject	Teaching Scheme (Weekly Load in hrs.)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
309365	Mass Transfer and Reaction Engineering	3	1	-	30	70	25	--	-	**125**

PREREQUISITES

Courses in Engineering Mathematics, Applied Sciences, Momentum Transfer, Heat Transfer and Process Calculation

COURSE OBJECTIVES

1. To understand the fundamental concepts of mass transfer principles and to apply those concepts to real engineering problems.
2. To learn basic design principles and applications relevant to stage-wise operations.
3. To be able to perform design calculations for Absorption, Distillation and Drying operations.
4. To understand basic principles of chemical reactor design for homogenous reactions.

COURSE OUTCOMES

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

1. apply the basic principles of diffusion and convective mass transfer for different operations
2. compare different equipments used for Mass Transfer Operations
3. analyze and design various mass transfer processes and equipments
4. identify and describe fundamentals of kinetics based on reaction datafor use in reactor design
5. describe the theory of chemical reactors and able to choose the ideal reactor types
6. analyze the effects of using multiple reactors of same or different type in series or in parallel

COURSE CONTENT

Unit I: Diffusion Mass Transfer (L 06)

Introduction to mass transfer operations, their classification, molecular diffusion in fluids, diffusivity of gases and liquid, diffusion in solids and its application, types of diffusion, mass transfer coefficient, film theory, surface renewal theory and penetration theory, mass, heat and momentum analogies.

Unit II: Absorption and Distillation Operations (L 06)

Equipments for Gas-liquid Operations, selection of solvent for absorption, absorption equilibrium, design concept of absorption. Distillation - Introduction, relative volatility, types of distillations, concepts designs and operation for distillation.

Unit III: Humidification and Drying Operations (L 06)

Basic concepts of humidification and psychrometric chart, cooling tower principle and operation, Principles, equilibrium in drying, type of moisture content,mechanism of batch drying, continuous drying, time required for drying, mechanism of moisture movement in solid, Classification and selection of industrial dryers, design and performances of various dryers.

Unit IV: Fundamental of Kinetics and Reaction Engineering (L 06)

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, search for a reaction mechanism.

Unit V: Batch and Ideal Flow Reactors (L 06)

Batch reactor concept, Constant volume and Variable Volume Batch reactor systems, Design equation for zero, first, Second and third order irreversible and reversible reactions, Differential and integral methods for rate analysis, Concept of ideality, Types of flow reactors and their differences, Space-time and Space velocity, Design equation for plug flow reactor and CSTRfor first and second order reversible and irreversible constant volume and variable volume reactors.

Unit VI: Chemical Reactor Systems (L 06)

Single and Multiple Reactor System: Size comparison of single reactors like batch, plug flow and CSTR for first and second order reactions; Optimum size determination; multiple reactors in series and parallel, Introduction to polymer reactors.

Books:

1. Treybal, R.E., Mass Transfer Operations, 3rd edition, McGraw Hill, 1980.
2. Coulson, J. M., Richardson, J. F., Chemical Engineering – Vol. I & II, 6th edition, Butterworth-Heinemann, 1999.
3. Geankoplis, C.J., Transport Processes and Unit Operations, PHI, 3rdedition, 1993
4. Lenvenspiel, O., Chemical Reaction Engineering, 3rd. edition, John Wiley and Sons, 2007.
5. Fogler, H. S., Elements of Chemical Reaction Engineering, 3rd edition, PHI, 2002.

Suggested List of Tutorials [Any 06 from the following list]:

1. Numerical Problems based on evaluation of diffusivity in solid, liquid and gas systems
2. Numerical Problems based on temperature effects in homogeneous reactions
3. Numerical Problems based on design of stage wise Mass Transfer operations
4. Numerical Problems based on Humidification- psychometric chart
5. Numerical Problems based on total time required for Drying of Polymeric raw materials
6. Numerical Problems based on Reaction Data Analysis
7. Numerical Problems based on size comparison of reactors
8. Study on Equipments use for gas-liquid operations
9. Study on Industrial Dryers used for Polymers
10. Study on Polymerization Reactors used in polymer manufacture.

Term Work:

The students should submit a certified journal for assessment of term work.

