B. Tech. Chemical Technology - Plastic Technology
Semester 1

BCY-101: ENGINEERING CHEMISTRY

L	T	P	C
3	0	2	4

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

CO1	Interpret UV-Visible and IR-Spectra	Understand, Analyze
CO2	Describe reaction rates for reactions of various orders	Understand, Apply, Analyze
CO3	Understand different aspects of corrosion and thermodynamic view of electrochemical processes, reversible and irreversible cells	Understand, Apply
CO4	Understand the stereochemistry of molecules and identify organic reactions on the basis of their mechanism	Remember, Apply, Analyze
CO5	Distinguish between different polymeric structures, classify polymers, and analyze the polymerization mechanism and use of polymers in different walks of life. Knowledge of conductivity of polymer, biodegradable polymers and fibre reinforced plastics. Acquire knowledge about water and treatment of municipal water	Understand, Apply, Evaluate, Create

BCY101/ 102	PO 1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO12	**PSOs**	
CO1	3	3	1	3	2	-	2	-	-	-	-	3	1	2
CO2	3	3	1	3	2	-	2	-	-	-	-	3	2	2
CO3	3	3	1	3	2	-	2	-	-	-	-	3	1	2
CO4	3	3	1	3	2	-	2	-	-	-	-	3	2	2
CO5	3	3	1	3	2	-	2	-	-	-	-	3	1	2
Average	3	3	1	3	2	-	2	-	-	-	-	3	1.4	2

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

SYLLABUS

Module I

(i) *Bonding*: CFT, Electronic Spectra and Ligands (strong and weak field), Phosphorescence and Fluorescence, Jablonski diagram, hydrogen bonding and their effect on physical properties, Metallic bonds, Classification and Applications of Liquid crystals, Band Theory of Solids and superconductors.

(Lectures: 7-8)

(ii) *Spectroscopy*: Basic Principles, Instrumentation and Applications of UV-VIS and IR Spectroscopy.

(Lectures: 5-6)

Module II

(i) *Chemical Kinetics*: Second order reactions. Determination of order, Fast and slow reaction, steady state approximation, Temperature effect, Concept of Activated Complex/Transition State: Energy of activation, Potential energy surface, Theories of reaction rate: Collision and Transition State theories in terms of enzyme catalysis.

(Lectures: 4-5)

Module III

(i) *Electrochemistry*: Dry and fuel cells, electrochemical cell, Solar cells, Disensitized cell, Photovoltaic cell.

(Lectures: 3-4)

(ii) *Environmental Chemistry*: Air and Water Pollution, analysis of gaseous effluents oxides of Nitrogen, oxides of Sulphur and H_2S, chemical analysis of effluents liquid streams, BOD, COD, control of pollution, Depletion of ozone layer.

(Lectures: 5-6)

Module IV

(ii) *Stereochemistry*: Stereoisomerism of organic compounds containing one & two chiral centers. Enantiomers & Diastereomers, E-Z nomenclature, R-S configuration, Atropisomerism, and Optical isomerism in Allenes, biphenyl and Spiranes, Circular Dichroism.

(Lectures: 5-6)

(i) *Reaction Mechanism*: Inductive, Electromeric and Mesomeric effects. Study of reaction intermediates (Carbanion, carbocation, carbene, nitrene and benzyne). Mechanism of nucleophilic and electrophilic substitution reactions. Mechanism and application of following reactions:

a) Suzuki-Miyaura Cross coupling reaction
b) Fries and Photo-Fries Rearrangement
c) Wagner- Meerweir Rearrangement
d) Umpolung Reactions
e) Reaction of vision

(Lectures: 4-5)

Module V

(i) *Polymers*: Introduction and their classifications, types of polymerization, Free radical, anionic and cationic polymerization, Preparation, Rheological properties and uses of some common polymers. Synthetic Polymers (carbon framework, silicon framework, fluorinated polymer), Conducting and Biodegradable polymers.

(Lectures: 4-5)

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

(Lectures: 4-5)

List of Experiments:

1. Determination of alkalinity in given water sample.
   a. Sodium Carbonate & Sodium Bicarbonate
   b. Sodium Carbonate & Sodium Hydroxide
2. Determination of temporary and permanent hardness in water sample using EDTA as standard solution.
3. Determination of Chloride content of water by Mohr's Method.
4. Determination of Chlorine content in Bleaching powder.
5. Determination of strength of supplied Ferrous Ammonium Sulphate (FAS) solution in using external, internal indicators.
6. Determination of viscosity of a given liquid by Ostwald's viscometer.
7. Determination of surface tension of a given liquid by Stalagmometer.
8. pH determination of given sample.
9. Determination of iron content of water by Mohr's Method.
10. Determination of Dissociation constant of weak acids by conductometric Titration.

Reference Books:

1. Advance Organic Chemistry by Jerry March, Third Edition Wiley Eastern Limited, New Delhi.
2. Organic Chemistry by Morrision & Boyd, Allyn and Bacon, Inc. Boston.
3. Physical Chemistry by Puri, Sharma & Pathania, Peter Atkins & Julio de Paula, Arun Bahl, B.S. Bahl & G.D.Tuli.

4. Textbook of Physical Chemistry by S. Glasstone, Macmillan and Co. Ltd., London.
5. Chemical Kinetics and Reaction Dynamics by Puri, Sharma & Pathania.
6. Principles of Polymerization by George Odian.
7. Polymer Science by V. R. Gowarikar, N. V. Vishwanathan and J. Shridhar, Wiley Eastern Ltd., New Delhi.
8. Principles of Instrumental Analysis by Douglas and Skoog, Saunder College Publishing Co., New York.
9. Engineering Chemistry by Jain & Jain, Dhanpat Rai Publication Co., New Delhi.
10. Application of Absorption Spectroscopy of Organic Compounds by John R. Dyer, Prentice Hall of India Pvt. Ltd., New Delhi.
11. Spectroscopy of Organic Compounds by P.S. Kalsi, Y.R. Sharma.

BMA -101 MATHEMATICS –I

L	T	P	C
3	1	0	4

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

- the convergence of infinite series, improper integrals and differential calculus.
- partial differentiation, multiple integrals and Beta, Gamma functions.
- vector calculus, matrices, linear algebra and optimization techniques.

Course Outcome

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

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

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

Detailed Syllabus:

Unit I- Functions of One Real Variable:

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

Unit II- Functions of Several Real Variables:

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

Unit III- Vector Calculus:

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

Unit IV- Matrices and Linear Algebra:

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

Unit V- Optimization:

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

Books Recommended:

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

PROGRAM CORE COURSES

EET 101/102	Electronics & Instrumentation Engineering	3L:0T:0P	3credits

P-N Junction Diode, V-I Characteristics, Diode Application as Rectifier (Half Wave & Full Wave), Zener Diode and its Applications.

Introduction to Bipolar Junction Transistor, Operational Amplifier, FET: Applications, demo, explanation,its Applications

Boolean Algebra, Logic Gates, Concept of Universal Gate, Minimization using K map, Number system
Basic Combinational Circuits: Adder, Subtractor.
Sequential Circuits: Flip-Flops, Registers.

Functional Elements of Instruments, Classification & Characteristics, Types of Errors,
Active and Passive Transducers and their Characteristics,
Display Devices: Seven Segment Display, Alphanumeric Display, LCD, LED, Plasma.
Electronic Ammeter and Voltmeter, Digital Multi-meter, Digital Storage Oscillcope(DSO) Projectors.

Text Books:

1. Malvino, A.P. / "Electronics Principles" / Tata McGraw-Hill / 6th Ed.
2. Boylestad, Robert & Nashelsky, Louis / "Electronic Devices & Circuit Theory" / Prentice Hall of India / 8th Ed.
3. H.S. Kalsi / "Electronic Instrumentation" / Tata McGraw-Hill
4. Malvino & Leach / "Digital Principles & Applications" / Tata McGraw-Hill / 5th Edition

Reference Books:

1. Sedra, Adel S., Smith, Kenneth C. / "Microelectronic Circuits"/ Oxford University Press / 5th Edition
2. Sawhney AK/ "Electrical and electronic Measurement and Instrumentation"/ Dhanpat Rai & sons.
3. Lectures of NPTEL

OUTCOMES:

The students will have basic knowledge of Electronics and instrumentation engineering related to Diode, BJT, FET, digital electronics, transducers, CRO etc. and they will apply fundamental principles of the related electronics circuit to solve practical problems related to engineering applications.

ENGINEERING GRAPHICS (ECE-101/102)

L T P C : 0 0 6 3

Syllabus

Unit-I

Lettering and Dimensioning

Introduction, lettering practice, Elements of dimensioning - systems of dimensioning.

Geometric Constructions

Free hand sketching, Conic sections, Special curves.

Engineering Scales

Unit-II

Projection of Points and Projection of Lines

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

Unit-III

Projection of Solids and Section of Solids

Projection of solids: Classification of solids, Projection of solids in simple position, Projection of solids inclined to one plane. Sections of Solids: Right regular solids and auxiliary views for the true shape of the sections.

Unit-IV

Development of Surfaces

Development of surfaces for various regular solids.

Isometric Projection and Perspective Projection

Isometric Projection: Isometric scales, Isometric projections of simple and combination of solids; Perspective Projection: Orthographic representation of a perspective views – Plane figures and simple solids - Visual ray method.

COMPUTER CONCEPTS & PROGRAMMING (ECS-101/102)

Type	L	T	P	C
Credits				
ESC	3	0	2	4

Prerequisite: NIL

Course Content:

Unit-1:

Introduction to Computers: Computer hardware Components, peripherals and their functions, Number Systems and conversion methods, Concept of an algorithm; termination and correctness. Algorithms to programs: specification, top-down development and stepwise refinement, Introduction to programming environment, use of high level programming language for the systematic developmentof programs. Introduction to the design and implementation of correct, efficient and maintainable programs, Structured Programming, Trace an algorithm to depict the logic.

Unit-2:

Basic operating System Concepts: Introduction of MS-DOS, WINDOWS, and LINUX Operating Systems, Functional Knowledge of these operating systems, Introduction of basic commands of LINUX and Editors, Managing Files and Directories in LINUX, Programming Environment in LINUX, Writing and executing programs in LINUX.

Unit-3:

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

Unit-4:

Operators: Unary operators, Arithmetic & logical operators, Bit wise operators, Assignment operators and expressions, Conditional expressions, Precedence and order of evaluation. Control statements: if-else, switch, break, and continue, the comma operator, goto statement. Loops: for, while, do-while. Functions: built-in and user-defined, function declaration, definition and function call, and parameter passing: call by

value, call by reference, recursive functions, Multi-file programs. Arrays: linear arrays, multidimensional arrays, passing arrays to functions, Arrays and strings.

Unit-5:

Structure and Union: definition and differences, self-referential structure. Pointers: value at (*) and address of (&) operator, pointer to pointer, Dynamic Memory Allocation, calloc and malloc functions, array of pointers, function of pointers, structures and pointers. File Handling in C: opening and closing a data file, creating a data file, read and write functions, unformatted data files.

Lab Work:

1. Write C program to find largest of three integers.
2. Write C program to check whether the given string is palindrome or not.
3. Write C program to find whether the given integer is

   (i). a prime number

   (ii). an Armstrong number.

4. Write C program for Pascal triangle.
5. Write C program to find sum and average of n integer using linear array.
6. Write C program to perform addition, multiplication, transpose on matrices.
7. Write C program to find Fibonacci series of iterative method using user-defined function.
8. Write C program to find factorial of n by recursion using user-defined functions.
9. Write C program to perform following operations by using user defined functions:

   (i) Concatenation

   (ii) Reverse

   (iii) String Matching

10. Write C program to find sum of n terms of series: n – n*2/2! + n*3/3! - n*4/4! + ...
11. Write C program to interchange two values using

    (i). Call by value.

    (ii). Call by reference.

12. Write C program to sort the list of integers using dynamic memory allocation.
13. Write C program to display the mark sheet of a student using structure.
14. Write C program to perform following operations on data files:
    (i) Read from data file.
    (ii) Write to data file.
15. Write C program to copy the content of one file to another file using command line argument.

Text and References Books:

1. Kernighan, Ritchie, “The C Programming Language”, PHI
2. V. Rajaraman, “Fundamentals of Computers”, PHI
3. Peter Norton’s, “Introduction to Computers”, TMH
4. Gottfried, “Programming in C”, Schaum’s Series, Tata McGraw Hill
5. YashwantKanitkar, “Working with C”, BPB
6. E. Balagurusamy, “Programming in ANSI C”, TMH

Course Outcomes:

1. Identify the parts of the computer system and explain the functioning of its componentsalongwith the process of problem solving. (Remember, Understand)
2. Design an algorithmic solution for a given problem and translate it into a program. (Design)
3. Understand different operating systems, related concepts and their functions. (Understand)
4. Use the appropriate control statements to solve the given problem. (Apply)
5. Implement different Operations on arrays and use functions to solve the given problem. (Apply)
6. Understand pointers, structures and unions &Implement file Operations in C programming. (Understand, Apply)

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSOs	
ECS-102 CO1		3	3	2	1	2	-	-	1	-	1	-	3	**1**	**2**
ECS-102 CO2		3	3	2	1	2	-	-	1	-	1	-	3	2	1
ECS-102 CO3		3	3	2	1	2	-	-	1	-	1	-	3	2	1
ECS-102 CO4		3	3	2	1	2	-	-	1	-	1	-	3	2	2
ECS-102 CO5		3	3	2	1	2	-	-	1	-	1	-	3	2	2
ECS-102 CO6		3	3	2	1	2	-	-	1	-	1	-	3	2	1
Average		3	3	2	1	2			1		1		3	1.8	1.3

Subject / Course Title : EWS 101 / 102 - WORKSHOP PRACTICE

Load / Credit : L : T : P : C
0 : 0 : 4 : 2

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

Course Outcome

- Acquire skills in basic engineering practice
- Identify the hand tools and instruments.
- Obtain practical skills in the trades.
- Gain measuring skills.

Course Outcome (CO)		Bloom's Knowledge Level (KL)
At the end of the course the student should be able to :		
CO 1	Study and practice on machine tools and their operations	Understand
CO 2	Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry, black - smithy and welding work	Apply
CO 3	Identify and apply suitable tools for machining processes including plain turning, step turning, taper turning, facing, thread cutting operations	Analyze
CO 4	Understand and practice welding and forging operations	Understand
CO 5	Select the appropriate tools required for specific operation	Understand, Apply
CO 6	Comprehend the proper safety measures required to be taken while using different tools.	Remember, Understand

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

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO(	PO10	PO11	PO12	**PSOs**	
CO1	2	-	-	1	1	1	-	-	-	-	-	1	**1**	**2**
CO2	2	-	-	1	1	1	-	-	-	-	-	1	2	1
CO3	2	-	-	1	1	1	-	-	-	-	-	1	2	1
CO4	2	-	-	1	1	1	-	-	-	-	-	1	2	2
CO5	2	-	-	1	1	1	-	-	-	-	-	1	2	2
Avg.	2	-	-	1	1	1	-	-	-	-	-	1	1.8	1.6

1. Slight (Low) 2. Moderate (Medium) 3. Substantial (High)

Course level Assessment Question :

Course Outcome 1 (CO1)

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

Course Outcome 2 (CO2)

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

Course Outcome 3 (CO3)

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

Course Outcome 4 (CO4)

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

Course Outcome 5 (CO5)

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

Course Outcome 6 (CO6)

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

Semester 2

BPH: 101/102 PHYSICS (Theory & Lab)

Course: B.Tech.	**Branches: All Branches**	**Year: Ist Year (Semester I & II)**
Sessional Marks	**50**	**Credit: 4**
End Semester Exam Marks	**50**	**L T P : 3 0 2**

Pre-requisites	Basic knowledge of Maths (12^{th} level)

Syllabus

MODULE- 1 (Lectures: 08)

Introductory Mechanics & Theory of Relativity:

Potential energy function $F = -\text{grad}\ (V)$, equipotential surfaces, meaning of gradient, divergence, curl and their physical significance, Conservative and Non-Conservative forces, Curl of a force, Central forces, Examples of Central forces, Conservation of Angular Momentum,.

Inertial and Non- Inertial Frames of reference, Galilean transformation, Michelson Morley Experiment, Lorentz Transformation, Length contraction, Time dilation and Evidences for time dilation, Relativistic velocity addition formula, Relativistic variation of mass with velocity, Evidence of mass variation with velocity, Einstein's Mass energy equivalence, Examples from nuclear physics, Relativistic energy momentum relation.

