**JSS MAHAVIDYAPEETHA**

**JSS SCIENCE AND TECHNOLOGICAL UNIVERSITY**

**SRI JAYACHAMARAJENDRA COLLEGE OF ENGINEERING, MYSURU**

# SCHEME III TO VIII SEMESTER: 2017-2018

# &

# SYLLABUS III & IV SEMESTER: 2017-2018

## DEPARTMENT OF POLYMER SCIENCE AND TECHNOLOGY

### Scheme of Teaching and Examination for B.E (PST)

**Credit details**

| Semester | Credits |
|---|---|
| I | 25.0 |
| II | 25.0 |
| III | 27.0 |
| IV | 27.0 |
| V | 27.0 |
| VI | 27.0 |
| VII | 21.0 |
| VIII | 21.0 |
| TOTAL | 200.0 |

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**Scheme of Teaching and Examination for B.E (PS&T)**

**III SEMESTER**

| Sl. No. | Subject code | Course title | Teaching department | Credits | | | | Contact hours per week | Marks | | | Exam duration in hours |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | Total | | CIE | SEE | Total | |
| 1 | MA310 | Engineering Mathematics–III (Numerical Methods) | MAT | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 2 | PT310 | Inorganic and Physical Chemistry | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 3 | PT320 | Organic Chemistry | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 4 | PT330 | Polymer Chemistry | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 5 | PT340 | Thermodynamics | PST | 3 | 1 | 0 | 4 | 5 | 50 | 50 | 100 | 3 |
| 6 | PT350 | Transport Phenomena in Materials Engineering-I | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 7 | PT36L | Organic Chemistry Lab | PST | 0 | 0 | 1.5 | 1.5 | 3 | 50 | 00 | 50 | - |
| 8 | PT37L | Fluid Mechanics Lab | PST | 0 | 0 | 1.5 | 1.5 | 3 | 50 | 00 | 50 | - |
| 9 | HU310 | Constitution of India | Humanity | - | - | - | 0 | 2 | 50 | 0 | 50 | - |
| Total | | | | | | | 27.0 | 33 | - | | 750 | - |

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**IV SEMESTER**

| Sl. No. | Subject code | Course title | Teaching department | Credits | | | | Contact hours per week | Marks | | | Exam duration in hours |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | Total | | CIE | SEE | Total | |
| 1 | MA410 | Engineering Mathematics–IV (Fourier Series, Integral Transforms and Applications) | MAT | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 2 | PT410 | Material Science and Engineering | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 3 | PT420 | Polymer Physics | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 4 | PT430 | Polymer Manufacturing Technology | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 5 | PT440 | Polymerization Kinetics | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 6 | PT450 | Transport Phenomena in Materials Engineering-II | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 7 | PT46L | Physical Chemistry Lab | PST | 0 | 0 | 1.5 | 1.5 | 3 | 50 | 00 | 50 | - |
| 8 | PT47L | Chemical Engineering Lab | PST | 0 | 0 | 1.5 | 1.5 | 3 | 50 | 00 | 50 | - |
| 9 | HU410 | Environmental Studies | ENV | - | - | - | 0 | 2 | 50 | 0 | 50 | - |
| Total | | | | | | | 27.0 | 33 | - | | 750 | - |

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**Scheme of Teaching and Examination for B.E (PS&T)**

**V SEMESTER**

| Sl. No. | Subject code | Course title | Teaching department | Credits | | | | Contact hours per week | Marks | | | Exam duration in hours |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | Total | | CIE | SEE | Total | |
| 1 | PT510 | Rubber Technology | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 2 | PT520 | Rheology of Polymers | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 3 | PT530 | Polymer-Structure Property Relationship | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 4 | PT540 | Processing Technology-I | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 5 | PT550 | Compounding Technology | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 6 | PT560 | Polymer Analysis and Evaluation | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 7 | PT57L | Polymer Analysis and Characterization Lab | PST | 0 | 0 | 1.5 | 1.5 | 3 | 50 | 00 | 50 | - |
| 8 | PT58L | Processing Technology Lab - I | PST | 0 | 0 | 1.5 | 1.5 | 3 | 50 | 00 | 50 | - |
| Total | | | | | | | 27 | 30 | - | | 700 | - |

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**Scheme of Teaching and Examination for B.E (PS&T)**

**VI SEMESTER**

| Sl. No. | Subject code | Course title | Teaching department | Credits | | | | Contact hours per week | Marks | | | Exam duration in hours |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | Total | | CIE | SEE | Total | |
| 1 | PT610 | Testing of Polymers | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 2 | PT620 | Polymer Blends and Alloys | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 3 | PT630 | Polymer Composites | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 4 | PT640 | Processing Technology-II | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 5 | PT650 | Product Design | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 6 | PT66X | Elective-1 (One from Group-1) | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 7 | PT67L | Processing Technology Lab - II | PST | 0 | 0 | 1.5 | 1.5 | 3 | 50 | 00 | 50 | - |
| 8 | PT68L | Polymer Testing Lab | PST | 0 | 0 | 1.5 | 1.5 | 3 | 50 | 00 | 50 | - |
| Total | | | | | | | 27.0 | 30 | - | | 700 | - |

| Courses offered in Elective Group-1 (One subject of this to be taken) | | |
|---|---|---|
| Sl. No. | Subject code | Course title |
| 1 | PT661 | Nanotechnology |
| 2 | PT662 | Engineering Plastics |
| 3 | PT663 | Fiber Technology |
| 4 | PT664 | Modeling and Simulation |

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**Scheme of Teaching and Examination for B.E (PS&T)**

**VII SEMESTER**

| Sl. No. | Subject code | Course title | Teaching department | Credits | | | | Contact hours per week | Marks | | | Exam duration in hours |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | Total | | CIE | SEE | Total | |
| 1 | PT710 | Rubber Products Manufacturing | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 2 | PT720 | Process engineering Management-I | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 3 | PT730 | Design of Moulds and Dies | PST | 3 | 1 | 0 | 4 | 5 | 50 | 50 | 100 | 3 |
| 4 | PT74X | Elective-2 (One from Group-2) | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 5 | PT75L | CAD Lab | PST | 0 | 0 | 1.5 | 1.5 | 3 | 50 | 00 | 50 | - |
| 6 | PT76P | Research Methodology | PST | 2 | 0 | 0 | 2 | 2 | 50 | - | 50 | - |
| 7 | PT77P | In plant Training | | 0 | 0 | 1.5 | 1.5 | - | 50 | - | 50 | - |
| 8 | | Foreign Language | | - | - | - | 0 | 2 | 50 | 0 | 50 | - |
| Total | | | | | | | 21 | 24 | - | | 600 | - |

| Courses offered in Elective Group-2 (One subject of this to be taken) | | |
|---|---|---|
| Sl. No. | Subject code | Course title |
| 1 | PT741 | Polymer Recycling |
| 2 | PT742 | Adhesives Technology |
| 3 | PT743 | Packaging Technology |
| 4 | PT744 | Total Quality Management |

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**Scheme of Teaching and Examination for B.E (PS&T)**

**VIII SEMESTER**

| Sl. No. | Subject code | Course title | Teaching department | Credits | | | | Contact hours per week | Marks | | | Exam duration in hours |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | Total | | CIE | SEE | Total | |
| 1 | PT810 | Process engineering Management-II | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 2 | PT82X | Elective-3 (One from Group-3) | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 3 | PT83X | Elective-4 (One from Group-4) | PST | 4 | 0 | 0 | 4 | 4 | 50 | 50 | 100 | 3 |
| 4 | PT84P | Project Work | PST | 0 | 0 | 9 | 9 | 20 | 70 | 30 | 100 | 3 |
| Total | | | | | | | 21 | 32 | - | | 400 | 12 |

| Courses offered in Elective Group-3 (One subject of this to be taken) | | | Courses offered in Elective Group-4 (One subject of this to be taken) | | |
|---|---|---|---|---|---|
| Sl. No. | Subject code | Course title | Sl. No. | Subject code | Course title |
| 1 | PT821 | Paints Technology | 1 | PT831 | Tire Technology |
| 2 | PT822 | Smart Materials | 2 | PT832 | Thermoplastic Elastomers |
| 3 | PT823 | Membrane Technology | 3 | PT833 | Operations Research |
| 4 | PT824 | Statistical Quality Control | 4 | PT834 | Biomaterials |

