Choice Based Credit System (CBCS)

UNIVERSITY OF DELHI

FACULTY OF SCIENCE

UNDERGRADUATE PROGRAMME
(Courses effective from Academic Year 2015-16)

SYLLABUS OF COURSES TO BE OFFERED
Core Courses, Elective Courses & Ability Enhancement Courses

Disclaimer: The CBCS syllabus is uploaded as given by the Faculty concerned to the Academic Council. The same has been approved as it is by the Academic Council on 13.7.2015 and Executive Council on 14.7.2015. Any query may kindly be addressed to the concerned Faculty.

Undergraduate Programme Secretariat

Preamble

The University Grants Commission (UGC) has initiated several measures to bring equity, efficiency and excellence in the Higher Education System of country. The important measures taken to enhance academic standards and quality in higher education include innovation and improvements in curriculum, teaching-learning process, examination and evaluation systems, besides governance and other matters.

The UGC has formulated various regulations and guidelines from time to time to improve the higher education system and maintain minimum standards and quality across the Higher Educational Institutions (HEIs) in India. The academic reforms recommended by the UGC in the recent past have led to overall improvement in the higher education system. However, due to lot of diversity in the system of higher education, there are multiple approaches followed by universities towards examination, evaluation and grading system. While the HEIs must have the flexibility and freedom in designing the examination and evaluation methods that best fits the curriculum, syllabi and teaching–learning methods, there is a need to devise a sensible system for awarding the grades based on the performance of students. Presently the performance of the students is reported using the conventional system of marks secured in the examinations or grades or both. The conversion from marks to letter grades and the letter grades used vary widely across the HEIs in the country. This creates difficulty for the academia and the employers to understand and infer the performance of the students graduating from different universities and colleges based on grades.

The grading system is considered to be better than the conventional marks system and hence it has been followed in the top institutions in India and abroad. So it is desirable to introduce uniform grading system. This will facilitate student mobility across institutions within and across countries and also enable potential employers to assess the performance of students. To bring in the desired uniformity, in grading system and method for computing the cumulative grade point average (CGPA) based on the performance of students in the examinations, the UGC has formulated these guidelines.

CHOICE BASED CREDIT SYSTEM (CBCS):

The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill based courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Therefore, it is necessary to introduce uniform grading system in the entire higher education in India. This will benefit the students to move across institutions within India to begin with and across countries. The uniform grading system will also enable potential employers in assessing the performance of the candidates. In order to bring uniformity in evaluation system and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations, the UGC has formulated the guidelines to be followed.

Outline of Choice Based Credit System:

1. **Core Course:** A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.
2. **Elective Course:** Generally a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill is called an Elective Course.
   - **2.1 Discipline Specific Elective (DSE) Course**: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).
   - **2.2 Dissertation/Project**: An elective course designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member is called dissertation/project.
   - **2.3 Generic Elective (GE) Course**: An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.
     P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/subject and vice versa and such electives may also be referred to as Generic Elective.
3. **Ability Enhancement Courses (AEC)/Competency Improvement Courses/Skill Development Courses/Foundation Course:** The Ability Enhancement (AE) Courses may be of two kinds: AE Compulsory Course (AECC) and AE Elective Course (AEEC). "AECC" courses are the courses based upon the content that leads to Knowledge enhancement. They ((i) Environmental Science, (ii) English/MIL Communication) are mandatory for all disciplines. AEEC courses are value-based and/or skill-based and are aimed at providing hands-on-training, competencies, skills, etc.
   - **3.1** AE Compulsory Course (AECC): Environmental Science, English Communication/MIL Communication.
   - **3.2** AE Elective Course (AEEC): These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based instruction.

Project work/Dissertation is considered as a special course involving application of knowledge in solving / analyzing /exploring a real life situation / difficult problem. A Project/Dissertation work would be of 6 credits. A Project/Dissertation work may be given in lieu of a discipline specific elective paper.