T.E. (Polymer Engineering) - 2015 Course
Course Code: 309366
Course Name: Employable Skill Development
Credits: 1

Code	Subject	Teaching Scheme (Weekly Load in hrs.)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
309366	Employable Skill Development	-	-	2	-	-	50	--	--	**50**

PREREQUISITES

Courses in Engineering Mathematics and Chemistry, Applied Sciences, Basic Courses in Chemical Engineering

COURSE OBJECTIVES

1. To get an integrated view of fundamental subjects
2. To formulate the solution to open ended problems of the industry
3. To use the computational tools effectively
4. Prepare the students to lead high-performing, successful professional career in the future

COURSE OUTCOMES

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

1. have an integrated approach of the fundamental engineering subjects
2. tackle the open ended problems from Polymer engineering
3. write, present and defend the technical report
4. use computational tools and its interface with professional software

COURSE CONTENT

The basic purpose of introducing this course is to make student proficient in the chosen area of his/her interest from amongst the following choices so as to equip him/her with skills.

The student can choose any one skill from the following:

1. Material development for specific application
2. Testing and properties optimization
3. Training on various processing equipments
4. Training on injection mold design
5. Hands on computational tools and its interface with professional 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 semester, students should submit a *'Project Report'*(about 25 pages).

The project report 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 and discussion; conclusion
5. Costing relevant to the mini-project
6. References

Term Work:

The students should submit a certified copy of project report for assessment of term work.

T.E. (Polymer Engineering) - 2015 Course
Course Code: 309367
Course Name: Audit Course 3

Practices in Polymer Industry-I

In addition to credits courses, it is recommended that there should be audit course (non-credit course). Audit course is for the purpose of self-enrichment and academic exploration. Audit course carry no academic credit. Selection of audit courses helps the learner to explore the subject of interest in greater details resulting in achieving objective of audit course's inclusion. Evaluation of audit course will be done at institute level. Method of conduction and method of assessment for audit courses is suggested.

Objective:

The objective of audit course is to expose students 'to different aspects of Polymer industry 'by organizing guest sessions on different topics including soft skills and personality development, industrial visits, mini projects, tutorials, assignments and also report based on internship carried out if any.

Criteria:

The student registered for audit course shall be awarded the grade 'PP' after successful completion of audit course and included in the semester grade report. No grade point is associated with this "PP" grade and performance in these courses is not accounted in the calculation of the performance indices SGPA and CGPA.

The students individually can register for any online course considered as value addition for the industry and produce a certificate after successfully completed the same. The students have to complete audit course as a part of curriculum. This can be divided into different components like preparing report on the industrial visit, Lecture/Guest lecture, workshop on soft skills, assignments given by the faculty members as a part special sessions conducted, Mini project, Hands on experience on specific focused topic, IIT Mooc/EDX/NPTEL, participation in national level competition organized by eminent institute on behalf of any professional body.

The students individually have to submit reports/assignments/case studies towards the end of the semester for assessment based on sessions conducted throughout the term. Successful completion of reports will allow students to earn 'PP' in the mark sheet and 'NP' is failed to complete the audit course.

SEMESTER - II

T.E. (Polymer Engineering) - 2015 Course
Course Code: 309368
Course Name: Polymer Chemistry-II
Credits: 4

Code	Subject	Teaching Scheme (Weekly Load in hrs.)			Examination Scheme (Marks)					
					Theory		TW	PR	OR	Total
		Lect.	Tut.	Pract.	In Sem.	End Sem.				
309368	Polymer Chemistry-II	4	-	2	30	70	--	50	--	**150**

PREREQUISITES

Courses in Engineering Chemistry, Polymer Chemistry-I, Polymer Structure-Property Relationships

COURSE OBJECTIVES

1. To impart advanced knowledge about synthesis and polymerization mechanism.
2. To make aware of high performance polymers and biodegradable polymers of present day relevance to the industry.
3. To create a sound understanding of the frontier areas of research and development.

COURSE OUTCOMES

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

1. demonstrate understanding of the physics of polymer solutions
2.apply advanced knowledge of polymerization mechanism
3.understand novel developments in biodegradable polymers

COURSE CONTENTS

Unit I: Polymer Solutions (L 06)

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

Unit II: Advanced Polymerization Mechanisms (L 06)

Metathesis polymerization, nitroxide-mediated radical polymerization, atom transfer radical polymerization, reversible addition-fragmentation chain transfer polymerization, electrochemical polymerizations, click polymerization, phase transfer polymerization, group transfer polymerization, plasma polymerization.