# III Semester

<table>
<tr><td colspan="3">MA310B: ENGINEERING MATHEMATICS–III (NUMERICAL METHODS) (4-0-0)<br>Course Objective: Computational techniques will be introduced in different topics like algebra, calculus, linear algebra.<br>Course Outcomes: Students will be able to</td></tr>
<tr><td>CO1:</td><td colspan="2">Understand how machine computation is done and the error analysis arising out of this;</td></tr>
<tr><td>CO2:</td><td colspan="2">Interpolate the given data using appropriate techniques;</td></tr>
<tr><td>CO3:</td><td colspan="2">Obtain values of various functions arising out of engineering problems using appropriate techniques;</td></tr>
<tr><td>CO4:</td><td colspan="2">Handle matrix computations that come up in linear algebra like accurate / approximate solutions of systems of linear equations, eigen values, eigenvectors, inverses, etc.;</td></tr>
<tr><td>CO5:</td><td colspan="2">Make differential and integral calculus related computations to determine physical quantities like area, volume, velocity, acceleration, etc., and numerically solve differential equations;</td></tr>
<tr><td colspan="3">Course Content:</td></tr>
<tr><td>1</td><td>Number representation on the computer: floating point arithmetic; machine precision and errors – truncation errors and round-off errors; random number generation.</td><td>6h</td></tr>
<tr><td>2</td><td>Curve fitting: Newton / Lagrange interpolation techniques, difference formulas, Bezier curves.</td><td>6h</td></tr>
<tr><td>3</td><td>Root finding: bisection method, method of false-position, Newton-Raphson's method, roots of polynomials.</td><td>6h</td></tr>
<tr><td>4</td><td>Linear system of equations: Eigen values and eigenvectors; Cayley-Hamilton theorem; LU-factorization, Gauss-Jordan elimination, Gaussian elimination; iterative methods, Jacobi's method, Gauss-Seidel method; Eigen values by power method; finding inverses of matrices; application to search engines.</td><td>10h</td></tr>
<tr><td>5</td><td>Numerical differentiation and integration: computing first and second derivatives, Richardson extrapolation; Newton-Cotes integration formulas, Trapezoidal rules, Simpson's rules; Gauss quadrature; Romberg integration; numerical methods of solving differential equations.</td><td>12h</td></tr>
<tr><td colspan="3">Text Books:</td></tr>
</table>

1. Schilling, R. J.; Harris, S. L. **Applied numerical methods for engineers,** Pacific Grove, CA, 2000.
2. Kreyszig, E. **Advanced engineering mathematics;** 3d ed.; Wiley: New York, 1972.

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| **PT310: INORGANIC AND PHYSICAL CHEMISTRY (4-0-0)** | | |
|---|---|---|
| **Course Outcomes:** Upon successful completion of this course, the students will be able to- | | |
| **CO1:** | Discuss the fundamentals of inorganic chemistry and inorganic polymers | |
| **CO2:** | Explain the basic concepts of coordination compounds | |
| **CO3:** | Determine the colligative properties and their applications | |
| **CO4:** | Explain catalysis and chemical equilibrium | |
| **CO5:** | Apply polymer colloidal solution and adsorption behavior knowledge to select suitable material for various end-use applications | |
| **Course Content:** | | |
| **Unit 1** | **Introduction:** basics of inorganic chemistry, overview of periodic table, classification and types of inorganic compounds, uses of inorganic molecules in polymer engineering.<br><br>**Inorganic Polymers:** Definition of inorganic polymers, comparison of organic polymers with inorganic polymers, A critical account (in brief) of preparation, properties, structure and applications of phosphonitrillic, silicon based, carbide, borohydride, borazine, iso- and hetero- poly acid classes of inorganic polymers. | **10h** |
| **Unit 2** | **Coordination compounds:** Definitions and terminologies- double salts, coordination compounds, coordination complexes, chelates, coordination numbers, ligands, chelating ligands and chelates. Nomenclature of coordination compounds. Physical methods in the study of complexes. Theories of Coordination complexes (Crystal field theory, Valence bond theory and molecular orbital theory Postulates and drawbacks of these theories). Stability of complex ions, stability constants, factors affecting the stability of a complex ion, stereo-regularity of coordination compounds with different coordination numbers, Isomerism, isomerism in coordination compounds, structural | **10h** |

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|---|---|---|
| | isomerism, coordination isomerism, coordination position isomerism, stereo isomerism, geometrical isomerism and optical isomerism. | |
| **Unit 3** | **Colligative Properties:** Definition and types; concept of mole and mole fraction, Lowering of vapor pressure, Raoult's law– statement, limitation, determination of molecular weight, Ostwald's and Walker's method.<br><br>Osmosis and osmotic pressure– explanation of the terms, effect of temperature and concentration and simultaneous effect; derivation of molecular weight, Berkeley and Hartely's method, isotonic solutions– explanation, molecular weight determination.<br><br>Elevation in boiling point of a solvent– derivation, experimental determination of molecular weight by ebullioscopic method; Depression in freezing point, experimental determination of molecular weight by cryoscopic method, numerical problems. | **10h** |
| **Unit 4** | **Catalysis:** Types with examples of catalytic reactions, homogeneous and heterogeneous, theory and mechanism of catalytic reactions, characteristics of catalytic reactions, negative catalysts, enzyme catalysts, acid-base catalysts. Zeigler Natta (coordination) catalysts, inorganic catalysts (like Zeolites, Silicates) and their applications.<br><br>**Chemical Equilibrium:** Spontaneous reactions, standard free energy change, Characteristics of chemical equilibrium, effects of temperature on equilibrium constant. Application of law of mass action. Equilibrium of ideal solutions. Thermodynamic treatment of the law of mass action, The Van't Hoff reaction isotherm, relation between $K_p$, $K_c$ and $K_x$; numerical problems. | **10h** |
| **Unit 5** | **The Colloidal State–** Colloidal systems, classification of colloids, lyophobic and lyophillic sols, preparation of lyophobic colloidal solutions, purification of colloidal solutions, properties of colloidal systems, electrical and electro-kinetic properties, determination of size of colloidal particles.<br><br>**Adsorption:** Definition, types of adsorption: chemisorption & physisorption; influence of temperature and pressure, nature of adsorbent and adsorbed gas, Freundlich's adsorption isotherm, unimolecular layers, Longmuir's adsorption isotherms (derivation of equation), and numerical problems | **10h** |

**Text books:**

1. B.R.Puri, L.R.Sharma and K.C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers & Distributors, New Delhi, 2008.
2. B.R.Puri, L.R.Sharma, and Pathania, Principles of Physical Chemistry, 46th Ed., Vishal Publication & Co., New Delhi, 2013. Author. Title, edition, Publisher, Place, Year.

**References:**

1. Okhil K. Medhi, Ellen A. K., James E. Huheey, Richard L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edition, Pearson, India, 2006.
2. Gary L. Miessler, Donald A. Tarr, Inorganic Chemistry, 3rd Edition, Pearson, India, 2008.
3. Shriver, Ed. by Peter Atkins, Inorganic Chemistry, 8th edition, Oxford Pub, UK, 2009.
4. Gurdeep Raj, Goel, Advanced Inorganic Chemistry, Vol. I, II; Publishing House, Meerut, India, 2011.
5. Philip Mattews, Advanced Chemistry, 1st Edition, Cambridge University Press, New Delhi, 2008.
6. Samuel Glasstone, Text book of Physical Chemistry, 2nd Ed., Macmillan India Press, Madras, 1984.