Details of courses under B.A (Honors), B.Com (Honors) & B.Sc. (Honors)

Course	*Credits	
	Theory+ Practical	Theory + Tutorial
I. Core Course		
(14 Papers)	14X4= 56	14X5=70
Core Course Practical / Tutorial*		
(14 Papers)	14X2=28	14X1=14
II. Elective Course		
(8 Papers)		
A.1. Discipline Specific Elective	4X4=16	4X5=20
(4 Papers)		
A.2. Discipline Specific Elective		
Practical/ Tutorial*	4 X 2=8	4X1=4
(4 Papers)		
B.1. Generic Elective/		
Interdisciplinary	4X4=16	4X5=20
(4 Papers)		
B.2. Generic Elective		
Practical/ Tutorial*	4 X 2=8	4X1=4
(4 Papers)		

- **Optional Dissertation or project work in place of one Discipline Specific** E**lective paper (6 credits) in 6th Semester**

III. Ability Enhancement Courses		
1. **Ability Enhancement Compulsory**		
(2 Papers of 2 credit each)	2 X 2=4	2 X 2=4
Environmental Science		
English/MIL Communication		
2. **Ability Enhancement Elective** (Skill Based)		
(Minimum 2)	2 X 2=4	2 X 2=4
(2 Papers of 2 credit each)		
Total credit	**140**	**140**

Institute should evolve a system/policy about ECA/ General Interest/Hobby/Sports/NCC/NSS/related courses on its own.

*** wherever there is a practical there will be no tutorial and vice-versa**

COURSE STRUCTURE

SEMESTER I

Paper Code	Name of paper	Lecture	Practical	Credit	Marks (T+P)
C-101	Introduction to Polymer Science	4	4	6	100+50
C-102	Raw Materials of Polymers	4	4	6	100+50
AECC1	English/MIL Communication or EVS	2	-	2	50
GE1	Generic Elective	4	4	6	100+50

SEMESTER II

Paper Code	Name of paper	Lecture	Practical	Credit	Marks (T+P)
C-201	Polymer Technology	4	4	6	100+50
C-202	Unit Operations	4	4	6	100+50
AECC2	English/MIL Communication or EVS	2	Or 4	2	50
GE2	Generic Elective	4	4	6	100+50

SEMESTER III

Paper Code	Name of paper	Lecture	Practical	Credit	Marks (T+P)
C-301	Polymer Rheology	4	4	6	100+50
C-302	Polymer Additives	4	4	6	100+50
C-303	Polymer Degradation	4	4	6	100+50
SEC1	Skill Enhancement Course	2	-	2	50
GE3	Generic Elective	4	4	6	100+50

SEMESTER IV

Paper Code	Name of paper	Lecture	Practical	Credit	Marks (T+P)
C-401	Polymer Processing & Mold Design	4	4	6	100+50
C-402	Polymer Testing	4	4	6	100+50
C-403	Recycling and Waste Management	4	4	6	100+50
SEC2	Skill Enhancement Course	2	Or 4-	2	50
GE4	Generic Elective	4	4	6	100+50

SEMESTER V

Paper Code	Name of paper	Lecture	Practical	Credit	Marks (T+P)
C-501	Polymer Characterization	4	4	6	100+50
C-502	Specialty Polymers	4	4	6	100+50
DSE1	Discipline Specific Elective	4	4	6	100+50
DSE2	Discipline Specific Elective	4	4	6	100+50

SEMESTER VI

Paper Code	Name of paper	Lecture	Practical	Credit	Marks (T+P)
C-601	Polymer Blends and Composites	4	4	6	100+50
C-602	Fibre Science and Rubber Technology	4	4	6	100+50
DSE3	Discipline Specific Elective	4	4	6	100+50
DSE4	Discipline Specific Elective	4	4	6	100+50

C: Core Courses; GE: Generic Elective; AECC: Ability Enhancement Compulsory Course; SEC: Skill Enhancement Courses; DSE: Discipline Specific Elective

Generic Elective Papers (GE) (Minor-Polymer Science) (any four) for other Departments/Disciplines: (Credit: 06 each)

GE: Paper 1- Basics of Polymer Science

GE: Paper 2- Chemistry of Polymers

GE: Paper 3- Polymer Testing and Characterization

GE: Paper 4- Polymer Modifiers and Waste Management

GE: Paper 5- Product Manufacturing and Processing

GE: Paper 6- Material Sciences

GE: Paper 7- Biomedical Applications of Polymers

GE: Paper 8- Fibres and Rubbers

SEC 1-2: Skill Enhancement Courses (any one per semester in semesters 3-4)

SEC: Paper 1- Biopolymers

SEC: Paper 2- Estimation of Polymers and Polymeric Compounds

SEC: Paper 3- Wire and Cable Technology

SEC: Paper 4- Footwear Technology

DSE 1-4: Discipline Specific Elective (any two per semester in semesters 5-6)