MODULE -2 (Lectures: 08)

Quantum Mechanics-Schrodinger Equation and its Applications:

Dual Nature of matter & Radiation, Heisenberg's uncertainty Principle and their applications, wave group concept, Davisson Germer experiment, Postulates of quantum mechanics, Significance of wave function, Derivation of Schrodinger equation for time independent and time dependent cases.

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

MODULE – 3 (Lectures: 08)

Electromagnetic Theory: Ampere's law and Faraday's law of electromagnetic induction, Maxwell's equations, Correction of Ampere's law by Maxwell (concept of displacement current), transformation from integral to differential form, Physical significance of each equation,Poyntingtheorem, Maxwell's equations in free space, velocity of electromagnetic wave, Transverse character of the wave and orthogonality of **E**, **H** and **v** vectors, Maxwell's equation in

dielectric medium and velocity of e.m. wave, Comparison with free space, Maxwell's equations in conducting media, Solution of differential equation in this case,penetration depth, its significance.

MODULE – 4 (Lectures: 09)

Materials of Technological Importance:

Dielectric Materials: Electric field in presence of dielectric medium,concept of electric polarization, different types of polarizations, dielectric in a.c. field,concept of dielectric loss and loss energy.

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

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

MODULE: 5 (Lectures: 09)

Statistical Mechanics & Lasers:

Phase space, the probability of distribution, most probable distribution, Maxwell-Boltzmann Statistics, Applicationsof Maxwell-Boltzmann Statistics, derivation of average velocity, RMS velocity and most probable velocity in the above case, Bose-Einstein Statistics, application to black body radiation, distribution law of energy, Planck's radiation formula and Stefan's law. Fermi – Dirac statics, application in case of free electrons in metals, energy distribution, Fermi energy.

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

References:

1. Physics, Marcelo Alonso, J. Finn Edwards, Addison Wesley
2. Perspectives of Modern Physics, Arthur Beiser, McGraw Hill
3. Engineering Physics, R. K.Shukla, Pearson Education
4. Electrical Engineering Materials, R.K.Shukla, McGraw Hill
5. Introduction to Electrodynamics, David Griffiths, Cambridge University Press
6. Principles of Engineering Physics, R.K.Shukla, Ira Books
7. Introduction to Solid State Physics, Charles Kittel, Willey

List of Experiments:(Any ten experiments)

1. To determine the energy of band gap of a N-type Ge-semiconductor using four probe method
2. Verification of Stefan's fourth power law for black body radiation, determination of the exponent of the temperature
3. Study of thermoelectricity: Determination of thermo-power of Copper-constantan thermo-couple
4. To study the variation of magnetic field with distance along the axis of current carrying coil and then to estimate the radius of the coil
5. Study of Carrey Foster's bridge: determination of resistance per unit length of the bridge wire and of a given unknown resistance
6. Determination of specific charge (charge to mass ratio; e/m) for electron
7. Study of tangent galvanometer: determination of reduction factor and horizontal component of earth's magnetic field
8. Determination of the wavelength of sodium light using Newton Rings' method
9. To determine the concentration of sugar solution using half shade polarimeter
10. Determination of wavelength of spectral lines of mercury (for violet, green, yellow-1 and yellow-2) using plane transmission grating
11. Determination of charge sensitivity and ballistic constant of a ballistic galvanometer
12. To determine the wavelength of spectral lines of hydrogen & hence to determine the value of Rydberg Constant
13. Draw the V-I characteristic of Light Emitting Diode (LED) and determine the value of Planck's constant

Course Objectives (COs)

CO 1	To understand and apply principle of conservation of momentum, theory of relativity	**Understand and apply**
CO 2	To understand the basics of quantum mechanics and apply its principles to learn the phenomena that occur at subatomic dimensions.	**Understand and analyze**
CO 3	To understand the Maxwell's equations of electromagnetic theory with aim to apply in communication systems.	**Understand and analyze**
CO 4	To apply the fundamentals of material Science especially dielectric materials, semiconducting materials and nano- materials, to apply them in different areas	**Understand and apply**
CO 5	To understand the statistical behavior of the constituent particles and apply the principles of statistical mechanics and basics of laser	**Apply**

CO – PO Matrix

Course	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSOs	
BPH 101/102	CO1	3	3	1	2	1	2						1	**2**	**2**
	CO2	3	3	1	2	1	2						1	2	2
	CO3	3	3	1	2	1	2						1	2	2
	CO4	3	3	1	2	1	2						1	2	2
	CO5	3	3	1	2	1	2						1	2	2
	Average	3	3	1	2	1	2						1	2	2

Subject Code: EEE-101/102
Name of Subject: Basic Electrical Engineering

L	T	P	C
3	0	2	4

OBJECTIVE: The objective of this course is to educate the students about:
Various electrical components, connections, DC circuit analysis and basic network theorems applicable to dc network
Single-phase AC fundamentals and its analysis
Three-phase AC circuit connections and analysis under various load conditions
Various measuring instruments with construction, working principle and applications
Basic structure of power system
Concept of magnetic circuits, magnetic coupling and losses occurred in magnetic circuit
Construction and working of single-phase transformers
Basic principle of electrical ac/dc machines with their construction, working principle and applications

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

CO1	An exposure to common electrical components and their ratings.
CO2	Learning of electrical connections by wires of appropriate ratings.
CO3	Learning the usage of common electrical measuring instruments.
CO4	Understanding the basic characteristic of magnetic circuits and transformers
CO5	Understanding the basic characteristic of electrical machines.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1O	PO11	PO12
CO1	**3**	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**2**
CO2	**3**	**3**	**1**	**1**	**2**	**2**	**1**	**1**	**2**	**2**	**1**	**1**
CO3	**3**	**3**	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**2**	**1**	**1**
CO4	**3**	**3**	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**2**	**1**	**2**
CO5	**3**	**3**	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**2**	**1**	**2**
Avg.	**3**	**3**	**1.8**	**1.8**	**2**	**2**	**1.2**	**1.8**	**1.8**	**1.8**	**1**	**1.6**

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) ifthere is no correlation, put "-'

EEE 102: ELECTRICAL ENGINEERING

L T P
3 1 0

Unit I

1. DC Circuit Analysis and Network Theorems:

Circuit Concepts: Concepts of Network, Active and Passive elements, voltage and current sources, concept of linearity and linear network, unilateral and bilateral elements. R L and C as linear elements. Source Transformation.

Kirchhoff's Law; loop and nodal methods of analysis; star – delta transformation; Network Theorems: Superposition Theorem, Thevenin's Theorem, Norton's Theorem, Maximum Power Transfer Theorem. (Simple Numerical Problems) 9

Unit II

2. Steady – State Analysis of Single Phase AC Circuits:

AC Fundamentals: Sinusoidal, Square and Triangular waveforms – average and effective values, form and peak factors, concept of phasors, phasor representation of sinusoidally varying voltage and current. Analysis of series, parallel, and series – parallel RLC Circuits: Apparent, Active & Reactive Powers, Power factor, causes and problems of low power factor, power factor improvement. Resonance in Series and Parallel Circuits, Bandwidth and Quality Factor. (Simple Numerical Problems) 8

Unit III

3. Three Phase AC Circuits:

Three Phase System – its necessity and advantages, meaning of phase sequence and star and delta connections, balanced supply and balanced load, line and phase voltage / current relations, three phase power and its measurement. (Simple Numerical Problems) 3

Unit IV

4. Measuring Instruments:

Types of instruments: Construction and Working Principles of PMMC and Moving Iron type Voltmeter & Ammeters, Single Phase Dynamometer Wattmeter and Induction Type Energy Meter, use of Shunts and Multipliers. (Simple Numerical Problems on Energy Meter, Shunts and Multipliers) 4

Unit V

5. Introduction To Power System:

General layout of Electrical Power system and functions of its elements, standard transmission and distribution voltages, concept of grid. 2

EME-101/102: ENGINEERING MECHANICS

Course: B.Tech.	**Branch:** All Branches	**Year: 1st Year**
Sessional Marks:	**50**	**Credit: 3**
End Semester Exam:	**50**	**LTP: 3 0 0**

Objective: To provide the basic fundamentals of forces, moments, stresses and strains.

Prerequisite: Class XII Mathematics & Physics

Course Content:

Unit-1:

Two Dimensional Force Systems: Basic concepts, Laws of motion, Principle of Transmissibility of forces, Transfer of a force to parallel position, Resultant of a force system, Simplest Resultant of Two dimensional concurrent and Non-concurrent Force systems, Distributed force system, Free body diagrams, Equilibrium and Equations of Equilibrium, Applications.

Friction: Introduction, Laws of Coulomb Friction, Equilibrium of Bodies involving Dry-friction, Belt friction, Applications.

Unit-2:

Beam: Introduction, Shear force and Bending Moment, Differential Equations for Equilibrium, Shear force and Bending Moment Diagrams for Statically Determinate Beams.

Trusses: Introduction, Simple Truss and Solution of Simple truss, Method of Joints and Method of Sections.

Unit-3:

Centroid and Moment of Inertia: Centroid of plane, curve, area, volume and composite bodies, Moment of inertia of plane area, Parallel Axes Theorem, Perpendicular axes theorems, Principal Moment Inertia, Mass Moment of Inertia of Circular Ring, Disc, Cylinder, Sphere and Cone about their Axis of Symmetry.

Unit-4:

Simple Stress and Strain: Introduction, Normal and Shear stresses, Stress- Strain Diagrams for ductile and brittle material, Elastic Constants, One Dimensional Loading of members of varying cross-sections, Strain energy.

Compound stress and strains: Introduction, state of plane stress, Principal stress and strain, Mohr's stress circle, Theories of Failure.

Unit-5:

Pure Bending of Beams: Introduction, Simple Bending Theory, Stress in beams of different cross sections.

Torsion: Introduction to Torsion of circular shaft, combined bending & torsion of solid & hollow shafts.

Text and Reference Books:

1. Engineering Mechanics by R.K.Bansal
2. Strength of Materials by R.K. Rajput
1. Engineering Mechanics by Irving H. Shames, Prentice-Hall
2. Mechanics of Materials by E. P. Popov, PHI
3. Strength of Materials by Ryder
4. Mechanics of Material by Gere & Timoshenko

5. Engineering Mechanics by A. Nelson
6. Engineering Mechanics by U.C. Jindal
7. Engineering Mechanics Statics by J. L. Meriam & L.G.Kraige

Course Outcomes (COs)

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

CO1	Apply basic principal of mechanics and its application in engineering problems.	Understand,Apply
CO2	Determine resultants and apply conditions of static equilibrium to plane force systems.	Apply
CO3	Identify and evaluate all forces associated with a static framework.	Evaluate
CO4	Analyze and sketch shear force and bending moment diagrams.	Analyze
CO5	Derive and apply stress and strain relationships in single and compound members subject to axial force, bending moment and torsion.	Apply
CO6	Stress analysis for two dimensional stress systems.	Analyze

Course Articulation Matrix (CO-PO Matrix of the selected Courses)

Course	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSOs	
EME-101/ 102	CO1	3	3	3			1	1	1	1	1		1	3	3
EME-101/ 102	CO2	3	3	3									1	3	3
EME-101/ 102	CO3	3	3	3									1	3	3
EME-101/ 102	CO4		3	2	2								1	3	3
EME-101/ 102	CO5		3	2	2								1	3	3
EME-101/ 102	CO6		3	2	3								1	3	3
														3	**3**

HHS-101/102: ENGLISH LANGUAGE AND COMPOSITION

Course: B. Tech	Branch: All branches	Year / Semester: Ist Year
Sessional Marks:	50	Credit: 2
End Semester Exam:	50	LTP: 2 0 0

UNIT I Basic Applied Grammar and Usage:

Sentence structure-1: constituent of a sentence- noun, verb, adjective, preposition, etc.; use of articles, adjectival forms, prepositions, adverbs; verb forms; finite and non-finite verbs, gerund and participles, auxiliary verbs. Tense and mood, Subject- verb concord, pronoun concord

UNIT II Sentence Structure-2:

(i) adverb clause, adjective clause, noun-clause; (ii) negation and interrogation; (iii) passive; (iv) exclamatory; (v) transformations; (vi) tense forms; (vii) varieties of sentences; (viii) placement of modifiers

UNIT III Paragraph Writing:

Structure of Paragraph, Topic Sentence, Construction of Paragraph, Technique of Paragraph writing, Unity, Coherence, Emphasis

UNIT IV Comprehension and Précis Writing

Reading and listening comprehension, improving comprehension skills, précis writing

UNIT V Short Essay Writing

Dimension of essay writing- literary, Scientific, Comparison and Contrast, Narrative, Descriptive, Reflective, Expository, Argumentative and Imaginative

References:

1. Das, B K and A David, 'A Remedial Course in English for Colleges', (Book -1,2,3) Oxford University Press, New Delhi.

2. Sinha, R P, 'Current English Grammar and Usage with Composition', Oxford University Press, New Delhi.

3. Wren, P C & Martin, 'English Grammar and Composition', S Chand & Co Ltd. New Delhi.

4. A. S. Horne, Guide to Pattern and usage in English, Oxford University Press, N.D.

5. M.L. Tickoo& A. E. Subramanian, Intermediate Grammar, usage & composition, Orient Longman

Course Outcome:

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

CO1	Understand the various techniques of writing effectively and write professional statements & organizational communications.	Apply, Understand
CO2	Develop writing skills by applying different strategies on organization system.	Understand and apply
CO3	Will write articles, reports, projects and different organizational proposals differently and efficiently.	Apply, Create
CO4	Write in concise with brevity and coherency all the messages of the organization.	Analyze and Create

Course	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSOs	
IHU 101/102	CO1	0	0	0	0	0	0	0	0	2	3	0	1	**1**	**2**
	CO2	0	0	0	0	0	0	0	0	2	3	0	1	1	2
	CO3	0	0	0	0	0	0	0	0	2	3	0	1	1	2
	CO4	0	0	0	0	0	0	0	0	2	3	0	1	1	2
Average										2	3		1	1	2

HHS-103/104, HHS-401: PROFESSIONAL COMMUNICATION

Course: B. Tech & MCA	Branch: All	Year / Semester: Ist Year
Sessional Marks:	50	Credit: 3
End Semester Exam:	50	LTP: 2 0 2

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

UNIT II Elements of Written Communication:
Words and phrases, word formation, synonyms and antonyms, homophones, one word substitution, sentence construction, paragraph construction,

UNIT III Forms of Technical Communication:
(A) business letters, job application letter and resume, business letters: sales & credit letters, letters of enquiry, letters of quotation, order, claim and adjustment letters, official letters: D.O. letters, government letters, letters to authorities, etc. ,
(B) Technical Reports: general format of a report, formal and informal reports, memo report, progress report, status report, survey report, trip report, complaint report, , Joining Report ,laboratory report, research papers, dissertations and theses. E-mail writing
Technical Proposals: purpose, characteristics, types, structure

UNIT IV Presentation Strategies:
Defining the subject, scope and purpose, analysing audience & locale, collecting materials, preparing outlines, organising the contents, visual aids, nuances of delivery, extemporaneous, manuscripts, impromptu, non- verbal strategies.

UNIT V Value-based Text Reading:
(A) Study of the following essays from the text book with emphasis on writing skills:
1. Man and Nature by J. Bronowski
2. The Language of Literature and Science by Aldous Huxley
3. The Aims of Science &The Humanities by Moody E Prior
4. Gods in this Godless Universe by Bertrand Russell
5. Science and Survival by Barry Commoner

(B) Readings of selected short stories:
1. The Renunciation by Rabindranath Tagore
2. The Lament by Anton P. Chekhov
3. The Barber's Trade Union by Mulk Raj Anand
4. The Eyes Are Not Here by Ruskin Bond

Text Books:

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

Reference Books:

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

Course Outcome:

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

CO1	Understand the basics of technical communication	Apply, Understand
CO2	Developing the skills of variety of the words like synonyms and writing skills.	Understand
CO3	Draft a business letters and resume for to develop for industry.	Apply, Create
CO4	Explore the body language for perfect professional presentation.	Analyze and Create
CO5	To develop the humanistic & scientific approach towards life.	Create
CO6	Present themselves effectively and in a confident manner in the contemporary competitive market.	Apply

CO-PO Matrix

Course	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSOs	
HHS 103/104	**CO1**	0	0	0	0	0	0	0	0	2	3	0	1	**1**	**2**
	CO2	0	0	0	0	0	0	0	0	2	3	0	1	2	1
	CO3	0	0	0	0	0	0	0	0	2	3	0	1	2	1
	CO4	0	0	0	0	0	0	0	0	2	3	0	1	2	1
	CO5	0	0	0	0	0	0	0	0	2	3	0	1	2	2
average										2	3		1	1.8	1.4

Semester- 3

BMA-201, MATHEMATICS-III

L	T	P	C
3	1	0	4

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

- various mathematical tools likes Laplace/ Fourier transforms and their applications.
- concepts and principle of complex analysis in solving various real life problems.
- various statistical methods and tests for analyzing experimental data.