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**PT320: ORGANIC CHEMISTRY (4-0-0)**

**Course Outcomes:** Upon successful completion of this course, the students will be able to-

| | |
|---|---|
| **CO1:** | Explain fundamentals of organic chemistry and it's applications; |
| **CO2:** | Explain organic reaction mechanism and stereo chemistry; |
| **CO3:** | Explain the nomenclature, reactions, properties & applications of acyclic, carbocyclic and aromatic hydrocarbons; |
| **CO4:** | Explain the nomenclature, reactions, properties & applications of hydroxyl/ halogenated/ amino/ carboxylic hydrocarbons; and fundamentals of selected organic families; |
| **CO5:** | Illustrate the synthesis reactions of monomers. |

**Course Content:**

| | | |
|---|---|---|
| **Unit 1** | **Introduction and Structure:** Definition of organic compounds; Classification based on structure and chemical family. IUPAC Nomenclature of organic compounds (general). Bonding in organic molecules: ethane, ethylene, acetylene and butadiene. Electron displacement effect (inductive, mesomeric, inductomeric, electromeric, hyper-conjugation and resonance effects); Polarity of bonds. | **10h** |

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|---|---|---|
| | **Application of Organic Chemistry: Organic Biomolecules:** General structure property and examples of: saccharides, amino acids, peptides, proteins, nucleic acids, steroids, fatty acids. **Organic Polymers-** Basic terminologies: organic polymers, functionality, polymerization, copolymer, polymer blend, polymer composite, polymer compound. Comparison between simple molecules, monomers and macro-molecules. Scope of organic chemistry in polymer technology. Overview of polymer applications. **Organo Metallic Compounds-** Grignard reagents. | |
| **Unit 2** | **Stereochemistry-** Chirality of organic molecules with or without chiral centers and determination of their absolute configurations; stereo isomerism (optical and geometrical). Bayers strain theory, Sasche and Mohrs theory, Homotopic, enantiotopic and diastereotopic atoms, groups and faces. Conformational analysis of acyclic and cyclic compounds.<br><br>**Reactivity and Mechanism:** Reactions- types and characteristics; homolysis and heterolysis (concept of ions and radicals); addition, substitution, elimination and rearrangement (general conditions and mechanism; electronic and steric effects); introduction to other types of reactions. Types of reagents– electrophiles and neucleophiles; Acids and bases: types and strengths. Elementary treatment of SN1, SN2, E1 and E2 reactions, Hoffmann and Saytzeff rules, Markownikoff rule and Kharash effect. Aromatic electrophilic substitutions. Nucleophilic and electrophilic substitution and addition reactions (both aromatic and aliphatic). Reactive intermediates – carbocations, carbanions, carbenes, nitrenes, arynes and free radicals. Oxidation and reduction reactions. | **10h** |
| **Unit 3** | **Study of organic families:** definition, types, chemical structure, nomenclature, synthesis approach, reactivity, properties & applications of each of the following class of organic molecules is to be discussed along with some characteristic reactions as mentioned-<br><br>**i) Acyclic hydrocarbons: Alkanes-** relative reactivity of higher alkanes with halogens. **Alkenes-** electrophyllic addition reactions with halogens, Markownikoff's rule, alkylation and polymerization. Addition of halogens to dienes, Diels Alder's reactions. **Alkynes-** Acidity and polymerization of alkynes.<br>**ii) Carbocyclic hydrocarbons: Alicyclic compounds:** cyclo-alkanes, cyclo- | **10h** |

| | | |
|---|---|---|
| | alkenes, and cyclo-alkynes. Brief introduction to polycyclic hydrocarbons (e.g. cyclopentene, DCPD, norbornene, etc).<br><br>**iii) Aromatic compounds (arenes):** aromaticity, resonance energy and substitution reaction.<br><br>**iv) Introduction to Heterocyclic organic compounds**: Brief study including saturated, unsaturated and aromatic types (e.g. oxirane, furan, thiophene, pyrrole, pyridine, thiazine, etc.) | |
| **Unit 4** | **v) Halogenated hydrocarbons.**<br><br>**vi) Hydroxy compounds: Alcohols; & Phenols-** effect of substitution on acidity of phenols.<br><br>**vii) Carboxylic acids**: Types (Dicarboxylic, Aromatic, Hydroxy, Amino acids, etc); Derivatives of acids; acidity and structure of carboxylic ions. Effect of substitution on acidity; effect of heat on hydroxy acids.<br><br>**viii) Amines.**<br><br>**ix) Brief introduction to:** Aldehydes, Amides, Anilides, Anhydrides, Carbohydrates, Ethers, Esters, Ketones, Nitrile compounds, Nitro compounds and Urethanes. | **10h** |
| **Unit 5** | **Synthesis of monomers:** Butadiene, isoprene, tetrafluoroethylene, adipic acid, maleic acid, phthalic acid, lactic acid, aniline, phthalic anhydride, maleic anhydride, caprolactone. | **10h** |

**Text book:** Bahl B S, Text Book of Organic Chemistry, 9th ed, S Chand & Co, Delhi, 1967.

**References:**


1. Morrison, R. T.; Boyd, R. N. Organic chemistry; 3d ed.; Allyn and Bacon: Boston, 1973.
2. Weissermel, K.; Arpe, H. Industrial organic chemistry: important raw materials and intermediates; 1. Aufl.; Verlag Chemie: Weinheim, 1978.
3. Jain, M. K. Principles of organic chemistry; 8th rev.; Nagiu: Jullundar, 1976.
4. Sykes, P. A guidebook to mechanism in organic chemistry; 6th ed.; Longman: Harlow, Essex, England, 1986.
5. Lloyd N. Ferguson, The Modern Structural Theory Of Organic Chemistry, Prentice Hall. 1962.
6. Waddams, A. L. Chemicals from petroleum: an introductory survey; 3d ed.; Wiley: New York, 1973 J. March, Advanced Organic Chemistry, 4th edition, McGraw Hill, New York, 1994.

7. R. O. C. Norman and J. M. Coxon, Principles of Organic Synthesis, Blackie Academic and Professional, Glasgow, NewYork, 1993.
8. P. H. Gorggins, Unit Processes in Organic Synthesis, 5th edition, McGraw-Hill, 1958.
9. J. March, Advanced Organic Chemistry, 3rd edition, McGraw Hill, New York, 1985.
10. I L. Finar, Organic Chemistry, Volume 1: The Fundamental Principles, VI edition, ELBS, 1989.
11. M. K. Jain and S. C. Sharma, Organic Chemistry, Shoban Lal Chand. & Co., 2000.

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| **PT330: POLYMER CHEMISTRY (4-0-0)** | | |
|---|---|---|
| **Course Outcomes:** Upon successful completion of this course, the students will be able to- | | |
| **CO1:** | Explain fundamentals of polymer chemistry and classification of polymers | |
| **CO2:** | Explain mechanism for polymerization reactions | |
| **CO3:** | Explain polymerization methods with importance | |
| **CO4:** | Explain the fundamentals of copolymerization and special topics in polymer synthesis | |
| **CO5:** | Outline the important polymer reactions and purification of polymers. | |
| **Course Content:** | | |
| **Unit 1** | **Introduction and Nomenclature:** Functionality of monomers and its role in deciding polymers' structure (linear, branched and cross-linked); Review of basics of polymer technology. IUPAC names, trade or commercial names, source based and structure based names of various polymers. Abbreviations and grades of polymers. General remarks on form or physical nature of polymeric materials-plastics, rubbers, fibers/textiles, latex/emulsions, resins.<br><br>**Classifications of polymers:** [brief description of each classification; names and chemical structures of polymers to be discussed in each type of classifications covering around seventy well known polymers]: On the basis of source (natural, synthetic & semi-synthetic); backbone composition (organic & inorganic polymer; homo & co-polymer; homo-chain & hetero-chain polymer); polymerization (addition & condensation); effect of heat (thermo-plastic polymers & thermo-setting polymers); geometric isomerism (cis & trans polymers) and stereo isomerism (tacticity- iso, syndio & atactic polymers); application (commodity, engineering & high-performance); molecular structure (linear, branched & cross- | **10h** |