DSE: Paper 1- Conducting Polymer
DSE: Paper 2- Fibre Manufacturing Technology
DSE: Paper 3- Paints, Coatings and adhesive
DSE: Paper 4- Polymeric Nanomaterials
DSE: Paper 5- Tyre Technology
DSE: Paper 6- Packaging Technology
DSE: Paper 7- Fabrication of Polymeric products
DSE: Paper 8- Polymer in Biomedical Applications

*(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

Ist SEMESTER

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

Paper C101: Introduction to Polymer Science

Unit 1. (15 L)

Introduction and history of polymeric materials, classification of polymers. Configuration and conformation of polymers. Nature of molecular interaction in polymers, cumulative interaction, entanglement, random chain model and RMS end-to-end distance. Various structures of copolymers such as linear branched and cross-linked copolymers and their types.

Unit 2. (10 L)

Crystal morphologies: extended chain crystals, chain folding, lamellae, and spherulites. Crystallization and crystallinity, determination of melting point and degree of crystallinity.

Unit 3. (10 L)

Properties of polymers (physical, thermal, flow & mechanical properties).

Unit 4. (5 L)

Glass transition temperature (T_g) and measurement of T_g. Factors affecting the glass transition temperature. WLF equation.

Unit 5. (10 L)

Nature and structure of polymers – structure-property relationships. Molecular weight of polymers (M_n, M_w etc.), molecular weight distribution and determination of molecular weight.

Unit 6. (10 L)

Polymer solution – solubility parameter, properties of dilute solutions.

Practicals:

1. Determination of heat deflection temperature, VICAT softening point.
2. Measurement of glass transition temperature (T_g).
3. To determine the melting point of crystalline polymers.
4. To check the solubility of the given polymeric sample in different solvents.
5. Determination of molecular weight by solution viscosity.

6. Determination of molecular weight by end group analysis.
7. Chemical identification of polymers-
    - Unsaturation
    - Testing of functional groups (associated with polymers).

Suggested Readings:

1. Plastics Materials by J. A. Brydson, Butterworth Heinemann (1999).

2. Polymer Science and Technology: Plastics, Rubbers, Blends and Composites by P. Ghosh, Tata McGraw Hill (2010).

3. Polymer Science by V.R. Gowarikar, New Age International Publishers Ltd. (2010).

4. Textbook of Polymer Science by Fred W. Billmeyer, Wiley, India (2007).

5. Polymer Crystallization by Schultz, American Chemical Society (2001).

6. Polymer Chemistry by R. B. Seymour and C. E. Carraher, Marcel Dekker (2000).

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

Paper C102: Raw Materials of Polymers

Unit 1. (10 L)

Oil, natural gas, coal: Capabilities and limitations. General consideration of petrochemicals, an overview of petroleum refining, desalting, distillation, cracking and its types.

Unit 2. (20 L)

Preparation of important monomers: Formaldehyde, ethylene, vinyl acetate, vinyl chloride, ethylene oxide and ethylene glycol, acrylonitrile, glycerol, toluene di-isocyanate, methyl methacrylate, isoprene, phenol, styrene, terephthalic acid, adipic acid.

Unit 3. (20 L)

Natural rubber from latex: Collection, concentration and stabilization of latex. Latex compounding: Vulcanizing agents, latex compounding acids, wetting, dispersing and emulsifying agents, stabilizers, thickening agents, fillers & other additives.

Unit 4. (10 L)

Manufacture of latex products: Spreading, casting, dipping, latex thread, latex coated coir and latex foam.

Practicals:

1. Fractional distillation of petroleum.
2. To calculate DRC of Latex.
3. To find out the coagulation strength of latex.
3. Prepare balloon by Dipping process of manufacturing.
4. Latex compounding for balloon and other products.
5. Determination of composition of petroleum product.

Suggested Readings:

1. Chemistry and Technology of Petroleum by Speight, CRC Press (2006).
2. Latex Technology by D. Kumar and R. Chandra, Dhanpat Rai & Co. (2001).
3. Modern Petroleum Refining Processes by B.K.B. Rao, Oxford and IBH (2007).
4. Introduction to Petrochemicals by S. Maiti; Oxford & IBH Publ. Co (2002).
5. Text book on Petrochemicals by B.K.B. Rao, Khanna Publishers (2007).
6. Hand book of Rubber Technology by Smith and Martin, CBS Publishers (2007).