Course Outcome

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

CO1	solve boundary value problems using Laplace transform and Fourier transform methods and solve difference equations and BVP_S using z transform.	Apply, Evaluate
CO2	construct conformal mapping between many kinds of domains.	Understand, Apply
CO3	evaluate complex integrals, improper real integrals using various formulae/theorems. find Taylor and Laurents series expansion of complex functions.	Apply, Evaluate
CO4	estimate relationship between two variable using curve fitting, regression and its strength using correlation.	Understand, Apply
CO5	various parametric and nonparametric tests parameter estimation, hypothesis testing and ANOVA.	Understand, Apply

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

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	
CO1	3	3	3	3	2	1	2	1	1	-	1	3	**2**	**2**
CO2	3	3	3	3	2	1	2	1	1	-	1	3	2	1
CO3	3	3	3	3	2	1	2	1	1	-	1	3	2	1
CO4	3	3	3	3	1	1	-	-	-	-	-	2	2	2
CO5	3	3	3	3	1	2	3	2	2	1	1	2	2	2
Average	3	3	3	3	1.6	1.2	1.8	1	1	.5	.8	2.6	2	1.6

Detailed Syllabus:

Unit – I: Transform Methods:

Fourier integral, conditions of convergence, Fourier sine and cosine integrals, complex form, applications, Fourier transform pairs, existence conditions, operational properties. Applications of Laplace transform and Fourier transform to solve boundary value problems, Discrete and Fast Fourier transforms and its applications.

Development of difference equations as models, operator method, method of undetermined coefficients, Z-transform pairs, ROC. Operational properties, limiting- value theorems, its applications to solve difference equations and BVP, systems of difference equations.

Unit- II: Functions of a Complex Variable and Conformal mapping:

Limit, continuity, differentiability and analyticity, Cauchy-Riemann equations, harmonic functions, complex functions as mappings, liner transformation, inverse transformation, bilinear transformations, conformal mapping, applications.

Unit- III: Integration of Complex Functions:

Contour integrals and evaluations, Cauchy- integral theorem, Cauchy's integral formulae, Liouville's theorem, convergence of power series, Taylor series, Laurent series, zeros and singularities of a complex function, residues and residue theorem, Fundamental theorem of algebra Rouche's theorem, Argument Principle and maximum modules theorem, evaluation of definite and improper integrals.

Unit- IV: Curve- Fitting, Correlation, Regression and Probability:

Curve-fitting, method of least- squares, fitting of straight lines, polynomials, non-linear and exponential curves etc., correlation analysis, linear, non-linear and multi-regression analysis, probability, random variables and probability distributions, expectation, moments and transform methods, Binomial, Poisson and Normal distributions.

Unit- V: Statistical Methods:

Sampling theory (small and large), parameter estimation, confidence intervals, tests of hypotheses and significance; Overview of t-distribution, F-distributions and χ^2-distribution. Z-, t-, F-, and χ^2 tests, goodness of fit test- χ^2 test, analysis of variance, non-parametric tests (Simple application). time series analysis, index numbers, quality control charts.

Books Recommended:

1. Dennis G, Zill & Michael R. Cullen; Advanced Engineering Mathematics, Jones & Bartlett Publishers. 2nd Edition.
2. R.K. Jain & S.R.K. Iyengar; advanced Engineering Mathematics, Narosa Publishing House, 2002.
3 Erwin Kreyszig; Advanced Engineering Mathematics, John Wiley & Sons 8th Edition.
4. R.V. Churchill and J.L. Brown, Complex Variables and Applications, McGraw Hill, 1990.
5. J.N. Kapur and H.C. Saxena, Mathematical Statistics, S.Chand. & Co., 2001.
6. H.C. Saxena, Practical Mathematical Statistics, S. chand & Co., 2000.
7. J.H. Mathews and R.W. Howell, Complex analysis for Mathematics and Engineering, 3rd Ed. Narosa, 1998.

TCH-201 MATERIAL AND ENERGY BALANCE

Assessment:

Sessional: 50 marks

End Semester: 50 marks

L	T	P	C
3	1	0	4

Course Objective:

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

Course Outcome

Students completing the course will be able to

CO 1. Demonstrate comprehensive understanding of material and energy balance equations for open and closed systems.
CO 2. Select appropriate basis and conduct degree of freedom analysis before solving material and energy balance problems.
CO 3.Make elementary flow-sheets and perform material and energy balance calculations without and with chemical reactions, and involving concepts like recycle, bypass and purge.
CO4. Perform process calculations utilizing psychrometric charts and steam tables.
CO 5. Apply simultaneous material and energy balance calculations for steady state continuous flow systems and unsteady state systems.

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

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

Module 1 (9 hours)

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

Module 2 (7 hours)

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

Module 3 (8 hours)

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

Module 4 (8 hours)

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

Module 5 (8 hours)

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

Suggested Text books

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

Suggested Reference Books

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

TCH-211 FLUID MECHANICS&MECHANICAL OPERATIONS

L	T	P	C
3	1	3	5

Assessment:

Sessional: 50 marks

End Semester: 50 marks

Course Objective:

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

Course outcomes:

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

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

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

Module I (8 hours)

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

Module II (8 hours)

Macroscopic Balances: derivation of integral balances for mass, energy and momentum; Derivation of engineering Bernoulli equation with losses, Application of macroscopic balances: Losses in expansion, Force on a reducing bend, Diameter of a free jet; Jet ejector. Flow measurement: Orifice meter, venturi meter, Pitot tube, and Rota meter.

Module III (8 hours)

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

Module IV (8 hours)

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

Module V (8 hours)

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

Reference

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

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

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

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

TPL – 201 : POLYMER CHEMISTRY

L	T	P	C
3	1	6	6

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

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

Course Outcome

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

CO1	Understand the fundamentals types and properties of polymers.	Understand
CO2	Understand and apply the chain growth polymerization and it's kinetics.	Apply
CO3	Understand and apply the step growth polymerization, its kinetics, and crosslinking.	Apply
CO4	Analyze polymerization components for determination of molecular weight and molecular weight distribution of polymers, copolymers, etc.	Analyze
CO5	Understand and Analyze Co-polymerization and its types, ring opening polymerization.	Analyze
CO6	Apply knowledge of chemistry for analyzing polymerization components.	Apply

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Polymers and their characteristics.
2. Concepts of thermoset and thermoplastic Polymers.
3. Functionality requirements for Polymer synthesis.
4. Applications of different Polymers.

Course Outcome 2 (CO2)

1. Mechanism of chain growth polymerizations.
2. Kinetics of chain growth polymer.
3. Modes of Initiation and Termination.

Course Outcome 3 (CO3)

1. Crosslinking reaction with mechanism and significance.
2. Determination of kinetics of Step growth polymerization.
3. Relation between molecular weight and extent of conversion.

Course Outcome 4 (CO4)

1. Concept of molecular weight averages for polymers.
2. Molecular weight distribution and polydispersity.
3. Types of molecular weight averages and their determination.

Course Outcome 5 (CO5)

1. Copolymerization reaction and selection of monomers.
2. Types of copolymerization.
3. Ring Opening polymerization.

Course Outcome 6 (CO6)

1. Determination of polymer characteristics and purity.
2. Determination of purity of polymerization ingredients.
3. Identification of known and unknown polymers.

Syllabus

Module-I: Basics of Polymer formation

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

Module-II: Introduction to Polymers & polymerizations

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

Module -III: Condensation Polymerizations

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

Module-IV: Molecular Weight and its Control

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

Module-V: Copolymerization and other Reactions

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

Module-VI: Laboratory Experiments

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

Reference Books and Suggested Readings :

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

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Basics of Polymer formation**	
1.1	What are polymers and their development history	01
1.2	Salient features of polymers with advantages/ disadvantages	01
1.3	Formation of polymers of various types and it's relations to functionality	02
1.4	Glam transition Temp and its signification, Tm	01
1.5	Different type of monomers and polymers obtained with formula's	01
1.6	Degree of polymerization and mot. wt. calculation with examples	01
2.	**Introduction to Polymers and Polymerizations**	
2.1	Overview of Plastic Industry	01
2.2	Applications with reasons in various sectors for popular Plastics Materials	02
2.3	Classification of Polymers on various basis	02
2.4	Differences in major categories of plastics	02
2.5	Stereochemistry of polymers with examples	01
2.6	Kinetics of free radical polymerization	02
2.7	Different modes of initiation	02
3.	**Condensation Polymerization**	
3.1	Mechanism of condensation polymerization with examples	02
3.2	General characteristics of condensation polymerization	01
3.3	Kinetics of condensation polymerization	02
3.5	Carothers's equation	01
3.7	Crosslinking reactions and their significance	01
4.	**Molecular weight and it's control**	
4.1	Concept and types of molecular weight averages	02
4.2	Factors affecting molecular weight and its distribution	01
4.3	Effect of temperature on polymerization	01
4.4	Chain transfer reactions, retarders, inhibitors and their role	02

4.5	Control of molecular weight during polymer production	01
5.	**Co-polymerizations and other reactions**	
5.1	Concepts of Co-polymerization, suitability and significance	02
5.2	Important Co-polymer applications	01
5.3	Types of Co-polymers & their structures	02
5.4	Co-polymerization mechanism and kinetics	01
5.5	Ring opening Co-polymerization with examples and applications	01
	Total Hours	**40**
6.	**Laboratory Experiments**	
6.1	Determination of refractive index of organic compounds	03
6.2	Purification of monomers and determining the yield and refractive index of the purified monomer	06
6.3	Purification of solvent by washing and determination of yield	06
6.4	Determination of percentage purity of initiators, viz. benzoyl peroxide, AIBN, etc.	06
6.5	Determination of percentage purity of potassium persulphate	06
6.6	Determination of percentage purity of phenol	06
6.7	Determination of percentage purity of phenol for maldehye	06
6.8	Determination of density of given polymer sample that sinks in water	03
6.9	Determination of specific gravity of given moulded sample of plastic	03
6.10	Identification of known and unknown polymer (unprocessed and processed) samples	12
	Total hours	**57**
	G. Total:	**97**

HHS-203/204: ORGANIZATIONAL BEHAVIOR

Course: IIIrd B. Tech	Branch: CS/IT	Year / Semester: IIIrd Year
Sessional Marks:	50	Credit: 3
End Semester Exam:	50	LTP: 3 0 0

Objective:

- To identify organizational objectives, components and models for better results in attaining organizational goals;
- To understand individual behavior dimensions and interpersonal behavior;
- To analyze group, group behaviour, team and team building with its key role in organization;

Unit 1: Introduction to organizations

What is an organization, components of organization, nature and variety of organizations (in terms of objectives, structure etc.), models of analyzing organizational phenomena, organizational and business variables, organizations in the Indian context, institutions and structures,

Unit 2: Dimensions of Individual Behavior

Individual Behavior, Dimensions of individual behavior: Perceptions, Learning, Motivation, Personality, Commitment, Attitudes, Values & Ethics, Stress Management

Unit 3: Dimensions of Interpersonal Behavior

Transactional Analysis, Interpersonal communication, Listening, Feedback, Counseling,

Unit 4: Group Behavior

Leadership, Communication, Group: Formal Vs Informal Groups, Group Decision making, Team: Team building, team problem solving.

Unit 5: Organizational Dimensions

Organizational Structure: Elements of Organizational Structure, Dimensions of Organizational Structure, Organizational change, Organizational Development, Power, Authority, Politics

Test Books:

1. Luthans Fred., "Organizational Behavior", McGraw Hill, 1998
2. Pareek, Udai, "Understanding Organizational Behavior, Oxford university press

Additional Reference Books:

1. Robbins (4th ed.), "Essentials of organizational behavior", Prentice Hall of India Pv1. Ltd., New Delhi, 1995
2. Keith Davis, "Organisational Behaviour,
3. Hersey and Blanchard (6th ed.). "Management of organizational behavior L utilising human resources", Prentice Hall of India Pv1. Ltd., New Delhi, 1996.
4. Nancy J. Adler, “International Organisational behavior’, Cengage Learning
5. Nelson Quick, ‘Organizational Behaviour Function Learning’ Fifth Edition

Course Outcomes (COs)

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

CO1	Understand organisation, features, key elements, components, types and OB Models	Understand
CO2	Demonstrate individual behavioural dimensions, learning theories, perceptual process, values & ethics with motivational techniques in stressed situations.	Understand and apply
CO3	Identify mechanism for conducive survival of individual in an organization with interpersonal understanding.	Analyze and apply
CO4	Ascertain group, group behaviour, team building with its key role in organization	Analyze, evaluate and apply
CO5	Demonstrate organisational structure, organisational change, organisational development for achieving higher productivity and accomplishing goals of organisation	Analyze and evaluate

CO-PO Matrix

Course	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSOs	
HHS-203/204	CO1	0	0	0	1	0	1	1	1	2	2	1	3	**3**	**3**
	CO2	0	0	0	1	0	1	1	3	3	3	1	3	3	3
	CO3	0	0	0	1	0	2	1	3	3	3	2	3	3	3
	CO4	0	0	0	2	0	2	2	3	3	3	2	3	3	3
	CO5	0	0	0	2	0	1	2	2	2	2	2	3	3	3
Average					1.4		1.4	1.4	2.4	2.6	2.6	1.6	3	3	3

Semester- 4

BCY-202: MODERN ANALYTICAL TECHNIQUES

L T P C

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

3 0 3 4

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

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

Chemistry												
BCY101/ 102	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	2	-	1	-	-	-	-	3
CO2	3	3	2	3	2	-	1	-	-	-	-	3
CO3	3	3	2	3	2	-	1	-	-	-	-	3
CO4	3	3	2	3	2	-	1	-	-	-	-	3
CO5	3	3	2	3	2	-	1	-	-	-	-	3
CO6	3	3	3	3	2	2	2	2	1	2	-	3
Average	3	3	2.17	3	2	0.33	1.17	0.33	0.17	0.33	-	3

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

SYLLABUS

Module I

(i) *Infrared Spectroscopy*: Introduction, Principle, Instrumentation, mechanics of measurements, Selection rules, fundamental vibration modes, Factors influencing the Band Position and intensities, some characteristics frequencies and co-relation of IR spectra with molecular structures, effect of Hydrogen Bonding on vibrational frequencies.

(Lectures: 6-7)

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

(Lectures: 4-5)

Module II

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

(Lectures: 4-5)

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

(Lectures: 3-4)

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

(Lectures: 2-3)

Module III

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

(Lectures: 3-4)

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

(Lectures: 3-4)

Module IV

(i) *Chromatographic methods*: Introduction to Chromatographic methods: TLC, Column and Gas chromatography, Principles, Instrumentation, GC column, Detectors and stationary phases and applications, hyphenated techniques (GC-MS).

(Lectures: 4-5)

Liquid Chromatography LC/HPLC, Column efficiency in LC, Detectors, Instrumentation, Partition/Adsorption/Ion Exchange Chromatography

(Lectures: 4-5)

Module V

(i) *Thermal Methods of Analysis*: Thermogravimetric analysis, differential thermal analysis and differential scanning calorimetry and applications.

(Lectures: 4-5)

CHEMISTRY LAB

List of Experiments:

1. Estimation of vitamin C in commercial soft drink / Glucon D.
2. Determine the strength of oxalic acid conductometrically using sodium hydroxide solution.
3. Separation of amino acids by thin layer chromatography.
4. Determination of Rf value of Methyl Orange and Phenolphthalein using paper/ thin layer chromatography.
5. Separation of metal ions by paper/thin layer chromatography.
6. Determine the adsorption isotherm of oxalic acid/acetic acid on activated charcoal and verify the Freundlich adsorption isotherm.
7. Determine the rate constant (K) of hydrolysis of ethyl acetate catalyzed by HCL.
8. Prepare p-nitro acetanilide from acetanilide and find its percentage yield.
9. Determine the viscosity and percentage composition of the given liquid using Ostwald's viscometer.
10. Determine the strength of given glucose solution by titration against Fehling's solution.
11. Evaluation of Dissociation Constant k for a weak acid using conductometry.
12. Elution of chemicals by Column Chromatography.
13. Elution of genomic DNA from plants suspension.
14. Estimation of Phosphoric acid from coca cola.