| | | |
|---|---|---|
| | linked); microstructure (amorphous, crystalline & semi-crystalline).<br><br>**Polymerization:** Difference between addition/chain & condensation/ step polymerization; Raw materials used in polymerization: Discussion about role & examples of- initiator, inhibitor, retarder, chain transfer agent, catalyst, short-stop, and medium; Factors affecting polymerization. | |
| **Unit 2** | **Chemistry of Polymerization**<br><br>**Chain (addition/vinyl) polymerization:** Definition & types. Addition polymerization (reaction and/or mechanism) - free radical, anionic and cationic- Initiation, propagation, and termination by different approaches under each technique has to be discussed along with examples of polymers produced and highlights of each technique.<br><br>**Step (condensation) polymerization:** Definition & types. Condensation polymerization reaction and/or mechanism (polyesters (PET & PBT), polyamides (nylon 6 and nylon 66), polyethers, phenol-formaldehyde. Poly-addition reaction (polyurethane, polyurea).<br><br>**Stereo regular (Co-ordination) polymerization:** Types and structures of initiators (Zeigler-Natta catalyst and other types), Polymerization mechanism, advantages & disadvantages, types and examples of stereo specific polymers with applications | **10h** |
| **Unit 3** | **Copolymerization:** definition of co-monomers & co-polymers; classification based on process and repeat units; need of copolymerization with specific examples; free radical copolymerization and its mechanism; ionic copolymerization and its mechanism<br><br>**Special topics in polymer synthesis-** Polyaddition**,** polymerization, metathesis polymerization, interfacial condensation, electrochemical polymerization, group-transfer polymerization, [brief and general mechanism or method, important polymers produced, advantages/ specialty and disadvantages/ limitations of each technique to be highlighted]. | **10h** |
| **Unit 4** | **Methods of Polymerization:** Bulk, solution, suspension, emulsion, solid phase, gas phase, ring opening, melt condensation, solution condensation and plasma polymerization (mechanism, important polymers produced, properties of the | **10h** |

| | | |
|---|---|---|
| | polymer produced, advantages and limitations of each technique to be discussed). | |
| **Unit 5** | **Polymer reactions:** introduction; types- hydrolysis, acidolysis, addition, substitution, halogenation, hydrogenation, crosslinking, curing, (brief mechanism and usefulness of each reaction to be highlighted with examples).<br><br>**Isolation and purification of polymers:** Need of isolation and purification; polymer fractionation, fractional precipitation and partial dissolution (extraction) technique. | **10h** |

**Text books:**

1. Padma L Nayak, Polymer Science, Kalyani Publishers, New Delhi, 1st Edn, 2005.
2. Gowariker, V. R.; Viswanathan, N. V., Polymer Science; Wiley: New York, 1986.

**References:**


1. Rodriguez, F. Principles of polymer systems; McGraw-Hill: New York, 1970.
2. Seymour, R. B.; Carraher, Polymer chemistry: an introduction; 4th ed.; M. Dekker: New York, 1996.
3. Odian, G. G. Principles of polymerization; Fourth ed, Wiley, 2004.
4. Young, R. J and P.A.Lovell, Introduction to polymers; Chapman and Hall: London, 1981.
5. Anil Kumar, Fundamentals Of Polymer Science and Engineering, Tata McGraw Hill, New Delhi, 1978
6. G.S. Misra, Polymer Chemistry, Wiley Eastern Ltd., New Delhi, 1993
7. Billmeyer Fred W. JR. Textbook of polymer science, John Wiley & Sons, New York, 1984


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**PT340: THERMODYNAMICS (3-1-0)**

**Course Outcomes:** Upon successful completion of this course, the students will be able to-

| | |
|---|---|
| **CO1:** | Explain first law of thermodynamics and its applications |
| **CO2:** | Derive and apply second law of thermodynamics |
| **CO3:** | Estimate the thermodynamic properties of fluids using the concept of Gibbs free energy, Helmholtz free energy and Maxwell equations. |
| **CO4:** | Apply the concepts of chemical potential and partial properties in binary solutions. |
| **CO5:** | Apply thermodynamic principles in polymer solutions and elastomers. |

**Course Content:**

| | | |
|---|---|---|
| **Unit 1** | **Introduction & I Law of Thermodynamics**: basic concepts and definitions, Thermodynamic terms, joule's experiment, internal energy (U), first law of thermodynamics, statement, mathematical expression, Constant volume and constant pressure process, Enthalpy (H), heat capacities at constant volume and constant pressure, the ideal gas, the internal energy of an ideal gas, isothermal process, adiabatic processes, isochoric process, isobaric process, numerical problems. | **10h** |
| **Unit 2** | **II Law of Thermodynamics:** II law of Thermodynamics; statements, Heat engines, Carnot's theorem, Thermodynamic temperature scales, Carnot cycle for a gas and Elastomers, entropy, entropy changes of an ideal gas; numerical problems. | **10h** |
| **Unit 3** | **Thermodynamic properties of fluids:** Property relations for homogeneous phases – Maxwell's relations, enthalpy (H) and entropy (S) as functions of Temperature (T) and Pressure (P), internal energy (U) as a function of (P), The ideal gas state. Alternative forms for liquids, Internal energy (U) and entropy (S) as functions of Temperature (T) and volume (V), residual properties, numerical problems. | **10h** |
| **Unit 4** | **Solution thermodynamics:** Fundamental property relations, the chemical potential and phase equilibria, partial properties, Equations relating molar and partial molar properties, Gibbs-Duhem equation, partial properties in binary solutions, relations among partial properties, fugacity and fugacity coefficient, ideal solution, excess properties, activity coefficient, numerical problems. | **10h** |
| **Unit 5** | **Thermodynamics of polymer solutions and elastomers:**<br>**Thermodynamics of polymer solution:** Thermodynamics of ideal solutions, Flory Huggin's theory, partial molar quantities and chemical potential, dilute polymer solutions, the solubility parameter approach, **Deformation of elastomers**: Thermodynamics of elastomer deformation, thermoelastic inversion effect. | **10h** |

**Text books:**


1. J.M.Smith and H.C.Van Ness. Introduction to Chemical Engineering thermodynamics; Mc.Graw Hill, New Delhi.1987.
2. R.J.Young & P.A. Lovell, Introduction to Polymers; Chapman & Hall; London, 1992.


**References:**


1. L.H.Sperling, Introduction to Physical polymer science; John Wiley and Sons; London, 1985

2. A.Tager, Physical chemistry of Polymers; Mir publishers; Moscow, 1978.
3. Joel. R.Fried, Polymer Science & Technology; Prentice Hall India Private Limited; New Delhi, 1995.
4. Narayanan K.V. Textbook of Chemical Engg. Thermodynamics, Prentice Hall India Private Limited, New Delhi, 2001.