Unit III: Stereochemistry of Polymerization (L 06)

Introduction, types of stereoisomerism in polymers, properties of stereoregular polymers, forces of stereo-regulation in alkene polymerization, mechanism of coordination polymerization, Ziegler-Natta polymerization, metallocene polymerization.

Unit IV: Chemistry of Thermosetting Polymers (L 06)

Synthesis, structure property relationship, curing reactions and applications of following polymers: phenolic resins, amino resins, epoxy resins and polyurethane resins.

Unit V: Chemistry of High Performance Polymers (L 06)

Requirement of high performance polymers.Synthesis, structure property relationship, curing reactions and applications of following polymers: silicones, polybenzimidazoles, polyketones, liquid crystalline polymers, heterocyclic polymers.

Unit VI: Biodegradable Polymers (L 06)

Biodegradable polymers.Isolation, synthesis, structure -Polyhydroxyalkanoates (PHAs), Polyhydroxybutrate (PHB), Polyhydroxyvalerate (PHV), Polyhydroxyhexanoate(PHH),Polylactic acid (PLA), Polybutylene succinate (PBS), Polycaprolactone(PCL), etc.Mechanism of breakdown.Evaluation of biodegradability.Advantages and Applications.

Books:

1. Odian George,Principles of Polymerization, 4th edition,Wiley India.
2. Gowariker V.R., Viswanathan N.V. and Sreedhar Jayadev, Polymer Science, 1st edition, New Age International Publishers Pvt. Ltd., New Delhi, 2008
3. Catia Bastioli, Handbook of Biodegradable Polymers, 2nd edition, Rapra Technology Limited, UK, 2005
4. Andreas Lendlein and Adam Sisson, Handbook of Biodegradable Polymers: Isolation, Synthesis, Characterization and Applications,1st edition, Wiley Interscience, 2011

Suggested List of Laboratory experiments (Any 08 experiments from the following list):

1. To find out the strength of formalin solution
2. To determine purity of given monomer.
3. Determination of epoxy value and epoxy equivalent.
4. To find out saponification value of oil samples
5. To determine functionality of given monomer.
6. Precipitation polymerization of acrylamide.
7. Synthesis of cellulose acetate from cellulose.
8. Preparation of cellophane.
9. Determination of molecular weight of PEG resin by end group analysis technique.
10. To determine molecular weight given polymer by viscometry technique.
11. Modification of polyvinyl acetate to polyvinyl alcohol.
12. Determination of acid value of polyester resin.

Practical Examination:

Evaluation of student should be based on the performance of student during examination alongwith understanding of the experiments and theoretical knowledge acquired during laboratory sessions.

T.E. (Polymer Engineering) - 2015 Course
Course Code: 309369
Course Name: Polymer Processing Operations-I
Credits: 4

Code	Subject	Teaching Scheme (Weekly Load in hrs.)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
309369	Polymer Processing Operations-I	4	-	2	30	70	--	--	50	**150**

PREREQUISITES

Courses in Engineering Mathematics, Momentum Transfer, Strength of Materials, Heat Transfer, Polymer Materials and Polymer Structure Property Relationship.

COURSE OBJECTIVES

1. To understand the fundamentals of polymer processing techniques - extrusion, injection molding, compression and transfer molding
2. To understand construction and working of the processing equipment.
3. To understand effect of processing parameters on product properties.
4. To understand specialized processing techniques.

COURSE OUTCOMES

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

1. apply basic principles of extrusion in processing of various polymeric materials, in manufacturing of various products and trouble shooting.
2. apply basic principles of injection molding process in processing of various polymeric materials, manufacturing of various products and trouble shooting.
3. apply basic principles of compression and transfer molding process in processing of various polymeric materials, manufacturing of various products and trouble shooting.
4. operate the processing equipments.