Reference Books:

1. Instrumental Analysis, Douglas A. Skoog, F. James Holler & Stanley R. Crouch.
2. Instrumental Methods of Analysis, Willard, Merit and Dean.
3. Handbook of Instrumental Techniques for Analytical Chemistry Ronald A. Hites, Indian University, School of Public and Environmental Affairs and Department of Chemistry.
4. Applications of absorption spectroscopy of organic compounds, John R. Dyer.
5. Instrumental Methods Analysis, B. K. Sharma.
6. Text book of Quantitative Inorganic Analysis, A. I. Vogel.
7. Spectroscopy of Organic Compounds by P.S. Kalsi, Y.R. Sharma, Robert M. Silverstein & Francis X. Webster.

BMA-202, COMPUTER ORIENTED NUMERICAL METHODS

L	T	P	C
3	0	2	4

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

- various numerical methods for solving linear and non linear equations.
- various numerical techniques of interpolation, integration and differentiation with their applications.
- various numerical methods to solve IVP_S and BVP_S.
- developing computer programs of numerical methods using C/C^{++} language.

Course Outcome

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

CO1	find roots of nonlinear equations and solve systems of algebraic equations.	Apply, Evaluate
CO2	use interpolation techniques and to find numerical differentiation/ integration of data function.	Apply, Evaluate
CO3	use numerical methods for finding solutions of ordinary differential equations, simultaneous and higher order equations.	Apply, Evaluate
CO4	learn numerical methods for finding solution of initial and boundary value problems, partial differential equations.	Apply, Evaluate
CO5	learn basic concepts of some Finite element methods.	Apply, Evaluate
CO6	developing computer programs of numerical methods using C/C^{++} language.	Apply, Evaluate, Create

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	1	1	1	-	-	-	-	3
CO2	3	2	3	3	1	1	1	-	-	-	-	3
CO3	3	2	3	3	1	1	1	-	-	-	-	3
CO4	3	2	3	3	1	1	1	-	-	-	-	3
CO5	3	2	3	3	1	1	1	-	-	-	-	3
CO6	3	2	2	2	3	2	1	2	2	2	2	3
Average	3	2	2.83	2.83	1.33	1.16	1	.33	.33	.33	.33	3

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

Detailed Syllabus:

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

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

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

UNIT II: Interpolation, Differentiation and Integration:

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

UNIT III: Numerical Solution of Ordinary Differential Equations:

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

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

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

UNIT V: Finite Element Method:

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

NT Lab

Develop Programs of the following techniques in C/C++ Language:

1. To implement iterative methods to solve a nonlinear equation.
2. To implement iterative methods to solve a system of linear equations.
3. To implement Forward, Backward and Central difference interpolation formulae.
4. To implement Newton's divided difference and Lagrange's interpolation formulae.
5. To implement Numerical differentiation.
6. To implement Numerical integration using Trapezoidal, Simpson 1/3 and Simpson 3/8 rules.
7. To implement single step methods to solve initial value problems.
8. To implement multi step methods to solve initial value problems.
9. Solution of Heat equations (Parabolic equations) by finite difference method.
10. Solution of Laplace equations (elliptic equations) by finite difference method.
11. Solution of wave equations (Hyperbolic equations) by finite difference method.

Books Recommended:

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

TCH-212 HEAT TRANSFER

L	T	P	C
3	0	0	3

Assessment:

Sessional: 50 marks

End Semester: 50 marks

Course Objective:

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

Course outcomes:

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

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

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

Module 1 (6 hours)

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

MODULE 2 (6 hours)

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

MODULE 3(6 hours)

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

MODULE 4(6 hours)

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

MODULE 5(6 hours)

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

BOOKS:

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

TCH-214 CHEMICAL ENGINEERING THERMODYNAMICS

Assessment:

Sessional: 50 marks

End Semester: 50 marks

L	T	P	C
3	**0**	**0**	**3**

Course Objective:

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

Course outcomes:

CO 1. Understand the basic of thermodynamics and the terminology associated with engineering thermodynamics.

CO 2. Understand the knowledge of contemporary issues related to chemical engineering thermodynamics

CO 3. Understand and apply the knowledge of phase equilibria in two-component and multi-component systems.

CO 4. Analyzethe thermodynamic properties of substances in gas or liquid state of ideal and real mixture

CO 5. Understand intermolecular potential and excess property behaviour of multi-component systems

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

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

Module 1 (8 hours)

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

Module 2 (6 hours)

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

Module 3 (6 hours)

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

Module 4 (6 hours) Fugacity and fugacity coefficient for pure species and in solution, Ideal solution model and excess properties.Solution thermodynamics Application: Liquid phase properties from VLE data, Models for the excess Gibbs energy, Property changes of mixing.

Module 5 (4 hours) Phase Equilibria: Nature of equilibrium, phase rule, VLE qualitative behavior, Simple Models for VLE, VLE by Modified Raoultslaw and VLE from K-value charts.

Reference

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

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

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

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

TPL – 202 : POLYMERIZATION ENGINEERING – I

L T P C

3 1 3 5

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

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

Course Outcome

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

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

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Different parts of a polymerization plant.
2. Problems associated with polymerization.
3. Measurement and control in polymerization.

Course Outcome 2 (CO2)

1. Stereospecific catalysts.
2. Mechanism of stereospecific polymerizations.
3. Metallocene catalysts.

Course Outcome 3 (CO3)

1. Production and properties of Low density polyethylene (LDPE).
2. Production and properties of High density polyethylene (HDPE).
3. Production and properties of Poly propylene.

Course Outcome 4 (CO4)

1. Production and properties of phenol formaldehyde resins.
2. Production of molding powders and resins.
3. Synthesis of urea formaldehyde and Melamine formaldehyde resins and molding powder.

Course Outcome 5 (CO5)

1. Production of Polystyrene & PVC.
2. Properties of common Plastics.
3. Commercially important Copolymers.

Course Outcome 6 (CO6)

1. Learn and conduct bulk and solution polymerization techniques.
2. Learn and conduct emulsion and suspension polymerization techniques.
3. Learn about other polymerization techniques, determination of molecular weight.

Syllabus

Module-I: Industrial Polymerization

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

Module-II: Stereospecific Polymerizations

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

Module-III: Production of Commodity Thermoplastics

Manufacturing processes, properties and applications of various polyethylene such as LDPE, HDPE, and their copolymer grades, polypropylene and its copolymer grades.

Module-IV: Production of thermoset resins

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

Module-V: Production of polymers and copolymers of styrene & Vinyl chloride

Production technology, properties and application of Polystyrene, Polyvinylchloride, and their copolymer grades.

Module-VI: Laboratory Experiments

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

Reference Books and Suggested Readings :

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

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Industrial Polymerization**	
1.1	Part of a polymerization on plant	02
1.2	Polymerization reactors and related problems	01
1.3	Separation process	01
1.4	Types of production processes	01
1.5	Industrial techniques of Polymerization and applicability	01
1.6	Bulk & Solution	02
1.7	Emulsion & Suspension	02
2.	**Sterospecific Polymerizations**	
2.1	Sterospecific Polymerizations	02
2.2	Their types and mechanisms	02
2.3	Examples of Industrial importance	01
2.4	Supported cataysts and their working and significance	01
2.5	Metallocene Catalysts	02
3.	**Production of Commodity Thermoplastics**	
3.1	Manufacturing process, properties and application for low density, polyethylene	02
3.2	Manufacturing process, properties and application for high density, polyethylene	02
3.3	Manufacturing process, properties and application for Polypropylene	02
3.4	Copolymers of Ethylene and propylene	01
4.	**Production of polymers and copolymers of styrene & Vinyl chloride**	
4.1	Production technology, properties and applications of polystyrene	02
4.2	Copolymers of styrene	02
4.3	Production technology, properties and applications of Poly Vinyl chloride	02
4.4	Copolymers of Vinyl chloride	01
5.	**Production of thermoset resins**	

5.1	Chemistry involved in the production of both types phenol formaldehyde resins	02
5.2	Manufacture of Phenol formaldehyde resin & molding powder	02
5.3	Properties and applications of PF resins	01
5.4	Chemistry, production and properties of Urea formaldehyde resin	02
5.5	Chemistry, production and properties of melamine formaldehyde resin	01
	Total hours	**40**
6.	**Laboratory Experiments**	
6.1	Polymerization of given Technique. monomer by Bulk Polymerization	03
6.2	Polymerization of given monomer by Solution Polymerization Technique.	03
6.3	Polymerization of given monomer by Suspension Polymerization Technique.	06
6.4	Polymerization of given monomer by Emulsion Polymerization Technique.	06
6.5	Preparation of Resol - type PF resin	03
6.6	Preparation of Novolac - type PF resin	03
6.7	Determination of molecular weight of polystyrene using Ostwald viscometer	03
6.8	Determination of K-value of PVC using Ostwald viscometer	03
	Total hours	**30**
	G. Total:	**70**

HHS-201/202: ENGINEERING ECONOMICS AND MANAGEMENT

L	T	P	C
3	0	0	3

Course: B. Tech.	**Branch:** All Branches	**Year: 2nd Year**
Sessional Marks:	**50**	**Credit: 3**
End Semester Exam:	**50**	**LTP: 3 0 0**

Objective:

- ✓ To provide useful knowledge to engineering students in their professional career particularly in corporate and manufacturing sector.
- ✓ To understand essential economic principles for solving economic problems with suitable policy alternatives.
- ✓ To study and analyze the contemporary market situations, market strategy to manage the business and industry.
- ✓ To understand fundamental of business management and apply management techniques for the benefit of business and society.

UNIT I Introduction to Economics:
Overview: production possibility curve, choices-what, how and for whom, micro- and macro economics, inflation, unemployment, GDP and business cycle; demand and supply, elasticity of demand, consumer surplus and its applications, utility theory.

UNIT II Production and Cost:
Factors of production, production function, law of variable proportion, isoquant analysis, return to scale, economies of scale;
Types of costs: direct and indirect costs, explicit and implicit costs, opportunity cost, economic cost, fixed cost and variable costs, average and marginal costs, short-run and long-run costs, optimal combination of factor-inputs.

UNIT III Market Structure:
Perfectly Competitive Market, Imperfect market: Monopoly, Oligopoly, Monopolistic Market

UNIT IV Fundamentals of Management:
Development of Management Thoughts, Objectives, Functions of Management: Planning, Organising, Directing, Controlling and Coordination.

UNIT V Business Enterprises-
Business Ownership: Sole Proprietorship, Partnership, Company: Promotion, Formation & Development, Cooperative Firms.

Text Books:

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

Additional Reference Books:

1. **Armstrong, Michel**, "A Handbook of Management Techniques", Kogan Page Limited
2. **Babcock, D L and Lucy C Morse**, "Managing Engineering and Technology", third edition, Pearson Education, 2006

3. **Pindyck, R S, Rubinfeld, D L &Mehta** , 'Microeconomics', 6th Edition, Pearson Education India.
4. **Barthwal, R R , Microeconomic Analysis**
5. **Samuelson, Paul A** , 'Economics', 5th edition, McGraw Hill New York.
6. **Henderson, J M and Quadnt, R E** , 'Microeconomic Theory: A Mathematical Approach.', Tata MacGraw Hill, New Delhi,2003
7. **H. Varian,** 'Intermediate Micro Economics'
8. **G. Mankiw,''**Principles of Micro Economics

Course Outcome (COs)

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

CO1	Understand essential economic principles for solving economic problems with suitable policy alternatives	Understand
CO2	Understand and evaluate the production system with different type of cost.	Understand, evaluate
CO3	Study and analyse the market, structure, types and characteristics	Analyze and apply
CO4	Understand fundamentals of management principles and functions	Understand and apply
CO5	Know various forms of business ownership, formation and their relevance	Analyze, evaluate and apply

CO-PO Matrix

Course	CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSOs**	
HHS-201/202	CO1	0	0	0	1	0	2	1	3	1	3	3	3	**1**	**2**
	CO2	1	0	0	0	0	2	1	3	3	3	3	3	2	1
	CO3	0	0	0	1	0	2	2	3	2	3	3	3	1	2
	CO4	0	0	0	0	0	2	2	3	3	3	3	3	1	2
	CO5	0	0	0	0	0	2	3	3	3	2	3	3	3	2
average		0.2	0	0	0.4	0	2	1.8	3	2.4	2.8	3	3	1.6	1.8

SEMESTER- 5

TCH 315 MASS TRANSFER OPERATION

L	T	P	C
3	1	0	4

Assessment:

Sessional: 50 marks

End Semester: 50 marks

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

Course outcomes:

CO1. Understand the principles of molecular diffusion and basic laws of mass transfer.

CO2. Ability to determine mass transfer rates using Fick's Law

CO3. Estimate diffusion coefficients

CO4. Ability to determine convective mass transfer rates

CO5. Analyze the Similarity of mass, heat and momentum transfer – Analogy and understand the humidification processes and use of psychometric chart

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

Module I (8 hours)

Mass Transfer and Diffusion: Steady-state ordinary molecular diffusion: Fick's law of diffusion; Velocities in mass transfer, Equimolar counterdiffusion; unimolecular diffusion, Diffusion coefficients: Diffusivity in gas mixtures, diffusivity in liquid mixtures, Diffusivity in solids, One-dimensional, steady-state, molecular diffusion through stationary media, Mass transfer in turbulent flow: Reynolds analogy;

Chilton-Colburn analogy; Other analogies, Models for mass transfer at a fluid-fluid interface: Film theory; Penetration theory; surface-renewal theory; film-penetration theory, Two-film theory and overall mass transfer coefficients. Introduction to absorption.

Module II (8 hours)

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

Module III (8 hours)

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

Module IV (8 hours)

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

Module V (8 hours)

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

BOOKS:

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

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

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

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

TCH-317 CHEMICAL REACTION ENGINEERING

L	T	P	C
3	1	0	4

Assessment:

Sessional: 50 marks

End Semester: 50 marks

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

Course Outcomes:

CO1. Able to develop an understanding of the basic concepts involved in using reaction rate equations and kinetic constants.

CO2. Perform derivations of rate equations for non-elementary reactions both in homogenous and in heterogeneous reacting systems.

CO3. Able to understand the role of temperature and concentration in the rate equation.

CO4. Perform constant volume batch reactor calculations

CO5. Develop calculations using the integral method and applying differential method of analysis using reactions with different orders.

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

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

Module I (8 hours)

Rate of Reaction, Elementary and non-elementary homogeneous reactions, Molecularity and order of reaction, Mechanism of reaction, temperature dependency from thermodynamics, collision and activated complex theories. Integral and differential methods for analyzing kinetic data, interpretation of constant volume reactor, zero, first, second and third order reactions, half life period, irreversible reaction in parallel and series, catalytic reaction, auto catalytic reaction, reversible reactions.

Module II (8 hours)

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

Module III (8 hours)

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

Module IV (8 hours)

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

Module V (8 hours)

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

Reference Books:

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

TPL –301: POLYMER PROCESSING – I **L T P C**

3 0 0 3

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

- To understand the various processing techniques of plastic materials.
- To learn the fundamentals of Extrusion and different extrusion processes of thermoplastic.
- To learn the basic principle of compounding of thermoplastics and calendaring process.

Course Outcome

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

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

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Description of extrusion process and its components.
2. Melting mechanism and optimization of extruder performance, Die characteristics and screw characteristics curves.

Course Outcome 2 (CO2)

1. Different screw zones and their importance; specifications for extruder viz. compression ratio and L/D ratio.
2. Design of screws for different plastics like PE/PP, PVC, etc.
3. Types of twin screw extruder, importance and utility of co-extrusion process.

Course Outcome 3 (CO3)

1. Description of process operations for various extruded plastic products like film, pipe, wire coating etc.

2. Comparison of various post processing operations involved.
3. Reactive extrusion processing.

Course Outcome 4 (CO4)

1. Functions of various compounding additives used for plastics.
2. Effect of these additives on performance of plastics.
3. Compounding and blending equipment.
4. Methods for finishing of plastics.

Course Outcome 5 (CO5)

1. Description of various steps for calendaring process.
2. Process variables for calendaring of plastics and their effects on product.
3. Various calendar arrangements and their utility.

Syllabus

Module-I: Introduction to Polymer Processing and Extrusion

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

Module-II: **Fundamentals of Extrusion Process of Polymers**

Fundamentals of single screw extrusion, twin screw extrusion and co-extrusion operation; Construction of Barrel and screw for commodity, heat sensitive and engineering plastics.