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| **PT350: TRANSPORT PHENOMENA IN MATERIALS ENGINEERING-I (4-0-0)** | | |
|---|---|---|
| **Course Outcomes:** Upon successful completion of this course, the students will be able to | | |
| **CO1:** | Explain the fundamentals of fluid mechanics and concepts of dimensional analysis. | |
| **CO2:** | Explain concepts of laminar and turbulent flow. | |
| **CO3:** | Apply the concepts of mass, momentum and mechanical energy balance. | |
| **CO4:** | Explain principles of various fluid flow measuring devices and basic concepts of chemical process calculation. | |
| **CO5:** | Perform material balance with chemical reaction and can apply the knowledge for problem solving. | |
| **Course Content:** | | |
| **Unit 1** | **Engineering Units and Pressure in Static Fluids:** Basic Engineering Units, Concept of Pressure, Pascal's law, Measurement of Pressure, numerical problems.<br>**Dimensional Analysis:** Step by step procedure for dimensional analysis, Buckingham's' Π theorem, example problems on dimensional analysis. Dimension less groups and their importance. | **10h** |
| **Unit 2** | **Momentum Transport and Laminar Flow of Newtonian Fluids**: Introduction, Newton's Law of Viscosity, Conservation of Momentum in Steady-State Flow, Fluid Flow in a horizontal and Vertical Cylindrical pipes, Fluid Flow in an Annulus, Fluid Flow Between Two Flat Parallel Plates, Capillary Flow meter, numerical problems.<br>**Turbulent Flow:** Introduction, Friction Factor and Turbulent Flow in Cylindrical Pipes, Flow Through Packed Beds and Fluidized Beds, numerical problems.<br>**Flow past submerged bodies, Prandtl boundary layer theory.** | **10h** |

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|---|---|---|
| **Unit 3** | **Mechanical Energy Balance and Its Application to Fluid Flow:** Introduction, Bernoulli's Equation, Frictional Loss, Influence of Bends, Fittings and Changes in the Pipe Radius, Concept of Head, Bernoulli's Equation for Flow of Compressible Fluids. Numericals. | **10h** |
| **Unit 4** | **Flow measuring devices:** Pitot Tube, Orifice meter, Venturi meter, numericals. **Chemical process calculations, material balance without reaction:** General material balance equation for steady and unsteady state. Process calculations, Typical steady state material balances in distillation, absorption, extraction, crystallization, mixing and evaporation, numerical problems. | **10h** |
| **Unit 5** | **Steady state material balance with reaction:** Principles of Stoichiometry, Concept of limiting, Excess reactants and inerts, Fractional and percentage conversion, Fractional and percentage yield, Selectivity, numerical problems. | **10h** |

**Text books:**


1. David R Gaskell. An Introduction to Transport Phenomena in Materials Engineering, 2nd Edition, Momentum press, LLC, New Jersey, 2012.
2. R K Bansal. A Textbook of Fluid Mechanics. 3rd edition, Laxmi publications (P) Ltd, New Delhi, 2005.


**References:**


1. Hougen O.A., Watson K.M. and Ragatz R.A. Chemical Process Principles, Part–I Material and Energy Balances, 2nd edition, CBS publishers and distributors, New Delhi, 1995.
2. Himmelblau, D.M. Basic Principles and calculations in Chemical Engineering, 6th Edn, Prentice Hall of India, New Delhi, 1997.
3. Poirier D. R., and Geiger G. H. Transport Phenomena in Materials Processing, Wiley Publications, 1998.
4. McCabe W.L. and Smith. Unit Operations of chemical Engineering, 6th edn., McGraw Hill Publications, New York , 2001.


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| **PT36L: ORGANIC CHEMISTRY (0-0-1.5)** | |
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| **Course Outcomes:** Upon successful completion of this course, the students will be able to- | |
| **CO1:** | Explain the fundamentals, procedure and significance of organic chemistry experiments; |
| **CO2:** | Conduct experiments by adopting laboratory disciplines; |

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|---|---|
| **CO3:** | Identify organic compounds by qualitative analysis; |
| **CO4:** | Synthesize or Quantitatively Analyze some important organic compounds; |
| **CO5:** | Analyze, interpret and report the experimental data suitably. |

**List of experiments:**

| **Part – A** | **Part - B** |
|---|---|
| **Identification of organic compounds of the following types:**<br>1. Hydrocarbons<br>2. Alcohols<br>3. Esters<br>4. Aldehydes<br>5. Ketones<br>6. Carboxylic acids<br>7. Amines<br>8. Amides<br>9. Carbohydrates<br>10. Nitro compounds<br>11. Halogen compounds<br>12. Phenols<br>13. Anilides | **I. Single step preparation of organic compounds by the following methods.**<br>1. Nitration<br>2. Acetylation<br>3. Bromination<br>4. Oxidation<br>5. Hydrolysis<br>**II. Qualitative estimation of**<br>1. Aniline<br>2. Phenol<br>3. Acetone<br>4. Acetamide<br>5. Ethyl or Methyl acetate |

**Text book:** Vogel A I. Elementary practical organic chemistry**,** 2nd ed, Wiley, New York, 1966.

**References:**


1. Bahl B S. Text Book of Organic Chemistry, 9th ed, S Chand & Co, Delhi, 1967.
2. Organic Chemistry Lab Manual (Department of PST).


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**PT37L:FLUID MECHANICS LAB (0-0-1.5)**

**Course Outcomes:** Upon successful completion of this course, the students will be able to

| | |
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| **CO1:** | Interpret the nature of flow and understand concept of flow through fluidized and packed bed. |
| **CO2:** | Practically determine hydraulic coefficients and pressure drops. |
| **CO3:** | Compare the efficiencies of various flow measuring devices. |
| **CO4:** | Experimentally determine minor and major energy losses in pipe flow. |
| **CO5:** | Construct performance characteristic curves for single and multi stage centrifugal pump. |

**Course Content: List of experiments**

1. Determination of Reynolds number
2. Determination of Hydraulic coefficients using a vertical orifice (circular) discharging fluid freely into atmosphere
3. Calibration of Venturimeter
4. Calibration of Orifice meter
5. Calibration of Rectangular and V-Notch
6. Determination of Darcy's friction factor for pipes of uniform diameter
7. Minor Losses in pipes: Determination of minor losses of head in pipes due to (i) Sudden expansion (ii) Sudden contraction and (iii) Bends and Elbows
8. Determination of hydraulic coefficients for different types of mouth pieces.
9. Flow through fluidized bed
10. Flow through packed bed
11. Experiments to determine the characteristics of a Single stage centrifugal pump
12. Experiments to determine the characteristics of a Multi-stage centrifugal pump**.**

**Text books:**

1. R K Bansal. A Textbook of Fluid Mechanics. First edition, Laxmi publications (P) Ltd, New Delhi, 2005**.**

**References:**

1. McCabe, W.L., Smith J C and Harriot P. Unit Operations of chemical Engineering, 6th edn., McGraw Hill Publications, New York , 2001.
2. Coulson J.M. and Richardson .J.F., Chemical Engineering, Vol. 1, 6th edn., Butterworth Heinemann, Oxford, 2002.
3. David R Gaskell. An Introduction to Transport Phenomena in Materials Engineering, 2nd Edition, Momentum press, LLC, New Jersey, 2012.

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**HU310: CONSTITUITION OF INDIA AND PROFESSIONAL ETHICS (2-0-0)**

**Course Objectives:**

- The objective of studying the Constitution of India is to increase the legal and social awareness of the engineers so that they are equipped to face challenges they may confront in their careers and also to encourage them to actively participate in the political process of the country.
- The objective of studying professional ethics is to equip an engineer to face such situations and to solve such conflicts in compliance with the accepted ethical principles and norms.

**Course Outcomes:** After the completion of the course the student will-

CO1: Have knowledge about and an understanding of constitutionally guaranteed rights and duties of every citizen. Have knowledge about the various forums that actively participate in protecting these rights in case of violation.

CO2: Have an understanding of the working of the electoral process, amendment procedure. Have an understanding of the different organs of the State, namely legislature, executive and the judiciary.

CO3: Have an understanding of the powers & functions of state legislature and Union legislature. Have an understanding of the powers & functions of state executive, and Union executive and emergency provisions.

CO4: Have an understanding of the special provisions related to SCs, STs, Women, children and backward classes. Have an understanding of the scope, limitation and functioning of the Indian judiciary. Have an understanding of the importance of fundamental duties and directive principles of state policy.

CO5: Be able to develop the ethical autonomy i.e., the skill and the habit of thinking rationally and critically about the ethical values viz honesty, integrity and reliability. Be able to build and contribute to a safe and healthy work environment. Be able to better serve in responsible positions of leadership and discharge his duties better.

CO6: Be equipped with better decision making abilities and will be able to make morally and ethically sound decisions. Be able to make positive contribution to the society. Be examples of faith, character, and high professional ethics.