IInd SEMESTER

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

Paper C201: Polymer Technology

Unit 1. (10 L)

Criteria for polymer synthesis. Classification of polymerization processes. Basic methods of polymerization and their mechanism: Addition, condensation, mass (bulk), suspension, emulsion and solution processes.

Unit 1. (20 L)

Concept of functionality, Carother's equation and its applications in polymerization reactions. Polymer formation by step growth polymerization and chain growth polymerization and their kinetics. Mayo's equation, cage effect, auto-acceleration, inhibition and retardation. Kinetics of copolymerization, Zeigler-Natta catalysts and polymerization.

Unit 1. (30 L)

Brief introduction to the preparation, structure, properties and applications of the following polymers:

a) Polyolefins (PE,PP)
b) Polystyrene and its copolymers
c) Poly(vinyl chloride) and related polymers
d) Poly(vinyl acetate) and related polymers
e) Acrylic polymers
f) Fluoropolymers
g) Aliphatic polyamides
h) Unsaturated polyester resins
i) Phenol formaldehyde resins
j) Polymers from amines
k) Polyurethanes
l) Silicones
m) Epoxides

Practicals:

1. Suspension polymerization of Styrene/MMA.
2. Preparation and testing of UF/PF/MF resins.
3. Preparation and testing of Diglycidyl ether of bis phenol-A (DGEBA).
4. Bulk and solution polymerization of Methyl Methacrylate/Styrene.
5. Emulsion polymerization of Styrene/ Methyl Methacrylate.
6. Copolymerization of styrene & MMA and determination of reactivity ratios.
7. Preparation of Poly(vinyl butyral).

Suggested Readings:

1. Principles of Polymerization by G. Odian, Wiley – Interscience (2004).

2. Plastics Materials by J. A. Brydson, Butterworth-Heinemann (1999).

3. Principles of Polymer Chemistry by P. J. Flory, Asian Books Private Limited (2006).

4. A Text book of Polymer Science by F.W. Billmeyer, John-Wiley and Sons (2011).

5. Polymer Chemistry by R. B. Seymour and C.E. Carraher, Marcel Dekker (2003).

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

Paper C202: Unit Operations

Unit 1. (5 L)

Industrial stoichiometry – material balance of physical and chemical processes, energy balance. Energy transport in non isothermal systems.

Unit 2. (15 L)

Velocity distribution in flow system, interface transport, microscopic and macroscopic balances. Flow of fluids in pipes –Bernoulli's equation and calculations for pipe size and pressure drop, flow measuring instruments, various types of pumps.

Unit 3. (10 L)

Mechanical operations –size reduction and its equipment, filtration and types of filters.

Unit 4. (15L)

Heat transfer – conduction, convection, radiation, heat exchangers.

Unit 5. (15 L)

Mass transfer – diffusion and its mechanism, gas absorption, various types of distillation, drying.

Practicals:

1. Handling of jaw crusher, ball mill for crushing and grinding.
2. Distillation of various mixtures.
3. Diffusion experiments.
4. Filtration of solids from slurry.
5. Calculation of pressure drop and pipe size.

Suggested Readings:

1. Unit Operations in Chemical Engg. by Mccabe, Smith and Harriott, McGraw- Hill Professional (2004).
2. Unit Operations in Chemical Engg. (Vol 1&2) by P. Chattopadhaya, Khanna Publishers (2003).
3. Chemical Engg. (Vol. 1 to 6) by Coulsan and Richardson, Elsevier (2010).
4. Heat and Mass Transfer by D. S. Kumar, S K Kataria & Sons Delhi (2009).
5. Solved Example in Chemical Engg. by G. K. Rao, Khanna Publishers (2002).
6. Mass Transfer Operations by R. Treybal, Tata McGraw Hill (2012).

IIIrd SEMESTER

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

Paper C301: Polymer Rheology

Unit 1. (10 L)

Viscosity and polymer processing, other rheological properties of fluids, shear stresses in polymer systems, non-Newtonian flow, practical melt viscosities, flow in channels, simple shear flow, melt-flow index.

Unit 2. (15 L)

Types of fluids and rheological models, techniques for rheological measurements by capillary, parallel plate and cone & plate viscometers. Simple elongational flow and its significance. Dynamic flow behavior, time dependent fluid responses.

Unit 3. (15 L)

The elastic and viscoelastic state of polymers – viscoelasticity - relationships of various approaches taken in describing the viscous and elastic properties, Maxwell model and Voigt model, Boltzmann superposition principles, dynamic mechanical testing.