Module-III: Extrusion Processes for plastic products

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

Module-IV: Compounding of Polymers

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

Module-V: Calendaring of plastics

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

Reference Books and Suggested Readings :

1. Plastics Extrusion, by Allen Grief
2. Plastic Engineering Handbook (SPI), by Frados
3. Screw extrusion of Plastics, by Jacobi

4. Plastic materials and processes (a concise encyclopedia), by Charles Harper
5. Polymer Mixing and Extrusion Technology, by Nicholas Cheremisinoff
6. Plastics Extrusion Technology, Hanser SPE, 1996
7.

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Introduction to Polymer Processing and Extrusion**	
1.1	Concept of plastic processing and short description of different processing techniques	01
1.2	Basic Extrusion process the types of extruders used, extruder design and construction	01
1.3	Different zones of extruders	02
1.4	Solid conveying and melting mechanisms of plastics during extrusion	03
1.5	Performance of extruder, die and screw characteristics curves	02
2.	**Fundamentals of Extrusion Process of Polymers**	
2.1	Design of screw for different types of plastics	03
2.2	Concepts of die Design and its utility in extrusion	01
2.3	Concept co-extrusion and variety of co-extruders used, operation of co-extruder	02
3.	**Extrusion Processes for plastic products**	
3.1	Extrusion Process for production of plastic film	02
3.2	Extrusion process for production of plastic pipe	02
3.3	Extrusion Process for production of plastic profiles	02
3.4	Extrusion Process for production for wire coating	02
3.5	Casting of films	01
3.6	Reactive extrusion	02
4.	**Compounding of Polymers**	
4.1	Importance of compounding in plastics	01
4.2	Compounding additives and their functions	02
4.3	Effect of compounding additives on performance and processing of plastics	02
4.4	Compounding equipments like Banbury mixer, etc.	02
4.5	Importance and methods of finishing of plastics	02
5.	**Calendaring of plastics**	
5.1	Basic concepts of Calendaring process	01
5.2	Preparation of plastic paste and plastisol for calendaring	02
5.3	Calendar roll arrangements	01
5.4	Description of process for making Calendared products	01
	Total hours	**40**

TPL –303: RHEOLOGY AND TESTING OF POLYMERS

L	T	P	C
3	0	6	5

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

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

Course Outcome

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

CO1	Understand the fundamentals of polymer rheology.	Understand
CO2	Apply mathematical models to interpret the flow behaviour of polymer melts.	Apply
CO3	Understand and apply the concept of measurement of viscosity and apply knowledge in handling rheological instruments.	Apply
CO4	Understand and apply testing of plastics materials for its mechanical, electrical, optical, and thermal properties.	Apply
CO5	Apply characterization techniques viz. FTIR, NMR, TGA & DSC to elucidate the properties of polymers.	Apply
CO6	Analyze testing of plastic materials on different testing equipments.	Analyze

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	1	1	1		3						3	3	3
CO2	3	2	2	2		3						3	3	3
CO3	3	3	3	2		3		1				3	3	3
CO4	3	3	3	2	2	3	1	1	3			3	3	3
CO5	3	3	3	2	2	3	1		3	1		3	2	3
CO6	3	3	3	2	2	3	3		3	1		3	3	3
Total	**3**	**2.5**	**2.5**	**1.8**	**2**	**3**	**1.2**	**1**	**3**	**1**		**3**	**3**	**3**

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

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Introduction to polymer rheology and importance of rheology on polymer processing techniques such as extrusion, injection moulding, etc.
2. Different view point of polymer rheology and it's correlation with theory of mechanics.
3. Newtonian and non-Newtonian fluids, concept of stress, strain-rate and viscosity, elastic and viscous responses.
4. Time-independent and time dependent fluids, concept of viscoelastic behavior, constitutive equations.

Course Outcome 2 (CO2)

1. Mechanical models – Maxwell and Kelvin models and it's correlation with deformation and flow of polymers, relaxation, creep and oscillatory experiments.
2. Concept of normal stresses and viscous heat generation and its importance for polymer deformation and flow.

Course Outcome 3 (CO3)

1. Concept of time-temperature sensitivity of viscoelastic solids and liquids.
2. Viscometers and Rheometers to measure polymer viscosity.

Course Outcome 4 (CO4)

1. Concept of polymer testing, different standard test methods.
2. Method, instrumentation and limitations of various thermal and mechanical test methods.
3. Methods, instrumentation and limitations of various electrical and optical test methods.

Course Outcome 5 (CO5)

1. Structural elucidation by Fourier-transform infra-red and nuclear magnetic resonance (NMR) spectrophotometers.
2. Thermal characterization by thermogravimetric analyzer (TGA) and Differential scanning calorimeter (DSC).

Course Outcome 6 (CO6)

1. Determination of various thermal and mechanical properties by standard test machines and it's correlation with actual performance.
2. Determination of viscosity.
3. Determination of polymer yield by microwave synthesizer.

Syllabus

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

Module-II: Mechanical Models and Polymer Rheology
Mechanical models, discussion of models for flow and deformation in polymers and treatment of measurable rheological properties

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

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

Module-V: Characterization of Polymers

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

Module-VI: Laboratory Experiments

Determination of Tensile Strength and Percent Elongation of polymer film/sheet/molded plastic specimen, Determination of the Izod/Charpy Impact Strength of given specimen, Determination of the Vicat Softening point/Melt Flow Index of given plastic sample, Determination of the Shore A Hardness of Rubber Sheet, Determination of the Percent Water Absorption in 24 hours of Molding Plastic samples, Determination of the Falling Dart Impact Strength of polyethylene film, Determination of viscosity of polymer by Brookefield viscometer, Determination of polymer yield by microwave synthesizer.

Reference Books and Suggested Readings :

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

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Basics of polymer rheology**	
1.1	Introduction to polymer rheology, concept of stress, strain, shear rate and viscosity, concept of elastic and viscose responses	02
1.2	Importance of rheology on polymer processing techniques such as extrusion, injection moulding, etc., Quality control	02
1.3	Newtonian and non-Newtonian Fluids, Flow behavior of polymer melts and solutions, Shear-rate dependence, temperature dependence, molecular-weight dependence, etc on viscosity	02
1.4	Time-independent and time-dependent fluids	02
1.5	Viscoelastic behavior, constitutive equations	02
2.	**Mechanical Models and Polymer Rheology**	
2.1	Role of mechanical models in polymer rheology, mechanical analogies	02
2.1	Discussion on flow and deformation in polymers by different mechanical models	02
2.2	Concept of relaxation, creep and oscillatory experiments	02
2.3	Treatment of measurable rheological properties	02
3.	**Measurement of Viscosity and Rheometers**	
3.1	Discussion on measurement of viscosity and normal stresses	01
3.2	Viscous heat generation – concept and application in polymers	02
3.3	Interpretation of time-temperature sensitivity of viscoelastic solids and liquids	02

3.4	Different types of viscometers and rheometers for the measurement of polymer viscosity	02
4.	**Testing of Polymer Properties**	
4.1	Testing and its importance	01
4.2	Testing of various mechanical properties, viz. tensile strength, elongation-at-break, modulus, izod/charpy impact strength, falling dart impact strength	02
4.3	Testing of various thermal properties, viz. MFI, Vicat softening point heat distortion temperature, etc	02
4.4	Testing of various optical properties, viz. haze, transparency, etc.	02
4.5	Testing of various electrical properties, viz. dielectric constant, power factor, etc.	02
5.	**Characterization of Polymers**	
5.1	Structural elucidation by Fourier-transform infra-red and nuclear magnetic resonance (NMR) spectrophotometers	02
5.2	Thermal characterization by thermogravimetric analyzer (TGA) and Differential scanning calorimeter (DSC)	02
5.3	Other characterization techniques	02
	Total:	**40**
6.	**Laboratory Experiments**	
6.1	Determination of Tensile Strength and Percent Elongation of polymer film/sheet	06
6.2	Determination of the Vicat Softening point of given plastic sample on Vicat Softening Point apparatus	06
6.3	Determination of Tensile strength, Modulus and Percent Elongation of moulded plastic test specimen on Microprocessor Controlled Universal Testing Machine (U.T.M)	06
6.4	Determination of the Izod/Charpy Impact Strength of given specimen	06
6.5	Determination of the Melt Flow Index of polymer raw material by MFI tester	06
6.6	Determination of the Shore A Hardness of Rubber Sheet	06
6.7	Determination of the Percent Water Absorption in 24 hours of Moulding Plastic samples	06
6.8	Determination of the Falling Dart Impact Strength of polyethylene film using Falling Dart Impact Tester	06
6.9	Determination of viscosity of polymer by Brookefield viscometer	06
6.10	Determination of polymer yield by microwave synthesizer	06
	Total hours	**60**
	G. Total:	**100**

EME-325 ENERGY CONVERSION SYSTEMS & DEVICES

L	T	P	C
3	0	0	3

Unit I

Properties of steam

Pure substance, Property of steam, Triple point, Critical point, Sub-cooled liquid, Saturation states, Superheated states, Phase transformation process of water, Graphical representation of pressure, volume and temperature, P-T & P-V diagrams, T-S and H-S diagrams, use of property diagram, Steam- Tables & Mollier charts, Dryness factor and it's measurement, Simple Rankine cycle.

Unit II

Zeroth Law, First Law and Second Law of Thermodynamics, Entropy, Enthalpy.

Boilers: Steam generators-classifications. Working of fire-tube and water-tube boilers, boiler mountings & accessories, Draught & its calculations, air pre heater, feed water heater, super heater. Boiler efficiency, Equivalent evaporation. Boiler trial and heat balance.

Condenser: Classification of condenser, Air leakage, Condenser performance parameters

Unit III

Classifications of centrifugal pumps, Vector diagram, Work done by impellor, Efficiencies of centrifugal pumps, Specific speed, Model testing, Cavitation, Separation and their control, Performance characteristics.

Positive Displacement Pumps: Reciprocating pump theory, Slip and coefficient of discharges, Indicator diagram, Effect and acceleration, Work saved by fitting air vessels, Comparison of centrifugal and reciprocating pumps, Positive rotary pumps, Gear and Vane pumps, Performance characteristics. Hydraulic accumulator, Special duty pumps, Intensifier, Hydraulic press, Air lift pumps.

Unit IV

Compressors, their classification**,** Atomizers, Centrifuges, Steam ejectors, homogenizers, chillers

Design of pressure vessels - thick and thin cylinders, pipe and joints, flanges and valves.

Unit V

Internal Combustion Systems, Introduction: Otto Diesel cycles, 2/4 stroke engines, thermal efficiency. Knocking and detonation.

Textbooks:

1. Thermodynamics : An Engineering Approach by Cengel & Boles, Mc Graw Hill
2. Hydraulic Machines: Theory & Design, V.P.Vasandhani, Khanna Pub

Reference Books:

1. Hydraulic Machines by Jagdish Lal, Metropolitan book co. pvt ltd.
2. Thermodynamics by J.P. Holman, McGraw Hill.

Course Objective:

This course is meant for technology branches students, offered by mechanical engineering department is basically designed for making them aware with some common mechanical concepts, laws and systems which is used by technology branch students.

Course Outcome:

After studying this subject students will be able to:

CO1	Apply fundamentals of thermodynamics to analyze systems that use steam as working substance.	Apply
CO2	Use and apply basic laws of thermodynamics basic laws of thermodynamics to analyze thermal systems like Boilers and condensers	Analyze
CO3	Elucidate working and performance of hydraulic pumps like centrifugal pump and reciprocating pump.	Evaluate/Apply
CO4	Gain knowledge to various thermal systems used in normal practice like centrifuges, atomizers, homogenizers etc also to design pressure vessels - thick and thin cylinders, pipe and joints, flanges and valves	Evaluate/ Design
CO5	Be knowledgeable to Two stroke/ Four stroke IC Engines and their cycles	Evaluate

CO-PO Matrix

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

HHS-341/342: ENTREPRENEURSHIP DEVELOPMENT

L	T	P	C
3	0	0	3

Course: B.Tech	**Branch: All**	**Year / Semester: Final Year**
Sessional Marks:	**50**	**Credit: 3**
End Semester Exam:	**50**	**LTP: 3 0 0**

UNIT I Entrepreneurship:
Definition, requirements to be an entrepreneur, entrepreneur and intrapreneur, entrepreneur and manager, growth of entrepreneurship in India, women entrepreneurship, rural and urban entrepreneurship.
Entrepreneurial Motivation: motivating factors, motivation theories-Maslow's Need Hierarchy Theory, McClelland's Acquired Need Theory, government's policy actions towards entrepreneurial motivation, entrepreneurship development programmes.

UNIT II Business Enterprises and Ownership Structure:
Small scale, medium scale and large scale enterprises, role of small enterprises in economic development; proprietorship, partnership, companies and co-operatives firms: their formation, capital structure and source of finance.

UNIT III Project Management:
Identification and selection of projects; project report: contents and formulation, concept of project evaluation, methods of project evaluation: internal rate of return method and net present value method.

UNIT IV Management of Enterprises:
Strategy & policy, introduction to human resource management, marketing strategies, financial management & strategies: raising and managing capital, shares, debentures and bonds, cost of capital; break- even analysis.

UNIT V Institutional Support and Policies:
Institutional support towards the development of entrepreneurship in India: Institutional framework, venture capitalist; technical consultancy organizations (TCOs), government policies for small scale enterprises.

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References:

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

Additional Reference Books

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

Course Outcome (COs)

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

CO 1	Describe what it takes an Entrepreneur; describe multiple ways to become an entrepreneur; including, intrapreneur, and manager, woman entrepreneur rural & urban: highlights motives to become entrepreneur	Understand
CO2	Apply the beginner concept, ownership and various forms with focus on small scale enterprises	Understand, Analyse, Apply
CO3	Identify opportunities using identification; project conceptualisation, formulation & evaluation	Analyse, Apply, Evaluate
CO4	Identify potential contribution of human resources, marketing, financial and strategic management with fund, opportunities	Analyse, Create
CO5	Decipher the role of Institution support and policy framework of Government for enterprises in India	Analyse, Apply

CO-PO Matrix

Course	CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSOs	
HHS 341/342	**CO1**	0	0	0	0	0	1	1	1	0	0	3	2	**2**	**2**
	CO2	0	0	1	0	0	1	1	1	1	0	3	2	2	2
	CO3	1	2	2	1	2	1	1	1	1	0	3	1	2	1
	CO4	0	0	1	0	1	1	1	2	1	1	3	2	2	2
	CO5	1	1	1	0	0	1	1	1	0	1	2	2	2	1
average		0.4	0.6	1	0.2	0.6	1	1	1.2	0.6	0.4	2.8	1.8	2	1.6

SEMESTER- 6

TCH 316 INSTRUMENTATION & PROCESS CONTROL

L	T	P	C
3	1	3	5

Assessment:

Sessional: 50 marks

End Semester: 50 marks

Course Objectives:

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

Course outcomes:

CO 1. Understand and interpret control diagrams

CO 2. Design and tuning of controllers for specific applications

CO 3. Calculate the dynamic response of closed loop systems

CO 4. Understand the principles involved in measurements, Attain knowledge on different measurement methodsemployed in industrial processing and manufacturing.

CO5. Understand and Analyze thedifferent temperature measurement devices in Chemical industries.

CO6. Analyze and create the instruments and experimental setup for pilot plant/ lab work.

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

Module 1 (8 hours)

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

Module 2 (8 hours)

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

Module 3 (8 hours)

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

Module 4 (8 hours)

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

Module 5 (8 hours)

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

Suggested Text Books

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

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

TPL–302: STRUCTURE AND PROPERTY OF POLYMERS

L	T	P	C
3	1	0	4

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

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

Course Outcome

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

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

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Concept of polymer and classification of polymers.
2. Salient features of basic structure of polymers.
3. Various parameters to establish a relation between the structure of polymer and its physical properties.
4. Role of chain extending bond, intermolecular forces and chemical stability to establish a structure-property relationship in polymers.

Course Outcome 2 (CO2)

1. Concept of average molecular weight (MW) in polymers, various types of molecular weight averages and establishment of mathematical equations for these averages.
2. Importance of molecular weight averages in polymer processing.
3. Determination of different types of molecular weights of polymers by different instrumental techniques and importance of each.
4. Concept of molecular weight distribution (MWD) and MWD curve.
5. Correlation of MW and MWD with the properties of polymers.