**Course Content:**

1. Preamble to the constitution of India. Fundamental Rights under Part III - details of Exercise of rights, Limitations and Important cases.
2. Relevance of Directive Principles of State Policy under Part IV. Fundamental duties and their significance.
3. Union Executive - President, Prime Minister, Parliament and the Supreme Court of India.
4. State executive - Governors, Chief Minister, State Legislator and High Courts.
5. Constitutional Provisions for Scheduled Castes and Tribes, Women & Children & Backward classes, Emergency Provisions.
6. Electoral process, Amendment procedure, 42nd, 44th, 74th, 76th, 86th and 91st Constitutional amendments.
7. Scope & aims of engineering Ethics, Responsibility of engineers. Impediments to responsibility.
8. Honesty, Integrity and reliability, risks, safety & liability on engineering.

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# IV Semester

**MA310A/MA410A: ENGINEERING MATHEMATICS–IV**

**(Fourier Series, Integral Transforms And Applications) (4-0-0)**

**Course Objective:**

- Fourier series and Integral transforms techniques will be introduced.
- Applications of Integral transforms to solution of differential equations will be discussed. Elementary Complex analysis is introduced.

**Course Outcomes:** Students will be able to-

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| **CO1:** | Find expansions of functions as Fourier series / half-range Fourier series in a given range of values of the variable. Obtain the various harmonics of the Fourier series expansion for the given numerical data. |
| **CO2:** | To find Fourier transforms, Fourier sine and Fourier cosine transforms of functions. |
| **CO3:** | Use Laplace transforms to determine solutions to linear differential equations. |
| **CO4:** | Solve difference equations using Z-transforms. |
| **CO5:** | Analyze functions of complex variable and handle analytic functions. |
| **CO6:** | Apply Cauchy-Riemann equations and harmonic functions to problems of Fluid Mechanics, Thermo Dynamics and Electromagnetic fields. |
| **CO7:** | Geometrically interpret conformal and bilinear transformations. |

**Course Content:**

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|---|---|---|
| **1** | **Fourier series:** Introduction, Fourier series for even and odd functions; half-range expansions; practical harmonic analysis. | **6h** |
| **2** | **Fourier transforms:** Fourier transforms, inverse transforms, applications to ordinary and partial differential equations; discrete Fourier transforms. | **6h** |
| **3** | **Laplace transforms and inverse Laplace transforms:** applications to differential equations. | **12h** |
| **4** | **Linear Algebra:** Real vector spaces; linear dependence/independence; basis / dimension; linear transformations; rank – nullity theorem. | **10h** |
| **5** | **Z-transforms:** z-transforms and inverse z-transforms; solution of difference equations. | **6h** |

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|---|---|---|
| **6** | **Complex Analysis:** Introduction, analytic functions; C-R equations; properties of analytic functions; construction of conformal mappings. | **8h** |
| **Text Book:** Kreyszig, E. **Advanced engineering mathematics;** 3d ed.; Wiley: New York, 1972. | | |

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| **PT410: MATERIAL SCIENCE AND ENGINEERING (4-0-0)**<br>**Course Outcomes:** Upon successful completion of this course, the students will be able to | | |
| **CO1:** | Analyze material atomic structure and bonding. | |
| **CO2:** | Modify material properties for an engineering application and construct the phase diagrams for given material systems. | |
| **CO3:** | Explain composite, ceramic properties and applications. | |
| **CO4:** | Explain electrical and mechanical properties of materials. | |
| **CO5:** | Explain properties and applications of advanced materials. | |
| **Course Content:** | | |
| **Unit 1** | **Structure:** Atomic structure and bonding in materials. Crystal structure of materials, crystal systems, unit cells and space lattices, determination of structures of simple crystals by x-ray diffraction, miller indices of planes and directions, packing geometry in metallic, ionic and covalent solids. Concept of amorphous, single and polycrystalline structures and their effect on properties of materials. Crystal growth techniques. Imperfections in crystalline solids and their role in influencing various properties, numerical problems. | **10h** |
| **Unit 2** | **Metals and Alloys:** Solid solutions, solubility limit, the phase rule, the lever rule, single component systems, binary phase diagrams, intermediate phases, iron-iron carbide phase diagram, heat treatment of steels, cold and hot working of metals, recovery, re-crystallization and grain growth, micro-structural changes during cooling. Microstructure, properties and applications of ferrous and non-ferrous alloys. Applications of phase diagrams, numerical problems. | **10h** |
| **Unit 3** | **Composites:** Properties and applications of various composites.<br>**Ceramics:** Structure, properties, processing and applications of traditional and advanced ceramics. Sintering process. | **10h** |

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|---|---|---|
| | **Mechanical Properties:** stress-strain diagrams of metallic, ceramic and polymeric materials, modulus of elasticity, yield strength, tensile strength, toughness, elongation, plastic deformation, visco-elasticity, hardness, impact strength, creep, fatigue, ductile and brittle fracture, numerical problems. | |
| **Unit 4** | **Magnetic Properties:** Origin of magnetism in metallic and ceramic materials, para-magnetism, diamagnetism, ferromagnetism, anti-ferromagnetism, ferrimagnetism, magnetic hysteresis. Numerical problems.<br><br>**Electrical Properties:** Concept of energy band diagram for materials – conductors, semiconductors and insulators, electrical conductivity – effect of temperature on conductivity, intrinsic and extrinsic semiconductors, dielectric properties, Hall effect, Numerical problems. | **10h** |
| **Unit 5** | **Advanced Materials:** Smart materials, materials exhibiting ferroelectric, piezoelectric, opto-electric, semiconducting behavior, lasers and optical fibers, photoconductivity and superconductivity, nano-materials – synthesis, properties and applications, biomaterials, superalloys, shape memory alloys.<br><br>Degradation of materials by corrosion and oxidation. | **10h** |

**Text books:**


1. V Raghavan. Materials Science & Engineering, 5th Edition, PHI Learning Pvt. Ltd., New Delhi, 2011.
2. R. Balasubramaniam. Callister's Materials Science and Engineering, 2nd Edition, Wiley India Pvt. Ltd. New Delhi, 2014.


**References:**


1. William D Callister. Materials Science and Engineering, John Wiley, New York, 2007.
2. A.K. Bhargava. Engineering Materials, Prentice-Hall of India Pvt. Ltd., 2005.
3. L.H. Van Vlack. Elements of Material Science & Engineering, 6th edition, Addison-Wesley Publishing Co., New York, 1989.


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| **PT420: POLYMER PHYSICS (4-0-0)**<br>**Course Outcomes:** Upon successful completion of this course, the students will be able to- | | |
| **CO1:** | Explain basic concepts of micro structure of polymers. | |
| **CO2:** | Explain the fundamental concepts of crystallization of polymers. | |
| **CO3:** | Explain the polymer thermal transition behavior. | |
| **CO4:** | Determine molecular weight of polymers using different experimental techniques and equations. | |
| **CO5:** | Apply the concepts of polymer solution in designing products such as colloidal dispersions, hydrogels and solvent based adhesives | |
| **Course Content:** | | |
| **Unit 1** | **Chain Configurations:** Conformation of polymers-constitutional isomerism, positional isomerism, branching; Configurational isomerism- geometrical isomerism, stereo isomerism; polymer conformation-conformation of small molecules and conformation of polymers; Conformation of macromolecules-General shape of macromolecules – general shape of macromolecules; definition of conformational parameters of a chain-end to end distance. | **10h** |
| **Unit 2** | **The Crystalline State:** Crystallizability, polymer crystallization (mechanism), factors affecting Crystallizability of polymer, Spherulites, methods used to determine crystallinity, effect of crystallinity on properties, melting behavior, factors affecting on $T_m$, Kinetics of Crystallization. Applications of Avrami equation, orientation crystallization and annealing. Crystal structure of polymers: Molecular aggregation, molecular arrangement in crystallites, polyethylene, syndiotactic Vinyl polymers, PTFE, PVA, polyesters, Polyamides, Polydienes; the principles of crystallite structure, Single crystals of polymers. | **10h** |
| **Unit 3** | **Methods of measuring molecular weight averages:** The concept of molecular weights (number average molecular weight, weight average molecular weight, viscosity average and z-average molecular weight – definition and mathematical expressions), molecular weight distribution and its importance and polydispersity. Methods of measuring molecular weight: Ebuilioscopy, Cryoscopy, membrane | **10h** |