Unit 4. (10 L)

Mixing: Types of mixing, concept and importance of master batches. Mixing of additives with the polymers, melt compounding and calendaring.

Unit 5. (10 L)

Types of mixers: High speed mixer, two roll mill, internal batch mixers (Banbury, Haake), single screw & twin screw extruders, flow mechanism, analysis of flow (drag, pressure and leak flow).

Practicals:

1. Determination of melt flow index.
2. Determination of intrinsic viscosity by Ubbelohde viscometer.
3. Determination of rheological properties of polymer melt by rheometers.
4. Measurement of resin/paint viscosity by Ford cup 4.
5. Measurement of viscosity by Brookfield Viscometer.
6. Compounding of polymers in the internal mixer and measurement of torque.

Suggested Readings:

1. Introduction to Polymer Viscoelasticity by J. Aklonis and W. J. Macknight, John Wiley & Sons (2005).

2. Polymer Science and Technology of Plastic and Rubber by P. Ghosh, Tata McGraw Hill (2010).

3. Fundamental Principles of Polymeric Materials by S.L. Rosen, Wiley-Interscience (2012).

5. Melt Rheology and Its Role in Plastic Processing by J. M. Dealy and K.F. Wissbrum, Springer (1999).

6. Applied Rheology in Polymer Processing by B. R. Gupta, Asian Books (2004).

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

Paper C302: Polymer Additives

Unit 1. (5 L)

Importance of additives and their selection criteria for commercial polymers.

Unit 2. (20 L)

Additives for plastics and their mechanism of function:

a. Stabilizers
b. Fillers
c. Plasticizers
d. Lubricants
e. Flame retardants
f. Foaming agents
g. Cross linking agents
h. Metal deactivators

Unit 3. (20 L)

Additives for rubbers and their mechanism of function:

a. Vulcanizing agents and retardants
b. Accelerators
c. Activators
d. Fillers
e. Softeners
i. Colors and pigments
f. Tackifying agents
g. Blowing agents
h. Surface property modifiers

Unit 4. (15 L)

Illustration of few formulations and their compounding procedures.

Practicals:

1. Determination of gravity of fillers.
2. Determination of bulk density of fillers.
3. Determination of pore size and net size of fillers.
4. Determination of heat stability of heat stabilizers.
5. Measurement of flash point of plasticizer.
6. Identification of additives.

Suggested Readings:

1. Polymer Modifiers and Additives, by Lutz, Marcel Dekker (2001).

2. Chemistry and Technology of Polymer Additives, by Al- Malaika, Elsevier Applied Science (1999).

3. Plastic Materials, by J. Brydson, Butterworth-Heinemann (1999).

4. Handbook of Rubber Technology, by Martin and Smith, CBS Publisher (2007).

5. Polymer Science and Technology: Plastic, Rubber Blends and Composites, by P. Ghosh, Tata McGraw Hill (2010).

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

Paper C303: Polymer Degradation

Unit 1. (25 L)

Introduction to degradation. Various types of polymer degradation:

(i) Thermal degradation
(ii) Oxidative degradation
(iii) Degradation by radiation
(iv) Mechanical degradation
(v) Chemical degradation
(vi) Biological degradation

Unit 2. (25 L)

Degradation of specific polymers.

(i) Polyolefins (PE and PP)
(ii) PVC
(iii) Natural Rubber
(iv) Polyamides
(v) PMMA
(vi) Cellulose
(vii) SBR
(viii) Polyacrylonitrile (PAN)
(ix) Polystyrene (PS)
(x) PET
(xi) PU

Unit 3. (10 L)

Degradation studies using DSC, TGA, DTA and DMA.

Practicals:

1. Biodegradation of polymers.
2. Mechanical degradation of polymers and its effect on properties.
3. To calculate the rate of Thermal ageing of polymer under various conditions.
4. Thermal analysis by DSC, DTA and TGA.

5. Photo-degradation of PVC.
6. Environmental stress cracking resistance of polymers.

Suggested Readings:

1. Encyclopedia of Polymer Science and Technology by W. J. Pesce and P. B.Wiley (2007).
2. Thermal Characterization of Polymeric Materials, E. A. Turi, Academic Press (1997).
3. Handbook of Polymer Degradation by S. H. Hamid and M. B. Amin, Marcel Dekker (1992).
4. Thermal analysis of plastics by G. W. Ehrenstein, G. Riedel and P. Trawiel, Hanser (2004).