Course Outcome 3 (CO3)

1. Concept of crystallinity and crystallisability, requirements of crystallinity in polymers.
2. Structure of polymer on the basis of given models.
3. Difference between melting of low and high molecular weight substances.
4. Concept of polymer melting and thermodynamics of melting.
5. Effect of crystallinity on mechanical properties and molecular weight of polymers.

Course Outcome 4 (CO4)

1. Fractionation in polymers and fractionation techniques.
2. Flory-Huggin's theory.
3. Solution viscosity and empirical relationship between viscosity-average molecular weight and viscosity.
4. Concept of solubility of polymer, solubility parameter, different polymer-solvent systems and their solubility.

Course Outcome 5 (CO5)

1. Concept of flexibility and glass transition temperature (Tg) of polymers.
2. Significance of Tg on the basis of states of aggregation and phases.
3. Factors affecting glass transition temperature.
4. Effect of copolymerization on properties.
5. Concept of degradation behaviour of polymers.

Syllabus

Module-I: General Structural Features of Polymers

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

Module-II: Molecular weight averages and Molecular mass heterogeneity

Molecular weight averages and distributions. Determination of molecular weight averages. Polydispersity and MWD.

Module -III: Polymer Crystallinity and its measurement

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

Module-IV: Polymer-in-solution

Polymer-solvent interaction, good and poor solvents, intrinsic viscosity and Mark-Houwink equation, concept of fractionation processes.

Module-V: Flexibility and movement of macromolecules

Concept of flexibility, various factors deciding flexibility of polymers, polymer properties affected by flexibility, glass transition temperature (Tg), factors affecting glass transition temperature. Effect of copolymerization on properties. Degradation behaviour of polymers.

Reference Books and Suggested Readings :

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

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**General Structural Features of Polymers**	
1.1	Concept of polymer, classification of polymer, salient features of basic structure of polymers	02
1.2	Various parameters to establish a relation between the structure of polymer and it's physical properties	02
1.3	Role of chain extending bond and intermolecular forces to establish a structure-property relationship in polymers	02
1.4	Role of chemical stability to establish a structure-property relationship in polymers	01
2.	**Molecular weight averages and Molecular mass heterogeneity**	
2.1	Concept of molecular weight average in polymer, comparison with low molecular weight compounds, polydispersity	02
2.2	Various types of molecular weight averages and establishment of mathematical equations for these averages	02
2.3	Importance of molecular weight averages in polymer processing	01
2.4	Determination of different types of molecular weights of polymers by different instrumental techniques and importance of each	04
2.5	Correlation of MW and MWD with the properties of polymers	02
3.	**Polymer Crystallinity and it's measurement**	
3.1	Concept of crystallinity, degree of crystallinity, and crystallisability in polymers, requirements for crystallinity	02

3.2	Proposed models for partially crystalline polymers, spherulites, unit cell, polymer single crystal	02
3.3	Theory of polymer crystallization	02
3.4	Determination of crystallinity	02
3.5	Effect of crystallinity on polymer properties	02
4.	**Polymer-in-solution**	
4.1	Polymer-solvent interaction, good and poor solvents, solubility parameter, calculation of solubility parameter for different polymers	02
4.2	Concept of intrinsic viscosity and determination of viscosity average molecular weight by Mark-Houwink's equation	02
4.3	Concept of fractionation and various fractionation processes	02
5.	**Flexibility and movement of macromolecules**	
5.1	Concept of flexibility, various factors deciding flexibility of polymers, polymer properties affected by flexibility	03
5.2	Glass transition temperature (Tg) and factors affecting glass transition temperature	02
5.3	Effect of copolymerization on properties	02
5.4	Degradation behaviour of polymers, types of degradation, role of degradation in polymer properties	03
	Total hours	**45**

TPL–304: POLYMER PROCESSING – II

L	T	P	C
3	0	6	5

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

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

Course Outcome

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

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

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Types of Injection units and their construction viz. injection unit, clamping unit, nozzle, etc.
2. Specifications of injection molding machines and process variables and determination of clamping force, etc.

3. Different elements of plasticization process of plastic in screw
4. Faults and remedies in injection molding operation
5. Gas assist injection molding

Course Outcome 2 (CO2)

1. Description of compression and transfer molding operation
2. Description of thermoset injection molding operation
3. Comparisons of different types of processes for thermoset polymers

Course Outcome 3 (CO3)

1. Material characteristics important for thermoforming process
2. Utility of thermoforming process for plastic products
3. Process parameters for thermoforming process
4. Defects and faults for thermoforming process

Course Outcome 4 (CO4)

1. Process description of Injection Blow Molding and Extrusion Blow Molding processes
2. Co-relation between process parameters and molding faults
3. Process description of Rotational Molding Process

Course Outcome 5 (CO5)

1. Process description for Reaction Injection Molding for polyurethane products
2. Description of casting process for epoxy resin, nylon, acrylics, etc.

Course Outcome 6 (CO6)

1. Formation of articles by using Laboratory scale processing machines for forming different plastic products.
2. Analyze variation in process parameters for preparation of different specimens and then testing.

Syllabus

Module-I: Injection Molding of Thermoplastics

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

Module-II: Molding Processes for Thermoset polymers

Concept of Injection molding of thermoset polymers and process details. General concept of compression and transfer molding process, the description of various types of compression and transfer molding processes and their utility in processing of thermosetting materials.

Module-III: Thermoforming Process

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

Module-IV: Molding Process for hollow products

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

Module-V: In-situ Reaction Molding process

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

Module VI: Laboratory Experiments

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

Reference Books and Suggested Readings :

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

Course contents and lecture schedule

Module	Topic	No. of Lectures
1.	**Injection Molding of Thermoplastics**	
11.	Concept of Injection Molding process, discussion of utility of this process for production of plastic products, advantages and disadvantages, plastic materials processed by injection molding	01
1.2	Elements of injection molding machine, types of injection unit, clamping unit, screws, molds and machine controls	03
1.3	Specifications for injection molding machines, determination of clamping force, torque and screw output. Discussion on screw plasticization process for efficient molding	03
1.4	Injection Molding Faults, the analysis of causes and suggestions and remedies	02
2.	**Molding Processes for Thermoset Polymers**	
2.1	Concept of Thermoset molding, Injection Molding Processes for Thermoset polymers, advantages, disadvantages, utility in various fields	01
2.2	Introduction of Compression molding process, material characteristics, important steps, variations in compression molding process, utility of this process for variety of products, molding faults and their solutions.	03
2.3	Introduction of Transfer molding process, types of Transfer molding process, advantages and disadvantages of transfer molding process,	03

	utility of this process for variety of products, molding faults and their solutions	
3.	**Thermoforming process**	
3.1	Concept of thermoforming process, various means of forming, advantages, disadvantages and utility of process for variety of products formed by this process, material characteristics for thermoforming, types of thermoforming processes, concept of plug assist forming	03
3.2	Thermoforming machines, thermoforming variables	03
3.3	Thermoforming faults, their probable causes and remedies, solutions	02
4.	**Molding Processes for hollow products**	
4.1	Concept of blow molding process, concept of neck to bottom diameter of hollow products, blown ratio, advantages and disadvantages of process, Blow molding faults, their probable causes and remedies	02
4.2	Concept and types of Extrusion and injection blow molding process, various arrangements of molds for efficient molding, neck molding, die shaping and parison programming, mold cooling, air entrance, etc.	04
4.3	Concept of Rotational blow molding process, various arrangements of molds and types of machines for efficient molding, material characteristics for rotational molding process, advantages, disadvantages and molding parameters	02
4.4	Concept of Stretch blow molding process, Conditions for stretching, types of processes and machines	02
5.	**In-situ Reaction Molding Process**	
5.1	Concept of Reaction Injection molding (RIM) process, material characteristics for RIM, process details and utility	03
5.2	Casting process for variety of polymers like epoxy, Nylon, Acrylics, polyurethanes	03
	Total Hours:	**40**
6.	**Laboratory Experiments**	
6.1	Preparation of simple plastic products using Vacuum forming machine	06
6.2	Preparation of simple plastic products using Injection Molding Machine	06
6.3	Preparation of simple plastic products using Compression Molding Machine	06
6.4	Preparation of film/sheet by extrusion process	06
6.5	Preparation of simple article on Blow Molding Machine	06
6.6	Preparation of Fiber reinforced plastic sheet by using glass fiber mat and unsaturated polyester resin	06
6.7	Mixing of plasticizer in PVC on Two Roll Mill	06
6.8	Preparation of sheet by Hydraulic press	
6.9	Preparation of PET Bottle on Stretch Blow Molding Machine;	06
6.10	Preparation of an article by Rotational Molding Machine	06
	Total Hours :	**60**
	G. Total Hours :	**100**

TPL –306: POLYMERIZATION ENGINEERING - II

L	T	P	C
3	0	6	5

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

- To understand synthesis, , manufacturing process, properties and applications of engineering plastics.
- To learn the manufacturing of thermoset properties and applications of polymers.
- To understand the synthesis and manufacturing of flexible and rigid polyurethanes and analyze then formations and projects.

Course Outcome

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

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

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Criterion for engineering plastics
2. Manufacturing process and flow sheet for production of engineering plastics like ABS and PC.
3. Properties and applications of engineering plastics.

Course Outcome 2 (CO2)

1. Monomers for various engineering plastics like nylons and polyesters.
2. Manufacturing process, properties and applications of nylons, PET, PBT, etc.
3. Properties and applications of fluorine containing polymers.
4. Importance of glass filled polymers.

Course Outcome 3 (CO3)

1. Utility of high performance specialty plastics like PEEK.
2. Chemistry of synthesis and applications of polymers like PES, PPS, etc.

Course Outcome 4 (CO4)

1. Chemistry of synthesis of various grades of epoxy resin and their characteristics.
2. Manufacturing process for thermoset polymers like epoxy resin, polyimides.
3. Curing agents and curing mechanism for thermoset polymers.

Course Outcome 5 (CO5)

1. Monomers and synthesis of polyurethane.
2. Concept of flexible and rigid polyurethanes.
3. Production of variety of polyurethane.

Course Outcome 6 (CO6)

1. Apply techniques for the preparation of copolymers, ester gum resin, graft copolymer, polyester resin, moulding powder, etc.
2. De-polymerization of polystyrene.
3. Determination of epoxide equivalent and amine values.
4. Analysis of gel time of epoxy resin.
5. Modification of epoxide equivalent of resin.
6. Apply modification methods for improvement of polymers like epoxy, resin, styrene.

Syllabus

Module-I: Engineering Thermoplastics-I

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

Module-II: Engineering Thermoplastics-II

Monomers, chemistry of synthesis, manufacturing process, properties and applications of polyamides, polyesters, fluorine-containing polymers, etc.

Module-III: Specialty Thermoplastics

Monomers, chemistry of synthesis, manufacturing process, properties and applications of polyphenylene oxide, acetal resins, polysulphones and other specialty plastics.

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

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

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

Reference Books and Suggested Readings :

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

Course contents and lecture schedule

Module	Topic	No. of Lectures
1.	**Engineering Plastics-I**	
1.1	Criterion for Classification of Thermoplastics, Definition and concept of Engineering Plastics	01
1.2	Monomers, Chemistry of synthesis of Polycarbonate, Manufacturing Processes, properties, and applications of polycarbonate. Utility of Polycarbonate in various of areas	O3
1.3	Monomers, Routs for synthesis, manufacturing process with flow sheet, properties and applications of ABS plastics. Utility of ABS plastics in various fields	03
2.	**Engineering Plastics-II**	
2.1	Introduction to Polyamides, Routs for synthesis of Nylons, Monomers, Flow sheets for manufacturing Nylon6 and Nylon66by batch and continuous polymerization reactors and discussion of various steps involved. Properties, relation of structure of polyamide with properties and applications of various nylons. Fillers for Nylons , properties and applications of Glass filled Nylons	04
2.2	Monomers, Chemistry of synthesis of Polyesters: PET and PBT,	03

	Manufacturing Processes, flow sheets, properties, and applications of Polyesters. Utility of Polycarbonate in various of areas. Glass filled Polyesters and their properties and applications	
2.3	Introduction of flourine containing Polymers. Monomers, Chemistry of synthesis of Poly tetra fluoro ethylene (PTFE), properties, and applications of PTFE	01
3.	**Specialty Plastics**	
3.1	Monomers, Chemistry of synthesis of Polyphenylene ether (PPE), Manufacturing Processes, properties, and applications of PPE. Properties and applications of PPE blends, their characteristics and applications	02
3.2	Introduction to Acetal resins. Monomers, Chemistry of synthesis of Acetal Homopolymer resins Acetal Copolymer resin, their properties and applications and comparison of these Polymers for various fields of applications	02
3.3	Monomers, Chemistry of synthesis, different routes, manufacturing Processes, properties, and applicationsof Polysuphones. Various Commercial grades available	02
3.4	Monomers, Chemistry of synthesis of Polyesters: PET and PBT, Manufacturing Processes, flow sheets, properties, and applications of Polyesters. Utility of Polycarbonate in various of areas. Glass filled Polyesters and their properties and applications	02
3.5	Monomers, Chemistry of synthesis, properties, and applications of other specialty plastics like Polysulphide (PPS), Poly ether ether ketone (PEEK), and Polyarylates	02
4.	**Thermoset Polymers-I**	
4.1	Introduction to Epoxy resin, monomers, chemistry of synthesis of DGEBA and BPA based epoxy resin effect of reaction conditions on molecular weight of resin, monomers, manufacturing processes with flow sheet for low and high molecular weight resins, characterization, properties and applications of resins. Curing agents and curing mechanism of epoxy resins. Fillers, diluents and flexiblizers for epoxy resins	04
4.2	Other glycidyl ether based and Non glycidyl ether based epoxy resins	01
4.3	Introduction to polyimides, Monomers, Chemistry of synthesis, different grades, manufacturing Processes, properties, and applications of Polyimides and various modified polyimides viz. Poly ether imide, Poly (bis malenimide) and poly(amideimide)	03
5.	**Thermoset Polymers-II**	
5.1	Introduction to unsaturated polyesters, Routs for synthesis of polyesters, Monomers, Flow sheets for manufacturing polyesters and discussion of various steps involved. Properties, and applications of various types of commercial polyesters. Curing mechanism, fillers and additives for polyesters.	04
5.2	Introduction to Poly urethanes. Concept of flexible and rigid PU. Monomers, Various Poly urethane reactions, manufacturing processes for flexible and rigid PU and discussion of various steps involved. Properties and applications of various Polyurethanes	03
	Total Hours :	**40**
6.	**Laboratory Experiments**	
6.1	Synthesis of copolymer of styrene and maleic anhydride	06
6.2	Synthesis of ester gum resin	06
6.3	Synthesis of polyester resin	06
6.4	Determination of epoxide equivalent weight of epoxy resin	06
6.5	Determination of amine content of curing agent	06

6.6	Determination of gel time of epoxy resin	06
6.7	Depolymerization of polystyrene	06
6.8	Modification of epoxide equivalent of resin	06
6.9	Preparation of Molding powder	06
6.10	Synthesis of graft copolymer	06
	Total Hours :	**60**
	G. Total Hours :	**100**

BMA-342, OPERATIONS RESEARCH

L	T	P	C
3	0	0	3

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

- mathematical formulation and solution of Linear programming problems by various method.
- transportation problems and assignment problems and their solutions.
- advanced LPP and Travelling salesman Problem and their solutions.
- fundamentals of Network problems and their solutions by CPM and PERT Methods.
- dynamic programming problem and genetic algorithm.

Course Outcome

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

CO1	understand and solve linear programming problems.	Apply, Evaluate
CO2	formulate and solve Transportations models, Assignment models and integer linear programming problems.	Apply, Evaluate, Create
CO3	formulate and solve sequencing and scheduling models.	Apply, Evaluate, Create
CO4	formulate and solve Replacement and inventory models.	Apply, Evaluate, Create
CO5	learn and use Dynamic programming and Genetic Algorithms.	Apply, Evaluate

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

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSO1**	**PSO2**
CO1	3	3	3	3	3	2	3	1	2	-	3	3	**1**	**2**
CO2	3	3	3	3	3	2	3	1	2	-	3	3	3	3
CO3	3	3	3	3	3	2	3	1	3	-	3	3	3	3
CO4	3	3	3	3	3	2	3	1	3	-	3	3	3	3
CO5	3	3	3	3	3	2	3	-	3	-	3	3	3	3
Average	3	3	3	3	3	2	3	.8	2.6	-	3	3	3	3
													3	**3**

Detailed Syllabus:

UNIT I: Linear Programming Problems (LPP)

OR model, Formulation of LPP. model, Graphical LPP solution and sensitivity analysis, simplex method, M-method, Two-phase method, Special cases in simplex method application, Duality theory, Dual simplex method, Revised simplex method, Degeneracy, Sensitivity analysis, Various industrial application of LP.