COURSE CONTENT

Unit I: Extrusion Process (L 08)

Fundamentals of the extrusion process, basic operation, Analysis of flow through Extruder- Drag flow, Pressure flow, leakage flow. Solids conveying in hopper, feeding mechanism, drag induced conveying, melting mechanism. Construction of barrel and screw; barrier screws, vented screws. Grooved screw barrel systems. types and selection of Extruder drives

Unit II: Downstream Equipment in Extrusion (L 08)

Downstream equipment and Auxiliary units for extrusion lines, Downstream equipments for profiles, pipes, blown film [monolayer and multilayer], monofilaments, cast film, sheet, cable, coating and laminating. Constructional features of extrusion dies for rods, profiles, blown film, pipes, flat sheets and films, Equipment for sizing, cooling, take off, cutting, winding, orientation. Analyzing effect of process parameters on product properties, troubleshooting.

Unit III: Injection Molding (L 08)

Moulding process, cycle, stages involved; PVT diagram and injection molding cycle. Fill and pressure phase analysis, different velocity – pressure switch – over techniques, Orientation in injection molding and its effects, Characteristics of typical materials and injection molding of these materials, processing parameters and their effect on product quality, process control in injection molding; close loop and open loop machines; trouble shooting in injection molding, machines specifications and selection.

Unit IV: Specialized Processes -I (L 08)

Gas assisted injection molding, water assisted injection molding. Two color pattern making injection molding; Two color two component injection molding machine and process; injection molding of thermosets; low pressure injection molding; injection – compression molding; injection molding of DMC; reaction injection molding; injection molding of elastomers.
Other polymer processing operations - Such as dip coating, slush molding, polymer casting matched metal molding.

Unit V: Specialized Processes-II (L 08)

Co-extrusion of sheet and film; co-extrusion of profiles, tubing and other products, Construction of co-extrusion dies, Extrusion of cellular / foamed plastic products, equipment requirement for foamed product; down-stream equipments for foamed product, Specialized processes used for making of netting, magnetized plastics strip, extrusion of hollow core panel, sandwich panel, coiled extrusion, twisted rod extrusion.

Unit VI: Compression and Transfer Molding (L 08)

Basic principle and molding cycle; Molding materials, effect of bulk factor, Flow properties, Cure time, temperature and pressure on molding cycle; effect of preheating and performing. Defects and remedies; compression press specifications; controls calculations of number of cavities based on rate of production.

Basic principles of mold design; cavity, punch, methods of ejection, heating of molds.Types of compression molds, Molding of thermoplastics, thermosets, Dough moulding compounding (DMC), Sheet Molding Compound (SMC). Analysis of compression molding; flow rate, compaction force for molding.

Transfer molding - Basic principle and molding cycle. Advantages and limitations of the process. Types - integral pot and auxiliary ram transfer. Process parameters and their effect on product quality.
Molding defects, causes remedies; Transfer molding of thermosets, Transfer molding of DMC. Types of transfer presses, specifications. Clamping tonnage calculations, molding defects and applications, design of transfer moulds. Transfer molding, materials, flow properties.

Books:

1. Rauwendaal Chris, Understanding Extrusion, 2nd Edition, Hanser, 2010.
2. Rauwendaal Chris, Polymer Extrusion, 4th Edition, Hanser, 2001.
3. Tadmor Zehev and Klein Imrich, Engineering Principles of Plasticizing Extrusion, Krieger Publishing Company, 1978.
4. Levy Sidney and Carley James, Plastic Extrusion Technology Handbook, 2ndedition Industrial Press Inc., U.S., 1989.
5. Fisher Edwin, Extrusion of Plastics, 3rdedition, Wiley, 1976.
6. Rosato Dominick V., Rosato Donald V. and Rosato Marlene G., Injection Molding Handbook, Springer Science & Business Media, 2000.
7. Rubin Irvin I., Injection Molding: Theory and Practice, Wiley, 1973.
8. Crawford R.J., Plastic Engineering, 3rd edition, Butterworth –Heinemann, 2006.
9. Gupta B.R., Applied Rheology in Polymer Processing, 1st edition, Asian Book Pvt. Ltd, 2005.

Suggested List of Laboratory experiments (Any 08 experiments from the following list):

1. To study Compression molding process for thermoplastic and thermosetting materials.
2. Study the working of blown film plant.
3. To study the effect on film properties by varying haul – off speed, temperature, blowratio, screw speed, etc.