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| | osmometry, vapor pressure osmometry, end group analysis, light scattering, viscometry, and ultracentrifugation methods. (Principle, theory, experimental procedure, merits, demerits of each techniques and problems should be discussed). | |
| **Unit 4** | **Transition of polymers– from glassy to rubber like and viscofluid states:** Five regions of viscoelastic behavior; glassy region, glass transition region, rubbery flow region, rubbery plateau region, the liquid flow region, Relaxation nature of glass transition, mechanism of glass transition, methods of determining glass transition temperature – Dilatometry, thermal methods, mechanical methods, other transitions and relaxations; main chain and side chain motions, $T_{LL}$ (liquid-liquid transition), Factors affecting $T_{g.}$ | **10h** |
| **Unit 5** | **True solutions of polymers:** Specific properties of true solution, dissolution and swelling of polymers, degree and kinetics of swelling, polyelectrolytic solutions, factors affecting dissolution and swelling of polymers, gels of polymers, colloidal dispersions of polymers, preparation of polymer solutions and their refining, resistance of polymeric materials to solvents. | **10h** |

**Text book:** Sperling, L. H. Introduction to physical polymer science; Wiley: New York, 1986.

**References:**


1. David I. Bower, An Introduction to Polymer Physics, Cambridge University Press, New York, 2002.
2. A.Tagar, Physical Chemistry of polymers, Sec. Edn, MIR Publishers, Prentice Hall Inc 1978.
3. V.N.Kuleznev & V.A. Shershnev, The chemistry and physics of polymer, Sec. Edn – MIR Publisher, Moscow, 1988
4. S. F. SUN St, Physical chemistry of macromolecules Basic Principles and Issues, Sec. Edn, Wiley-Interscience Publication, John Wiley & Sons Inc., New York, 2004.
5. Yves Gnanou, Michel Fontanille, Organic and physical chemistry of polymers, Wiley-Interscience Publication, John Wiley & Sons Inc New York, 2008.
6. Padma L Nayak, Polymer Science, Kalyani Publishers, New Delhi, 1st Edn, 2005.
7. Jerold Schutz, Polymer Material science, First Edn. Prentice Hall Inc, 1974.
8. Fried, J. R., Polymer science and technology, Prentice Hall PTR: Englewood Cliffs, N.J., 1995.


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| **PT430: POLYMER MANUFACTURING TECHNOLOGY (4-0-0)**<br>**Course Outcomes:** Upon successful completion of this course, the students will be able to explain- | | |
| **CO1:** | Chemistry, manufacturing process, compounding ,properties and applications of polyolefin's | |
| **CO2:** | Chemistry, manufacturing process, compounding, properties and applications of styrene's and acrylics. | |
| **CO3:** | Chemistry, manufacturing process, compounding, properties and applications of PVC and engineering thermoplastics. | |
| **CO4:** | Chemistry, manufacturing process, compounding, properties and applications formaldehyde based thermosets. | |
| **CO5:** | Chemistry, manufacturing process, compounding, properties and applications of epoxy resin and urethane. | |
| **Course Content:** | | |
| **Unit 1** | **Polyethylene**: HDPE, LDPE, LLDPE, VLDPE, UHMWPE, chlorinated PE (CPE), chloro sulphonated PE, copolymers of PE (EVA).<br>**Polypropylene**: Isotactic, Syndio tactic and Atactic PP. | **10h** |
| **Unit 2** | **Polystyrene**: Polystyrene, HIPS & copolymers of styrene (SAN & ABS).<br>**Acrylics:** PMA, PMMA, PAN<br>**Polyvinyl chloride** | **10h** |
| **Unit 3** | **Polyamides**: Nylon 6 and Nylon 66<br>**Poly esters**: Thermoplastic (PET & PBT)<br>**Poly carbonate** | **10h** |
| **Unit 4** | **Phenol formaldehyde. Urea formaldehyde. Melamine formaldehyde.** | **10h** |
| **Unit 5** | **Epoxy resins. Polyurethanes. Unsaturated Polyester resins.** | **10h** |
| **Text book:** Brydson, J. A. Plastics materials; Butterworth-Heinemann; 7 edition, Iliffe; London, 1966. | | |
| **References:**<br>1. W. Mayo Smith, Manufacture of Plastics - Vol. I & II; Van Nostrand Reinhold; New York, 1964 | | |

2. Irvin.I. Rubin, Hand Book of Plastics Materials & Technology**;** John Wiley & Sons Inc.; New York, 1990.

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| **PT440: POLYMERIZATION KINETICS (4-0-0)** | | |
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| **Course Outcomes:** Upon successful completion of this course, the students will be able to- | | |
| CO1: | Discuss the basic concepts of chemical kinetics | |
| CO2: | Explain kinetics of addition polymerization. | |
| CO3: | Derive kinetic expression for condensation polymerization. | |
| CO4: | Apply the kinetic aspects to derive kinetic expression for ionic & coordination polymerization | |
| CO5: | Derive kinetic equations for copolymerization and evaluate monomer reactivity ratio. | |
| **Course Content:** | | |
| **Unit 1** | **General Chemical Kinetics:** Definition of reaction rate, order, molecularity, different theories of reaction rate - collision theory, transition state theory, Arrhenius law, activation energy, kinetic expressions for simple first order & second order chemical reaction. Different methods to determine order of reaction. Numerical problems. | **10h** |
| **Unit 2** | **Kinetics of addition polymerization:** Expressions for rate of initiator decomposition, chain initiation, chain termination, rate of propagation, steady state assumption, overall rate of polymerization, experimental approaches for determination of polymerization rate, Initiator efficiency, kinetic chain length, chain transfer, control of molecular weight by transfer, determination of individual rate constants by sector method. Numerical problems. | **10h** |
| **Unit 3** | **Kinetics of condensations polymerization:** Rate expression for acid catalyzed and non catalyzed reaction, statistics of linear step reaction polymerization, molecular weight control, principle of equal reactivity of functional groups. Multi chain polymer, poly functional step reaction polymerization, prediction of gel point, molecular weight distribution in 3-dimensional step reaction polymers. Numerical problems. | **10h** |

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| **Unit 4** | **Kinetics of ionic and co-ordination polymerization:** Kinetics of cationic polymerization, anionic polymerization, living polymers, kinetic expression for co-ordination polymerization. Smith-Ewart's kinetics. Numerical problems. | **10h** |
| **Unit 5** | **Kinetics of co-polymerization:** The co-polymeric equation, monomer reactivity ratios, ideal & alternating co-polymerization, instantaneous composition of feed and polymer, evaluation of monomer reactivity ratios, rate of co-polymerization, integration of co-polymer equation. Numerical problems. | **10h** |

**Text books:**

1. Keith J Laidler. Chemical Kinetics; Tata Mc.Graw Hill; New Delhi, 1975.
2. Fred W.Billmeyer. Text book of Polymer Science; JR John Wiley & Sons, New York.1984.