UNIT II: Transportation Models, Assignment Models and Integer Programming:

Formulation and Optimal solution of transportation models, Assignment models, Transshipment models, Degeneracy in TP model, Industrial application, Formulation and Solution of integer linear programming problems; Cutting-plane algorithm, Branch and Bound algorithm, 0-1 ILPP, applications, Knapsack problem, facility-location problem.

UNIT III: Sequencing and Scheduling Model:

Sequencing problems- Travelling salesman problem, Machine-scheduling problem (Job shop), Network based planning models, Objectives of CPM and PERT, Characteristics of CPM/PERT projects, Network diagram, Terminology, Critical path, Project duration, PERT Network, Activity time, Probabilities of project completion, Optimal crashing of project activities.

UNIT IV: Replacement and Inventory models:

Replacement Problems: Optimal age of equipment replacement, capital equipment discounting cost, Replacement of items that fail, Individual and group replacement policies.

Inventory Models: Deterministic inventory models, Classic EOQ model, EOQ with price breaks, Multiterm, stochastic inventory models under probabilistic demand and lead times.

UNIT V: Dynamic Programming and Genetic Algorithms:

Dynamic programming: Bellman's principle of optimality, computations in DP, Forward and Backward recursions, Dynamic Programming formulations, Investment problem, General allocation problem, Storage coach problem, Production scheduling.

Genetic Algorithms: Working principles, similarities and differences between Gas and Traditional methods, Gas for constrained optimization, Applications of Gas to solve simple problems.

Text Books Recommended:

1. S.S. Rao, "Optimization: Theory and Applications" Willey Eastern Limited.
2. H.A. Taha, " Operations Research- AN Introduction", Macmillan.
3. Hiller, F.S., G.J. Lieberman, "Introduction to Operations Research", Hoiden-Day.
4. Kalyanmoy Deb, "Optimizaton for Engineering Design: Algorithms & Examples " Prentice- Hall of India.
5. B.E. Gillet, Introduction Operations Research- A Computer Oriented Algorithmic Approach, McGraw Hill 1989.

SEMESTER- 7

L	T	P	C
3	0	3	4

TPL – 401: ADVANCED POLYMER MATERIALS

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

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

Course Outcome

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

CO1	Understand chemistry of synthesis of polymers for high tech applications and analyze the properties of high performance polymers for specific application like aerospace, telecomm, biomedical, defense etc.	Understand
CO2	Understand and apply chemistry, preparation, properties and applications of high temperature resistant polymers.	Apply
CO3	Understand the preparation, properties and applications of liquid crystalline polymers, silicone polymer, and any newly developed material. Nano-fillers and nano-composites, their processing and economics.	Understand
CO4	Understand and analyze self-reinforced polymer composite, high energy absorbing polymer, super absorbent polymers, and polymers for biomedical applications.	Analyze
CO5	Understand modification techniques for preparation of specific polymers like polymer blends & alloys.	Understand
CO6	Characterize polymers using analytical instruments like DSC, TGA, UV spectrophotometer.	Analyze

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Understand the chemistry of synthesis of polymers for high tech applications such as aerospace, telecommunication, defense, medical, etc.
2. Analyze the properties of high performance polymers for specific applications like aerospace, telecomm, biomedical, defense etc.

Course Outcome 2 (CO2)

1. Chemistry, preparation, properties and applications of high temperature resistant polymers like polyether imide, etc.
2. Concept of high temperature resistant specialty polymers.
3. Properties and applications of high temperature resistant polymers.

Course Outcome 3 (CO3)

1. Preparation, properties and applications of liquid crystalline polymers.
2. Preparation, properties and applications of silicone polymer.
3. Preparation, properties and applications of any newly developed material.
4. Concept of nanofillers and nanocomposites, carbon nanotube (CNT).

Course Outcome 4 (CO4)

1. Processing and economics of advanced polymers like self-reinforced polymer composite, high energy absorbing polymer, super absorbent polymer, etc.
2. Processing and economics of polymer for biomedical applications.

Course Outcome 5 (CO5)

1. Concept of polymer blends and alloys, polymer miscibility, methods of blending.
2. Various commercial polymer blends and their applications.

Course Outcome 6 (CO6)

1. Determination of glass transition temperature/crystallinty/heat of reaction by using Differential Scanning Calorimeter (DSC).
2. Determination of Initial Degradation Temperature (IDT), Final Degradation Temperature and char yield (FDT) of polymers by using Thermo Gravimetric Analyzer (TGA).
3. Dispersion of two liquid or solid-liquid sample using Ultrasonicator.
4. Rheological properties of given polymer blends or mixtures.

Syllabus

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

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

Module-II: High performance polymers – I

Chemistry, preparation, properties and applications of high temperature resistant polymers like polyetherether ketone (PEEK), etc. Speciality polymers.

Module-III: High performance polymers – II

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

Module-IV: High performance polymers – III

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

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

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

Reference Books and Suggested Readings :

1. Encyclopedia of polymer science and technology, Vol. 14, H. F. Mark, N. G. Gaylord and N. M. Bikales, Eds., Interscience Publishers, 1971.
2. Plastic Materials, J. A. Brydson, Butterworth-Heinemann, 1999.
3. Polymer Science, by Gowarikar, Viswanathan & Jayadev
4. Macromolecular Synthesis, by J.R. Fllyott
5. Hand Book of Fibre glass and Advanced Plastic Composites, by G. Lubin
6. Polymer modification by John J. Merister
7. Polymer gels and Network by Yoshihido osada
1. Polymer Blends Hand Book – Vol. I & II, by L.A.Utracki

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Role of Polymers for High-tech areas**	
1.1	Role of polymers for high-tech areas such as aerospace, telecommunication, defense, medical, etc.	03
1.2	Development of newer polymers	02
2.	**High performance polymers – I**	
2.1	Chemistry, synthesis, processing and applications of high temperature resistant polymers like polyetheretherketone (PEEK), etc.	04
2.2	Processing and applications of specialty polymers	03
3.	**High performance polymers – II**	
2.1	Chemistry, classification, synthesis, processing and applications liquid crystalline polymers	03
2.2	Chemistry, classification, synthesis, processing and applications of silicone polymers	03
2.3	Concept of nanofillers, processing and economics of polymer nanocomposites	03
3.	**High performance polymers – III**	
3.1	Processing and economics of self reinforced polymer composite	02
3.2	Processing and economics of high energy absorbing polymer	02
3.3	Processing and economics of super absorbent polymers	03
3.4	Processing and economics of polymers for biomedical applications	02
3.5	Nanofillers and nanocomposites	03
4.	**Modification of Polymers**	
4.1	Concept of Polymer blends and alloys	02

4.2	Methods of blending and theories of polymer miscibility	03
4.3	Various commercial blends and their applications	03
	Total Hours :	**41**
5.	**Laboratory Work**	
5.1	Determination of glass transition temperature/ crystallinty/ heat of reaction by using Differential Scanning Calorimeter (DSC)	06
5.2	Determination of Initial Degradation Temperature (IDT), Final Degradation Temperature and char yield (FDT) of polymers by using Thermo Gravimetric Analyzer (TGA)	06
5.3	Determination of the presence of U.V. Stabilizer in polycarbonate sample by UV-VIS Spectrophotometer	03
5.4	Determination of the percentage transmittance of given film or sheet sample by UV-VIS Spectrophotometer	03
5.5	Recording of spectra for given chemical in U.V. band visible range using UV-VIS Spectrophotometer	03
5.6	Study of wear and friction of the given plastic/composite materials sample using wear and friction monitor	03
5.7	Dispersion of two liquid or solid-liquid sample using Ultrasonicator	03
5.8	To determine the rheological behaviour of given polymer blends or mixtures	03
	Total hours :	**30**
	G. Total Hours :	**71**

PROGRAMME ELECTIVE COURSE I

TPL-403: PLASTIC PRODUCT AND MOULD DESIGN

L	T	P	C
3	0	0	3

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

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

Course Outcome

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

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

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Differences in plastic product design features.
2. Constraints related to molding.
3. Choice of plastic material for specific products.

Course Outcome 2 (CO2)

1. Design checklist and important information.
2. Basic structural design parameters.
3. Specific design features for molds.

Course Outcome 3 (CO3)

1. Basic functions of Injection mold.
2. Types of injection molds.
3. Standard structural design features and materials for mold base.

Course Outcome 4 (CO4)

1. Difference between compression and injection Molds.
2. Compression mold structure and types.
3. Types and structure of transfer molds.

Course Outcome 5 (CO5)

1. Basic Die Characteristics.
2. Types of Extrusion Dies.
3. Die design for simple films, sheet etc.

Syllabus

Module-I: Plastic product design criteria

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

Module-II: Product Design Features

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

Module-III: Injection Mold Design

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

Module-IV: Design Concept of other Mold types

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

Module-V:Computer Aided Design

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

Reference Books and Suggested Readings :

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

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Plastic product design criteria**	
1.1	Need to study plastic product design	01
1.2	Product Checklist	01
1.3	Design criteria based upon product functions	02
1.4	Material selection process	02
1.5	Selection of forming process	01
2.	**Product Design Features**	
2.1	Introduction to moulding consideration	01
2.2	Basic structural design features wall thickness, draft, radii etc	03
2.3	Flow of melt in mould	01
2.4	Special design features	02
2.5	Feeding system, gate location	02
3.	**Injection Mold Design**	
3.1	Basic functions of injection mold, cycle time	01
3.2	Main structural parts of injection mold	01
3.3	Types of Injection mold	02
3.4	Automatic and semiautomatic molds	01
3.5	Multicavity molds with design criterias	01
3.6	Materials and mold making	01
4.	**Design Concept of other Mold types**	
4.1	Differences between Injection and compression molds	01
4.2	Basic design of compression mold	01
4.3	Types of compression mold	02
4.4	Transfer molds	01
4.5	Basics of extrusion dies	02
4.6	Types of Extrusion dies	03
5.	**Computer Aided Design**	
5.1	Concept of CAD in plastic product design	02
5.2	Application of CAD/ CAM in making molds	01
5.3	Advantages and applicability of CAM	01
5.4	Use of modeling and simulation in product & mold design	01
5.5	Advantages and cost reduction using CAD /CAM	02
	Total Hours	**40**

PROGRAMME ELECTIVE COURSE II

TPL –407: TECHNOLOGY OF ELASTOMERS

L	T	P	C
2	0	0	2

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

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

Course Outcome

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

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

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Characteristic properties of elastomers and relation between structure and elastic properties.
2. Concept of vulcanization of rubbers.
3. Concept of thermoplastic elastomers.
4. Utility of compounding ingredients for variety of applications.
5. Compounding equipments.

Course Outcome 2 (CO2)

1. Source of natural rubber.
2. Methods for obtaining dry rubber.
3. Vulcanization, Properties & Applications of NR.
4. Derivatives of NR, Modified rubbers & technically opened rubber.

Course Outcome 3 (CO3)

1. Chemistry of synthesis and manufacturing process for variety of synthetic rubbers like SBR, Nitrile rubber, etc.
2. Vulcanization of synthetic rubbers, their properties and applications.

Course Outcome 4 (CO4)

1. Vulcanization techniques for curing of rubbers.
2. Processing methods like compression, transfer molding, extrusion, injection molding.

Course Outcome 5 (CO5)

1. Testing methods for rubber properties.
2. Concepts of cure characteristics and assessment of level of curing & optimum curing.

Syllabus

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

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

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

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

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

Reference Books and Suggested Readings :

1. Rubber Technology & Manufacture, by C.M.Blow
2. Encyclopedia of Polymer Science and Technology Vol. 1-23, by Mark &Overberger

3. Rubber Technology, by Maurice Morton
4. Synthetic Rubbers, by D.C. Blacklay
5. Anil .K. Bhowmic, Howard L. Stephens (Edt), Handbook of Elastomers – New Developments & Technology, Marcel Decker Inc. New York 1988.

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Introduction to elastomers and compounding**	
1.1	Introduction to elastomers characteristic features of polymer chains to behave like an elastomers, sources of natural and synthetic rubber. History and brief discussion of structure and behavior of natural and various synthetic rubber available	01
1.2	Introduction of compounding and compounding ingredients, their importance and utility for rubbers. Importance of compounding recipe for rubber goods manufacturing. Mastication of rubbers	01
1.3	Vulcanization process, Vulcanization agents, various types of Vulcanization agents, Vulcanization conditions. Accelerators, their classification with examples, accelerator activators. Age resistors-antioxidants, antioxidants, their mechanism softeners or plasticizers, miscellaneous ingredients	01
1.4	Utility of filers in rubbers, types of fillers used in rubbers, reinforcement concepts, introduction of carbon blacks. Various methods for manufacturing C-black and size obtained from each, typical filler characteristics and their influence on Vulcanizate properties, filler characteristics and mixing process, bound rubber, reinforcement and cross linking	01
2.	**Natural rubber**	
2.1	Brief history of natural rubber, plantation, agriculture involved in growing NR plants, latex tapping	01
2.2	Preparation of different types of dry rubber, properties of natural rubber	01
2.3	Importance, synthesis and characteristics of various rubber derivatives. various types of modified rubbers, their importance and method of synthesis. Technically specified rubbers, methods for manufacturing these rubbers	01
2.4	Various methods for processing of rubbers- compression, transfer molding, injection molding, extrusion. various Vulcanization methods e.g. open cures, continuous Vulcanization, radiation cures	01
2.5	Chemistry and mechanism of sulphur Vulcanization rate of cure state of cure, optimum cure time, overawe, scorch. Chemistry and mechanism of non-sulphur Vulcanize and peroxide curing	01
3.	**Synthetic Rubber -I**	
3.1	Introduction to styrene butadiene rubber, various methods of synthesis, composition of SBR & percent cis-trans contents. Description of manufacturing process with flow diagram for production of SBR, typical formulation. Physical properties, compounding and processing of SBR, uses of SBR, introduction and importance of polybutadiene mechanization properties and uses	02
3.2	Introduction to nitrite rubber, various grades, property trends influenced by composition i.e. percent Acrylonitrile content. Manufacturing process	02

	description of Nitrite rubber with diagram, oil resistance of these rubber, effect of polymer structure and compounding ingredients on it. Specific compounding ingredients used with Nitrite rubbers, various uses of nitrite rubber0	
3.3	Introduction to butyl rubber, description of manufacturing process with flow sheet. Molecular characteristics, mole percent unstauration, cis- and trams- structures, properties and applications of butyl rubber, Vulcanization of butyl rubber. Introduction to chlorobutyl rubber, advantage of chlorination manufacturing process, stabilization and Vulcanization, applications	02
3.4	Introduction to Neoprene rubbers, classification of grades on basis of basis of applications compounding of neoprene's, processing, vulcanization and applications of neoprenes.	01
4.	**Synthetic Rubber -II**	
4.1	Introduction to Ethylene/propylene rubbers, their, structure compositional distribution , variables in molecular structure, polymer, properties. Polymer unstauration in EPR and various denies introduced for unstauration, structure, property relationship, EPDM varieties. Manufacturing process description of EPDM with flow sheet, application of EPDM.	01
4.2	Chlorosulphonated polyethylene introduction, synthesis, types of Hypalon available, compounding, curing and applications. Introduction to polysulfide rubbers, type A and B polysulfide, and FA and ST types polysulfide plasticization and curing, solvent resistance and other properties, application of polysulfide rubber	01
4.3	Introduction to silicon rubbers, synthesis of silicon rubbers. Vulcanization, compounding and processing of silicon rubbers, various applications of silicon rubbers, room temperature vulcanizing rubbers	01
4.4	Introduction to Urethane elastomers, chemistry and structure, casting system thermoplastic PU rubbers.	01
4.5	Thermoplastic elastomers- introduction, concept of rigid and electrometric block i.e. A-B-A type polymers, example like S-B-S block copolymers, advantages over vulcanizing type rubbers, chemical nature of TPR's processing of TPR	01
5.	**Industrial fabrication of Rubber Products**	
5.1	Various types of compounding machines:- mills, internal mixers. Various continuous mixers, extruders etc.	01
5.2	Calendaring process for producing rubber sheets. Coating of textile fabric by rubber direct manufacturing articles from latex. Moulding of rubber articles like footwears, bonding of rubber to metals	01
5.3	Manufacturing process for pneumatic tyres, fabrication of tyre, tyre construction, tyre components, flow sheet for manufacturing plant, brief description of various steps involved	01
5.4	Manufacturing process for transmission belt	01
5.5	Dip coating process	01
	Total hours	**26**

PROGRAMME ELECTIVE COURSE III

TPL –411: POLYMER COMPOSITES

L	T	P	C
2	0	0	2

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

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

Course Outcome

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

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

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Definition & components of polymer composites
2. Principle of reinforcement
3. Effect of fibers on strength of composites
4. Concepts of interface
5. Advantages & disadvantages of polymer composites

Course Outcome 2 (CO2)

1. Types of reinforcement used in polymer composites
2. Types and forms of glass fibers, their production process
3. Production process for carbon fibers
4. Production process for boron and aramid fibers
5. Surface treatment for enhancement of bond strength

Course Outcome 3 (CO3)

1. Utility of thermoset types of matrix materials like epoxy resin, vinyl ester resin, etc for polymer composites and their characteristics properties
2. Utility and characteristics properties of thermoplastic materials for polymer composites.