4. To plot screw and die characteristics and to study the effect of variation of process parameters on screw and die characteristics.
5. Study the working of an injection molding machine.
6. Study of injection molding of thermoplastics.
7. Study of Gas-Assisted injection molding.
8. Study of injection molding of thermosets.
9. Study of dip coating and slush molding.
10. Study of injection molding of DMC.
11. Study of compression and transfer molding of DMC.
12. Study of vented screw barrel systems.
13. Study of grooved barrel systems.

Oral Examination:

Evaluation of student should be based on the performance of student during examination along with understanding of the experiments and theoretical knowledge acquired during laboratory sessions.

T.E. (Polymer Engineering) - 2015 Course
Course Code: 309370
Course Name: Polymer Rheology
Credits: 5

Code	Subject	Teaching Scheme (Weekly Load in hrs.)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
309370	Polymer Rheology	3	1	2	30	70	--	--	50	**150**

PREREQUISITES

Courses in Engineering Mathematics, Momentum Transfer, Polymer Materials, Polymer Structure Property Relationship.

COURSE OBJECTIVES

1. To learn flow behavior of fluids and polymers
2. To understand effect of flow during various processing techniques.
3. To learn the effect of temperature, pressure, flow profiles on polymer viscosity

COURSE OUTCOMES:

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

1. understand polymer melt flow behavior and to bring out co-relation between polymer rheology and polymer processing
2. apply the concept of effect of various flow profiles on viscosity and thus study the effect on polymer properties.
3. choose the right processing conditions for various processing techniques.
4. carry out rheological testing and correlate them to set the processing parameters and also choose the right polymeric grade during processing.
5. interpret the practical data and analyze it using certain mathematical models.

COURSE CONTENTS

Unit- I*:* Introduction to Polymer Rheology (L08)

Introduction to Rheological Principles, Definition and importance of Rheology, types of fluids, Non-Newtonian fluids, time-dependent fluids, time independent fluids, viscous elastic fluids, Pseudoplastic fluids, Dilatant fluids, Bingham plastic fluids, Normal stress difference and

Weissenberg's effect.Introduction to tensors, stress tensors and strain tensors, Basic equations of fluid mechanics -Continually equation, Cauchy's equation, Navier – stokes equation.

Unit- II :Viscoelastic Behavior (L08)

Stress relaxation, relaxation modulus, creep compliance dynamic modulus, dynamic compliance, dynamic viscosity.Mechanical models – Maxwell model, Voigt – Kelvin model, Zener model, Boltzmann Principle of Superposition.WLF equation.Glass-transition and theories of glass transition - free volume theory.Molecular theories – Rouse theory, Doi – Edward theory, Curtis – bird model.

Unit- III :Parameters Influencing Polymer Rheology (L08)

Effect of pressure on viscosity, Effect of temperature, activation energy, effect of molecular weight and molecular weight distribution on viscosity, molecular at dependence of zero shear viscosity, effect of crosslinking, crystallinity branching, copolymerization, effect of fillers, fiber filled polymer melts, effect of plasticizers, shear rate dependence of viscosity.

Unit- IV :Melt Flow Analysis (L08)

Laminar flow through circular cross section, annulus, slit, parallel plates, irregular profiles. Flow analysis using power law, turbulent flow analysis, turbulence dumpling. Rheological models for extensional viscosity, Transition between laminar & turbulent flow, Ryan Johnson criterion, Application of Ryan Johnson criterion to power low fluids, extensional flow and rheological models for extensional viscosity. Flow in coni-cylindrical dies – pressure drop due to shear, pressure drop due to extensional flow and pressure drop at die entry, flow in wedge shaped die. Swelling due to shear stresses and swelling due to tensile stresses.

Unit- V :Rheometry (L08)

Basic concept of constant stress and constant strain, Different types of Rheometers - Cone and platerheometer, Concentric cylinder rheometer, Parallel disk rheometer, Concentric rotating disk rheometer, Controlled stress rotational rheometer, Torque rheometers – Extruder type.