**References:**

1. Premamoy Ghosh. Polymer Science and Technology of Plastics & Rubbers; Tata McGraw-Hill, N.Delhi,India, 1990.
2. Anil Kumar & S.K.Gupta. Fundaments of Polymer Science and Engineering; Tata Mc Graw Hill, New Delhi, 1978

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**PT450:TRANSPORT PHENOMENA IN MATERIALS ENGINEERING-II (4-0-0)**

**Course Outcomes:** Upon successful completion of this course, the students will be able to-

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| CO1: | Explain the principles and governing equations of heat transfer by conduction |
| CO2: | Explain the individual and overall heat transfer coefficients of convective heat transfer. |
| CO3: | Apply the knowledge of heat transfer in designing different types of heat exchange equipment. |
| CO4: | Explain the principles of diffusion and develop relevant mathematical relations. |
| CO5: | Develop mathematical relations for mass transfer applications which involve binary mixtures in process engineering. |

**Course Content:**

| | | |
|---|---|---|
| **Unit 1** | **Transport of Heat by Conduction**: Introduction, Fourier's Law and Newton's Law, Conduction, Conduction in Heat Sources, **C**onduction through a multi | **10h** |

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| | layered wall, General Heat Conduction Equation, Numerical Problems**.** | |
| **Unit 2** | **Transport of Heat by Convection:** Introduction, relation between individual and overall heat transfer coefficient. Heat Transfer During Fluid Flow in Cylindrical Pipes, Energy Balance in Heat Transfer by Convection Between a Cylindrical Pipe and a Flowing Fluid, Heat Transfer by Forced Convection from horizontal Cylinders, General Energy Equation, and Numerical Problems. | **10h** |
| **Unit 3** | **Heat exchangers:** Introduction, heat transfer to a jacket, double pipe heat exchanger, and Finned tube heat exchanger. Numerical Problems. | **10h** |
| **Unit 4** | **Mass Transport by Diffusion in the Solid State:** Introduction, Atomic Diffusion as a Random-Walk Process, Fick's First Law of Diffusion, One-Dimensional Non-Steady-State Diffusion in a Solid; Fick's Second Law of Diffusion, numerical problems. | **10h** |
| **Unit 5** | **Mass Transport in Fluids:** Introduction, Mass and Molar Fluxes in a Fluid, Equations of Diffusion with Convection in a Binary Mixture A–B, One-Dimensional Transport in a Binary Mixture of Ideal Gases, Equimolar Counter diffusion, One-Dimensional Steady-State Diffusion of Gas A Through Stationary Gas B, Numerical problems. | **10h** |
| **Text book:** David R Gaskell, An Introduction to Transport Phenomena in Materials Engineering, 2nd Edition, Momentum press, LLC, New Jersey (2012). | | |
| **References:**<br>1. D. R. Poirier, G. H. Geiger, Transport Phenomena in Materials Processing, Wiley, (1998).<br>2. McCabe, W.L., Smith J C and Harriot P., Unit Operations of chemical Engineering, 6t$^{h}$ ed., Mc Graw Hill, NY 2001. | | |

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| **PT46L: Physical Chemistry Lab (0-0-1.5)**<br>**Course Outcomes:** Upon successful completion of this course, the students will be able to- | |
|---|---|
| **CO1:** | Explain the fundamentals, procedures and significance of physical chemistry experiments; |
| **CO2:** | Work in team and Conduct experiments by adopting laboratory disciplines; |
| **CO3:** | Determine intensive and extensive physical properties of liquids and solids; |

| | |
|---|---|
| **CO4:** | Analyze, interpret and report the experimental data suitably. |

**Course Content:**

1. Determination of density and surface tension of pure liquids.
2. Determination of viscosity of a binary liquid mixture using viscometer.
3. Determination of molecular weight of a non volatile substance by cryoscopic method using water as a solvent.
4. Determination of molecular weight of a non-volatile substance by cryoscopic method using benzene as a solvent.
5. Determination of molecular weight of a compound using Landsberg's apparatus by ebulioscopic method.
6. Determination of degree of dissociation of a electrolyte (KCI) by cryoscopic method.
7. Determination of degree of hydrolysis of potassium acetate near 0 $^{o}$C.
8. Determination of heat of neutralization of a monobasic acid.
9. Determination of partition coefficient.
10. First order kinetics - Acid hydrolysis of methyl acetate.
11. Second order kinetics - Potassium per sulfate and potassium iodide.
12. Langmuir's adsorption isotherm - adsorption of acetic acid on activated charcoal.
13. Determination of molar heat of solution of a sparingly soluble organic acid by solubility method.
14. Determination of degree of association of benzoic acid.
15. Chemical equilibrium in solutions - validity of law of mass action.
16. Determination of partial molar volume of NaCl solution.

**Text book:** David P. Shoemaker and Carl W.Garland, Experiments in physical chemistry, Mc-Graw Hill, 2nd Edition, NewYork, 1967.

**References:**


1. Physical Chemistry Lab Manual (Department of PST).
2. J. B. Yadav, Advanced Practical Physical Chemistry, Goel Publishing House, 16th Edition, Meerut, 2006.

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**PT47L: Chemical Engineering Lab (0-0-1.5)**

**Course Outcomes:** Upon successful completion of this course, the students will be able to

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| **CO1:** | Acquire the knowledge of unit conversion and concept of dimensional homogeneity. |
| **CO2:** | Learn usage of steam tables, nomographs and other property tables. |
| **CO3:** | Familiarize with conducting experiments on different types of heat exchangers and distillation methods. |
| **CO4:** | Experimentally generate VLE data and its validation with literature. |

**Course Content: List of experiments**

1. Double pipe heat exchanger
2. Heat transfer in packed beds
3. Heat transfer through bare and finned tubes
4. Heat transfer in jacketed vessel
5. Calibration of thermocouples
6. Simple distillation
7. Packed bed distillation
8. Steam distillation
9. Vapour- liquid equillibrium
10. Tray drier
11. Condensers
12. Study of Single effect evaporator

**Text books:**

1. McCabe, W.L. and Smith J C. Unit Operations of chemical Engineering, 6th Edn., Mc Graw Hill, New York , 2001.

**References:**

1. Treybal, R. E. Mass-transfer operations; 3d ed.; McGraw-Hill: New York, 1980.
2. Don Green, Robert Perry, Perry's Chemical Engineers Hand Book, 8th ed.; Mcgraw-

hill, 2007.

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**HU410: ENVIRONMENTAL STUDIES (2-0-0)**

**Course Outcome:** At the end of the course, students will have gained complete fundamental concepts of Environmental pollution sources, their impacts, control measures and preventive actions. The course also reinforces the concepts of role of individuals, NGOs and Governmental organizations, legal frame work, Acts, Regulations and Rules pertaining to Environmental Protection and Conservation.

**Learning Objectives:**

- Understand the basic concepts of earth's spheres, ecosystem and food chain
- Know the different types of pollution sources and their impacts on the environmental compartments such as water, air, land and ecosystems
- Appreciate and understand the importance of various cycles of elements
- Assess the energy requirements, different forms of energy. Conventional and alternative energy sources
- Get a feel of current environmental issues of concern such as urbanization, population, climate change, ozone layer depletion etc.,
- Know the role of individuals and other related agencies including governmental organizations involved in Environmental Protection and Pollution Control

**Course Content:**

1. Environment, spheres of earth (lithosphere, hydrosphere, atmosphere, biosphere); Ecosystem-Balanced ecosystem, Biome, food chain and food web.
2. Effects of human activities on environment-Agriculture, Housing, Industry, Mining and Transportation activities, Environmental Impact Assessment (EIA), Sustainable Development.
3. Natural resources - Water resources-Availability and quality aspects. Water borne diseases, water induced diseases, Fluoride problems in drinking water. Mineral Resources; Forest Resources.

4. Biogeochemical Cycles - Carbon, Nitrogen, Phosphorus and Sulphur Cycles.
5. Energy- Different types of energy, Electro-magnetic radiation. Conventional energy sources.
6. Non-conventional sources-hydro electric fossil fuel based nuclear, solar, biomass and biogas.
7. Hydrogen as an alternative future source of energy, Environmental pollution and their effects.
8. Water pollution, land pollution, noise pollution, public health aspects.
9. Current Environmental issues of importance: population growth; climate change; global warming- effects, urbanisation, automobile pollution; acid rain, ozone layer depletion, animal husbandry.
10. Environmental protection- role of government, legal aspects, initiatives by non-governmental organization, environmental education, women education.

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