Course Outcome 4 (CO4)

1. Description of Hand layup, spray molding and bag molding
2. Description of filament winding process and pultrusion.
3. Description of sheet and dough molding compounds and their processing preform and resin transfer molding

Course Outcome 5 (CO5)

1. Production of hybrid structures based on polymer composites
2. Production of sandwiched polymer composites.

Syllabus

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

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

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

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

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

Reference Books and Suggested Readings :

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

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Introduction to polymer composites**	
1.1	Concept polymer composites their advantages and disadvantages	01
1.2	Components and principle of composites reinforcement and effect of fibrous reinforcement on polymer	01
1.3	Determination of composites strength	01
1.4	Importance of interface between reinforcement and polymer matrix	01
2.	**Reinforcements for Polymer composites**	
2.1	Introduction to glass fiber, their types, production process and their characteristics properties	01
2.2	Different forms of glass fibers and their utility	01
2.3	Production of carbon fibers, their structures and methods for enhancement of strength of carbon fiber and their properties. Graphitization of carbon fibers	01
2.4	Production odd boron fibers and their properties. Production of aramid fibers and their characteristics properties	03
2.5	Types of natural fibers used in polymer composites and their source and characteristics	01
3.	**Matrices for Polymer composites**	
3.1	Characteristics properties of epoxy and vinyl ester resins, its utility for polymer composites	02
3.3	Properties and applications of glass filled thermoplastics like PC, PBT, Nylons etc.	01
4.	**Production Techniques -I**	
4.1	Process description of techniques for production of polymer composites like hand layup and spacey layup	01
4.2	Process description of Filament Winding technique for production of polymer composite pipes	01
4.3	Process description of Pultrusion technique for production of polymer composite rods, etc.	01
5.	**Production Techniques -II**	
5.1	Prepegs, their manufacture and characterization	01
5.2	Sheet and dough moulding compounds and their processing	04
5.3	Perform and resin transfer moldings.	01
5.4	Hybrid and sandwich type composites.	02
	Total Hours	**25**

OPEN ELECTIVE (PLASTIC TECHNOLOGY)

TPL- 415: INTRODUCTION TO POLYMER TECHNOLOGY

L	T	P	C
3	0	0	3

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

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

Course Outcome

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

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

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Introduction of Polymers.
2. Classification of Polymers.

Course Outcome 2 (CO2)

1. Mechanism and Kinetics of Polymerization.
2. Techniques of Polymerization.
3. Copolymerization

Course Outcome 3 (CO3)

1. Manufacturing process of common thermoplastics.
2. Their properties and applications.

Course Outcome 4(CO4)

1. Chemistry of different thermoset based on formaldehyde.
2. Their production and molding powder preparation.

Course Outcome 5(CO5)

1. Common processing techniques for thermoplastics and thermoset.
2. Plastic industries in India.

Syllabus

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

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

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

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

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

Reference Books and Suggested Readings :

1. Polymer Science and Technology, by J.R.Fred
2. Introduction to polymer science, by F. W. Billmeyer
3. Properties and structure of polymers, by Tobolosky
4. Principles of Polymerization, by G. Odian
5. Plastics Materials, by J.A. Brydson
6. Plastic Engg. HandBook, by Frados

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Introduction to Polymers/ Plastics**	
1.1	Introduction to polymeric materials	02
1.2	Monomer and respective polymer structures	02
1.3	Classification of polymers with details	02
1.4	Important properties of polymers	02
2.	**Chemistry of polymerizations**	
2.1	Principle of addition polymerization with mechanism examples and kinetics	02
2.2	Principle of Condensation polymerization with mechanism examples and kinetics	02
2.3	Techniques of polymerization	02
2.4	Copolymerization	02
3.	**Thermoplastic resins**	
3.1	Manufacture of Low density polyethylene	02
3.2	Manufacture of High density polyethylene & using stereospecific catalysis	03
3.3	Manufacture of other commodity plastics	02
3.4	Properties and application of these plastics	01
4.	**Thermoset resins0**	
4.1	Chemistry of both types of phenol formaldehyde resin	02
4.2	Production and molding powder manufacture for Phenol formaldehyde resin	01
4.3	Chemistry and production of Urea formaldehyde resin	02
4.4	Chemistry and production of Melamine formaldehyde resin	01
4.5	Properties and applications of these resin	02
5.	**Processing of Plastics**	
5.1	Processing Techniques for Thermoplastics	04
5.2	Processing Techniques for Thermosets	03
5.3	Indian Plastics Industries current scenario and future growth	01
	Total Hours	**40**

TPL - 461: INDUSTRIAL TRAINING

L	T	P	C
0	0	4	2

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

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

Course Outcome

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

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

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

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

TPL - 471: SEMINAR

L	T	P	C
0	0	4	2

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

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

Course Outcome

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

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

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

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

TPL – 497: PROJECT

L	T	P	C
0	0	8	4

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

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

Course Outcome

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

CO1	Understand a topic of latest developments/innovative technology.	Understand Individual & Team Work
CO2	Apply the knowledge to prepare a feasibility/dissertation report on this topic.	Apply Project Management and Finance
CO3	Deliver a lecture on the topic on power point format.	Apply
CO4	Improve the communication skills of the students.	Communication
CO5	Analyze environment and sustainability of related technology	Analyze Environment & Sustainability

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

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

SEMESTER- 8

PROGRAMME ELECTIVE COURSE IV

TCH 422 PROCESS MODELING AND SIMULATION

L	T	P	C
2	1	0	3

Assessment:
Sessional: 50 marks
End Semester: 50 marks

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

Course Outcomes:
Students completing the course will be able to
CO 1. Model deterministic systems and differentiate between nonlinear and linear models.
CO2. Numerically simulate linear and non linear ordinary differential equations for deterministic systems
CO 3. Estimate and validate a model based upon input and output data.
CO 4. Create a model prediction based upon new input and validate the output data
CO 5. Develop steady state models for flash vessels, equilibrium staged processes, distillation columns, absorbers, strippers, CSTR, heat exchangers and packed bed reactors.

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

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSOs**	**PSOs**
CO1	3	3	3	3	2	-	-	1	-	1	1	2	**1**	**1**
CO2	3	3	3	3	3	1	-	1	-	1	1	2	3	3
CO3	3	3	3	2	3	1	-	1	-	1	1	2	3	3
CO4	3	3	3	2	2	1	-	1	-	1	1	2	3	3
CO5	3	3	3	3	3	1	1	1	-	1	2	3	3	3
Avg.	3	3	3	2.6	2.6	0.8	0.2	1	-	1	1.2	2.2	3	3
													3	**3**

Module1 (6 hours)

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

Module2 (6 hours)

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

Module3 (6 hours)

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

Module4 (6 hours)

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

Module5 (6 hours)

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

Suggested Text Books

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

Suggested Reference Books

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

	L	T	P	C
TPL- 402: POLYMER PACKAGING AND WASTE MANAGEMENT	**3**	**1**	**0**	**4**

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

- To understand concept of packaging and utility of plastics in packaging.
- To analyze properties of polymers for their utility in packaging of vanity of products.
- To know various sources of plastics waste generation and its management.
- To understand the recycling techniques used for various plastics.

Course Outcome

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

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

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Concept of plastic packaging.
2. Scope and frictions of package.
3. Advantages and disadvantages of polymeric packages over conventional packaging materials.
4. Plastic packages and their applications.

Course Outcome 2 (CO2)

1. Selection criteria of suitable polymeric packages for household and industrial goods.
2. Testing and quality control in polymeric packaging.
3. Newer developments in plastic packaging.

Course Outcome 3 (CO3)

1. Global policies and regulations.
2. Plastic waste management.

Course Outcome 4 (CO4)

1. Recycling and recovery of various plastics items/materials.
2. Plastics and Environment.
3. Methods of recycling.

Course Outcome 5 (CO5)

1. Various modification techniques/latest development in polymers to improve waste management.
2. Biodegradable programs for various applications viz. food packaging, agriculture.
3. Waste treatment of various plastic plants, estimation of power requirement and efficiency of size reduction operation of plastics.

Syllabus

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

Module-II: Polymer Packages and Quality Control
Selection criteria of various household and industrial polymeric packages. Printing on polymeric packages. Testing and quality control. Newer developments in polymer packaging.

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

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

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

Reference Books and Suggested Readings :

1. Hand Book of Polymer Science and Technology – V0l. 4, by N.P.Cheremisinoff
2. Comprehensive Polymer Science – Vol. 7, by Sir Geoffrey Allen
3. Plastics films and packaging, by C.R.Oswin
4. Science and Technology of Polymer films, by J.F.Hamlin

5. Protective Wrapping, by C.R.Oswin
6. Environmental effect on polymeric materials, by Dominick V. Rosato & Robert T. Schwartz
7. Plastic waste management and environment, by V.P.Malhotra
8. Synthetic Rubber Waste Disposal, by L.D.Dougan & J.C.Bell
9. Plastic waste and its recovery, by M.E.Bocqueye

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Elements of packaging**	
1.1	Concept of plastic packaging, present state of packaging technology, scope of a packaging	02
1.2	Polymeric packages over conventional packaging materials – advantages and disadvantages	02
1.3	Plastic packages and their applications	03
2.	**Polymer Packages and Quality Control**	
2.1	Selection criteria of various household polymeric packages	03
2.2	Selection criteria of various industrial polymeric packages	03
2.3	Printing on polymeric packages	02
2.4	Testing and quality control	03
2.5	Newer developments in polymer packaging	02
3.	**Plastic Waste Management**	
3.1	Global policies and regulations, plastics and environment.	02
3.2	Social and environmental challenges of plastic waste in India.	02
3.3	Salient features of the plastic waste management (PWM) rules.	02
3.4	Waste treatment of various plastic plants.	02
3.5	Estimation of power requirement and efficiency of size reduction operation of plastics.	01
4.	**Recycling Technology**	
4.1	Recycling and recovery of various plastics items/materials-their effect on environment.	03
4.2	Waste collection and recycling methods	02
4.3	Comparative study of conversion of plastic waste into value added products.	02
5.	**Biodegradable Polymers**	
5.1	Biodegradable polymers - prospects & utilization.	02
5.2	Prospects for biodegradable plastics based on renewable resource polymers	02
5.3	Biodegradable programs for various applications viz. food packaging, agriculture, etc.	03
	Total hours	**45**

PROGRAMME ELECTIVE COURSE VI

L	T	P	C
3	0	0	3

TPL – 406: POLYMERIC ADHESIVES AND FOAMS

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

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

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

CO1	Understand the concept of adhesive, adhesive joints and mechanism of adhesives.	Understand
CO2	Understand and apply the surface preparation and surface treatments for various substrates.	Apply
CO3	Understand the principle of adhesives formulation and production techniques.	Understand
CO4	Analyze properties of polymers for constitution of variety of adhesives.	Analyze
CO5	Understand concept of polymer foams and their utility in variety of applications and analyze production, process and properties of Polyurethane, Polystyrene and Epoxy foams .	Understand and Analyze

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1)

1. Define adhesive and adhesive joints.
2. Classification of adhesives.
3. Mechanism of adhesive bond failure.
4. Theories of adhesion.

Course Outcome 2 (CO2)

1. Surface characteristics.
2. Surface preparation for various substrates.
3. Surface treatment of various substrates.
4. Techniques for the evaluation of bond strength.

Course Outcome 3 (CO3)

1. Principle of adhesives formulation.
2. Principle of adhesive production techniques.
3. Adhesives formulation for various industries such as packaging, textiles, automotive, consumer, etc.

Course Outcome 4 (CO4)

1. Properties of polymers for constitution of hot melt adhesives.
2. Properties of polymers for constitution of solvent-activated adhesives.
3. Properties of polymers for constitution of anaerobic and pressure sensitive adhesives, etc.

Course Outcome 5 (CO5)

1. Definition of polymer foam.
2. Chemistry and physical formation of polymer foam.
3. Foaming ingredients.
4. Concept, production process, properties and applications of variety of polymeric foams.

Syllabus

Module – I: Introduction and adhesion theories

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

Module – II: Surface preparation and surface treatments

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

Module – III: Adhesives formulation and production techniques

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

Module – IV: Characteristics and applications of adhesives

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

Module – V: Polymeric foams

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

Reference Books and Suggested Readings :

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

Course contents and Lecture schedule

Module No.	Topic	No. of Lectures
1.	**Introduction and adhesion theories**	
1.1	Definition of adhesives and adhesive bonding and functions of adhesives	02
1.2	Classification of adhesives	02
1.3	Advantages and disadvantages of joining using adhesives	01
1.4	Requirements of a good bond, theories of adhesion	02
1.5	Definition of failure modes	01
1.6	Mechanisms of bond failure	01
2.	**Surface preparation and surface treatments**	
2.1	Surface characterization	02
2.2	Surface preparation and surface treatments for various substrates	02
2.3	Techniques for evaluation of adhesives bond strength	02
2.4	Testing and quality control	02
3.	**Adhesives formulation and production techniques**	
3.1	Principle of adhesives formulation and production techniques	02
3.2	Adhesives formulation for construction and packaging industries	02
3.3	Adhesives formulation for textiles and automotive industries	02
3.4	Adhesives formulation for shoe, electrical and aerospace industries, etc.	02
3.5	Adhesives formulation for abrasives and friction materials	02
4.	**Characteristics and applications of adhesives**	
4.1	Characterization and applications of hot melt adhesives	02
4.2	Characterization and applications of solvent-activated adhesives	02
4.3	Characterization and applications of anaerobic adhesives	02
4.4	Characterization and applications of pressure sensitive adhesives, etc.	02
4.5	Structural adhesives	02
5.	**Polymeric foams**	
5.1	Introduction to polymer foams, chemistry and physical formation	02
5.2	Foaming ingredients, their effect on foam morphology and physical properties and applications of polymer foams	03
5.3	Polyurethane foam (rigid & flexible), polystyrene foams and epoxy foams	03
5.4	Recent developments in foam technology	02
	Total hours	**46**

TCH 420 TRANSPORT PHENOMENA

L	T	P	C
2	1	0	3

Assessment:
Sessional: 50 marks
End Semester: 50 marks

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

Course Outcomes:

Students completing the course will be able to

CO 1. Understand and perform basic vector and tensor analysis
CO 2. Solve transport problems using shell balances
CO 3. Formulate and solve one-dimensional transport problems by using the conservation equations
CO 4. Formulate simple multi-dimensional transport problems.
CO 5. Understand and apply the shell balance and boundary conditions on various types of systems.

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

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

Module1 (7 hours)

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

Module2 (7 hours)

The equation of continuity, the equation of motion, use of the equations of change to set up steady flow problems and applications.

Module3 (4 hours)

Flow near a wall suddenly set in motion, Boundary layer theory and applications.

Module4 (6 hours)

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

Module5 (6 hours)

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

Suggested Text books

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

Suggested Reference Books

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

TPL – 498: PROJECT

L	T	P	C
0	0	20	10

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

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

Course Outcome

CO1	Understand a topic of latest developments/innovative technology.	Understand Individual and Team Work
CO2	Apply the knowledge to prepare a feasibility/dissertation report on this topic.	Apply Project Management and Finance
CO3	Deliver a lecture on the topic on power point format.	Apply
CO4	Improve the communication skill of the students.	Communication
CO5	Analyze environment and sustainability of related technology	Analyze Environment & Sustainabilitity

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

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

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