Unit- VI :Rheology in Polymer and Rubber Processing (L08)

Rheology as applicable to following processes –

a) Injection molding
b) Extrusion :sheet, pipe, blown film, etc.
c) Blown film extrusion
d) Compression and transfer moulding

Books:

1. Ghosh Premamony, 'Polymer Science & Technology, 2nd edition, Tata McGraw Hill Publication, 1990.
2. Gupta B.R., Applied Rheology in Polymer Processing, 1st edition, Asian Book Pvt. Ltd, 2005.
3. Cogswell F.N., Polymer Melt Rheology, 1st edition, John Wiley and Sons, 1981,
4. Wissburn Kurt F., Nostrand Reinhold Van and Dealy John M.,Melt Rheology and its Role in Plastic Processing Theory and Applications,Chapman & Hall,1995.
5. CrawfordJ., Plastics Engineering, 3rd edition, Butterworth–Heinemann, 2006
6. Rao Natti. S.,Design Formulas for Plastic Engineers, Hanser Publishers, 1999.

Suggested List of Laboratory experiments (Any 08 experiments from the following list):

1. To study different types of fluids with examples.
2. To find M.F.I. of different polymers using melt flow indexer.
3. To study the variation in viscosity with respect to temperature using capillary rheometer.
4. Fitting of rheological models using capillary rheometer [power low model, Ellis model etc.].
5. Estimation of Bagley's correction factor using capillary rheometer.
6. Study of cone and plate viscometer.
7. Study of Torque Rheometer.
8. Study of Brook field's viscometer.
9. Study of oscillating disc viscometers for rheological characterization of elastomers.
10. To study small amplitude oscillatory shear properties using parallel plate geometry.

Oral Examination:

Evaluation of student should be based on the performance of student during examination along with understanding of the experiments and theoretical knowledge acquired during laboratory sessions.

T.E. (Polymer Engineering) - 2015 Course
Course Code: 309371
Course Name: Design of Equipment and Machinery
Credits: 4

Code	Subject	Teaching Scheme (Weekly Load in hrs.)			Examination Scheme (Marks)					
					Theory		TW	PR	OR	Total
		Lect.	Tut.	Drg.	In Sem.	End Sem.				
309371	Design of Equipment and Machinery	3	-	2	30	70	25	--	50	**125**

PREREQUISITES

Courses in Engineering mathematics, Engineering graphics, Engineering Mechanics, Basic Mechanical Engineering, Engineering Materials and Solid Mechanics, Machine Drawing and Workshop Practices**.**

COURSE OBJECTIVES

1. To impart practical and theoretical knowledge of machine elements
2. To impart knowledge of process equipment design.
3. To impart knowledge of Hydraulic circuits.

COURSE OUTCOMES:

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

1. understand the basics of machine element design required to build subassemblies and subsequently machine
2. learn different hydraulic actuators, pumps and valves eventually required for building hydraulic circuits and understand the functioning by performing experiments with basic hydraulic circuits
3. familiarize with basics of hydraulics so as to enable them to build small elementary hydraulic circuits eventually required in building complete hydraulic circuit of injection moulding machine
4. understand complete hydraulic circuit of injection moulding machine including the logic circuit.

COURSE CONTENTS

Unit- I Fundamentals of Design (L06)

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 Design of Shafts and Belts (L06)

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 Design of Bearings and Gears (L06)

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 Pumps and Valves (L06)

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 Hydraulic Drives (L06)

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 Design of Pressure Vessels (L06)

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

List of Drawings:

(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

Books:

1. Juvinall Robert C**.** and Marshek Kurt M., Fundamentals of Machine Component Design, John Wiley &Sons, 2005.
2. Rubin Irvin, Injection Molding: Theory and Practice, John Wiley & Sons Publication, New York, 1972.
3. Joshi M.V. and Mahajani V.V., Process Equipment Design, 3rdedition, Macmillan Publication, 2000.
4. Khurmi and Gupta, A text book of Machine Design, S. Chand Publication, 2009.
5. Vickers, Industrial Hydraulics Manual, 3rdedition, 2004.
6. Bhandari V.B., Design of Machine Elements, 2ndedition, Tata McGraw Hill Publication Co. Ltd., New Delhi, 2010

Term Work:

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

T.E. (Polymer Engineering) - 2015 Course
Course Code: 309372
Course Name: Process Instrumentation and Control
Credits: 4

Code	Subject	Teaching Scheme (Weekly Load in hrs.)			Examination Scheme (Marks)					
		Lect.	Tut.	Pract.	Theory		TW	PR	OR	Total
					In Sem.	End Sem.				
309372	Process Instrumentation and Control	3	-	2	30	70	25	--	--	**125**

PREREQUISITES

Engineering Mathematics, Basic Chemical Engineering courses

COURSE OBJECTIVES

1. To impart basic understanding of instrumentation systems used in polymer industry
2. To make use of different mathematical tools for dynamics and stability of control system
3. To illustrate different control strategies needed to optimize process plants

COURSE OUTCOMES

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

1. identify and analyze the dynamic characteristics of transducers and its interface with control system.
2. select suitable sensor for different process parameters such as temperature, pressure, flow, density, etc. and their calibration
3. apply basic knowledge of mathematics to study dynamic behavior of process systems.
4. design stability analysis in feedback control system.
5. apply knowledge of the techniques, modern tools and skills required to solve problems involving advanced control system in a wide area of industrial processes.

COURSE CONTENT

Unit I: Fundamentals of Process Instrumentation (L 06)

Introduction to process instrumentation, Functional elements of instruments, Static and Dynamic characteristics of measuring instruments, Transducer element, Intermediate elements,Signal conditioners, Filtering and signal analysis, Data acquisition and conversion, Digital signal transmission and processing, Indicating and recording elements, Calibration of instruments.

Unit II: Temperature, Pressure, and Strain Measuring Instruments (L 06)

Temperature Measuring Instruments -Introduction, Classification, Temperature scales, Mechanical temperature sensors such as filled- system and expansion thermometers; Electrical temperature sensors such as RTD, thermistors, thermocouples; Radiation sensors such as optical and radiation, Calibration of thermometers.

Pressure Measuring Instruments - Classification, Pressure scales, Manometers, Elastic element pressure gauges, Electrical sensors, Force-balance transducers, 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 III: Level and Flow Measuring Instruments (L 06)

Level Measuring Instruments -Classification, Direct methods (point contact methods, sight or gauge glass methods, and buoyancy methods), Indirect methods (hydrostatic pressure methods, capacitance methods, radiation methods, and ultrasonic methods), and Solid level measurement.

Flow Measuring Instruments -Introduction, Classification, Pressure head-type flow meters; Variable-area flow meters, Electromagnetic, Mechanical (positive displacement and turbine-type); Anemometer - Ultrasonic-type, Vortex-flow type, Laser anemometers; Mass flow meters.

Unit IV: Dynamic Behavior of Processes (Process Dynamics) (L 06)

Introduction, Mathematical tools for process control, Ideal forcing functions, Transfer function, First order and second order systems, Dead- time systems, Inverse response systems, Transportation lag.

Unit V: Feedback Control Systems (L 06)

Classification of process variables, Block diagram of feedback control system, Servo and regulator operations-derivation, Feedback controllers(ON-OFF, P, PI, PD, PID); Control 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 VI: Control of Polymer Processing Systems (L 06)

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, Supervisory control and data acquisition systems. Distributed control systems.

Control schemes for polymer manufacturing and processing operation such as Injection molding, Blow molding, continuous and batch polymerization processes, etc.

Books:

1. Eckman D.P.,Industrial Instrumentation,3rdedition, CBS Publishers, New Delhi, 2004
2. Coughanowr Donald R., Process Systems Analysis and Control,3rdedition,McGraw-Hill Higher Education, Boston, 2009
3. Stephanopoulos, Chemical Process Control, Pearson India Education Services,Noida, 2015.
4. Bolton W.,Instrumentation and Control Systems, , 2ndedition,Waltham, MA: Newnes, Oxford, 2015
5. Liptak Bella G., Instrumentation Engineers Handbook, 4thedition, Elsevier, 2003

Suggested List of Laboratory experiments (Any 08 experiments from the following list):

1. Characteristics and calibration of temperature measuring instrument.
2. Characteristics and calibration of pressure measuring instrument.
3. Characteristics and calibration of level measuring instrument.
4. Characteristics and calibration of flow measuring instrument.
5. Control valve characteristics
6. Estimation of response of first order system.
7. Estimation of damping coefficient for U tube manometer.
8. Experiments on Proportional integral and derivative control actions.
9. Controller tuning using Ziegler Nichols rules.
10. Feedback temperature, pressure, level and flow control loop.
11. Study of Programmable logic control of polymer processing equipments.
12. Experiment on cascade control.
13. Study of control stability analysis.
14. Study of Data Logger.

Term Work:

The students should submit a certified copy of project report for assessment of term work.

T.E. (Polymer Engineering) - 2015 Course
Course Code: 309373
Course Name: Seminar
Credits: 2

Code	Subject	Teaching Scheme (Weekly Load in hrs.)			Examination Scheme (Marks)					
					Theory		TW	PR	OR	Total
		Lect.	Tut.	Pract.	In Sem.	End Sem.				
309373	Seminar	-	-	2	--	--	50	--	--	**50**

PREREQUISITES

Basic Polymer Engineering Courses, Technical Communications

COURSE OBJECTIVES

1. Investigate some of the current Scientific and Technological issues
2. Develop approach learning tools that will help student be life-long learners
3. To improve skills in writing, oral presentation
4. Develop skills related technical report and presentation
5. Develop professional competence and ethics

COURSE OUTCOMES

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

1. conduct literature review relevant to a contemporary topic
2. present the work in a variety of formats (written, oral, formal presentation) in front of an audience
3. evaluate the reliability of sources of information
4. understand professional ethics by acknowledging original resource material

COURSE CONTENTS

The topic should be of current commercial or research interest, and should preferably be related to Polymer Engineering and Science. The work may encompass detailed literature review and analysis, synthesis, design and development, generation of innovative ideas, modification in the existing process/system, development of computer programs, solutions, modeling and simulation.

Topics of interdisciplinary nature may also be taken up. A technical report is required to be submitted at the end of the term and a presentation made based on the same.

It is expected that the student should collect the information from journals, web-source and reference books in consultation with his/her guide. The report submitted should reveal the students assimilation of the collected information from various resources. Mere compilation of information from the web-sources and any other resources is strictly discouraged.

Format of the seminar report:

The report shall be presented in the format provided by the Department.
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 20 minutes (15 min. + 5 min.) Audience can ask questions only if the examiner permits. Such questions will not have any bearing on marks.

Seminar – Conduct:

1. Review – I: during month of February (Compulsory) as per the Academic Calendar.
2. Review – II : The last week of March (Optional)
3. Seminar is an individual activity with separate topic and presentation.
4. Duration of presentation – 15 minutes
5. Question and answer session – 5 minutes

Seminar Evaluation Scheme: based on rubrics developed on following lines**:**

1. Attendance during Semester
2. Attendance during Seminar presentations
3. Relevance of Seminar topic
4. Timely Abstract submission
5. Literature review
6. Technical contents
7. Presentation
8. Question and answer Session

Term Work:

The students should submit seminar report for assessment of term work.

T.E. (Polymer Engineering) - 2015 Course
Course Code: 309374
Course Name: Audit Course 4

Practices in Polymer Industry-II

In addition to credits courses, it is recommended that there should be audit course (non-credit course). Audit course is for the purpose of self-enrichment and academic exploration. Audit course carry no academic credit. Selection of audit courses helps the learner to explore the subject of interest in greater details resulting in achieving objective of audit course's inclusion. Evaluation of audit course will be done at institute level. Method of conduction and method of assessment for audit courses is suggested.

Objective:

The objective of audit course is to expose students 'to different aspects of Polymer industry 'by organizing guest sessions on different topics including soft skills and personality development, industrial visits, mini projects, tutorials, assignments and also report based on internship carried out if any.

Criteria:

The student registered for audit course shall be awarded the grade 'PP' after successful completion of audit course and included in the semester grade report. No grade point is associated with this "PP" grade and performance in these courses is not accounted in the calculation of the performance indices SGPA and CGPA.

The students individually can register for any online course considered as value addition for the industry and produce a certificate after successfully completed the same. The students have to complete audit course as a part of curriculum. This can be divided into different components like preparing report on the industrial visit, Lecture/Guest lecture, workshop on soft skills, assignments given by the faculty members as a part special sessions conducted, Mini project, Hands on experience on specific focused topic, IIT Mooc/EDX/NPTEL, participation in national level competition organized by eminent institute on behalf of any professional body.

The students individually have to submit reports/assignments/case studies towards the end of the semester for assessment based on sessions conducted throughout the term. Successful completion of reports will allow students to earn 'PP' in the mark sheet and 'NP' is failed to complete the audit course.