IVth SEMESTER

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

Paper C401: Polymer Processing and Mold Design

Unit-1 (10 L)

Extruder and die design: Extrusion process, the extrusion die, extruder and die characteristics. Classification of extrusion dies, die swell.

Unit 2. (10 L)

Injection moulding: Principles, the moulding cycle, the injection moulding machine, some aspects of product quality, reaction injection moulding (RIM).

Unit 3. (5 L)

Blow moulding: Blow moulding principles, extrusion blow moulding, injection blow moulding, stretch blow moulding, blow moulding of PET.

Unit 4. (5 L)

Compression and transfer moulding: Introduction, thermosetting compounds, compressing moulding process, transfer moulding.

Unit 5. (5 L)

Thermoforming: Principles, types and applications. Miscellaneous processing methods – casting and rotational moulding.

Unit 6. (7 L)

Mould Making – introduction, casting, electrodeposition, cold hobbing, pressure casting, spark machining, bench fitting. Feed system: Runner and gates.

Unit 7. (8 L)

Ejection: Ejector grid, ejector plate assembly, ejection techniques, ejection from fixed half and sprue pullers.

Unit 8. (10 L)

Moulding internal undercuts: Form pin, split cores, side cores, stripping internal undercuts, moulds for threaded components. Daylight moulds – general, underfeed moulds, triple daylight mould.

Practicals:

1. Compounding of PVC and rubbers in two roll-mills with fillers and reinforcing agents.

2. Preparation of Polymeric sheets by Compression moulding.

3. Preparation of testing specimens by Injection moulding.

4. To find out output of various polymeric materials by single screw and twin screw extruders.

5. Solution casting of polymeric membranes.

6. Measurement of the rheological properties of rubber compounds by Oscillating Disc Rheometer (ODR).

7. Tool room visits.

Suggested Readings:

1. Injection mould design, by R.G.W. Pye, Affiliated East West Press Pvt. Ltd (2000).

2. Plastics: Materials & Processing by A. B. Strong, Prentice Hall (2005).

3. Injection Moulding Handbook, by Dominick V. Rosato and D. V. Rosato, CBS Publisher (2000)

4. Polymer Processing by Morton and Jones, Chapman & Hall (2007).

5. Plastic Engg. by R. J. Crawford, Butterworth-Heinemann (1998).

7. Plastic Processing Data Handbook by D. V. Rosato, Springer (2001).

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

Paper C402: Polymer Testing

Unit 1. (10 L)

Principles and methods of standardization, statistical method of analysis. Standards: BIS standards – BIS standards of few polymers. ASTM standards – ASTM standards of few polymers. Evaluation of errors in polymer testing.

Unit 2. (15 L)

Mechanical properties: Thermal and mechanical analysis of polymers

(a) Short term strengths: Tensile, Flexural, Impact, Tear resistance, Abrasion etc.
(b) Long term strengths: Creep and fatigue properties.
(c) Thermal properties: Thermal conductivity, thermal diffusivity, specific heat capacity, linear thermal expansion, heat distortion temperature, vicat softening point, low temperature flexibility etc.

Unit 3. (10 L)

Flow properties: Melt flow index, cup flow test, solution and inherent viscosity, melt viscosity etc.

Unit 4. (5 L)

Flammability properties: Oxygen index, critical temperature index, smoke density, flammability tests etc.

Unit 5. (5 L)

Optical properties: Gloss, haze, refractive index, degree of yellowness etc.

Unit 6. (15 L)

Permeability: Definition, permeability to gases, standard methods of measuring, permeability of gases, other methods of measuring permeability. Environment resistance – cause of deterioration of polymer by weathering, assessment of deterioration, natural weathering, artificial weathering. Chemical resistance.

Practicals:

1. Determine the melt flow index of LLDPE, PP etc.
2. Evaluate limiting oxygen index (LOI) of Poly(vinyl chloride) and Nylon- 6.
3. Determination the Heat Distortion Temperature and Vicat softening temperature of polymer film.
4. Measurement of abrasion resistance of polymer sheets.
5. Determination the coefficient of friction and izod Impact strength of PVC and PP samples.
6. Determination of environment stress cracking resistance of PE/PP films.
7. Determination of Shore Hardness of plastics.

Suggested Readings:

1. Handbook of Plastic Testing & Technology by V. Shah, Wiley-Interscience (2007).
2. Rubber Technology Handbook by Martin and Smith, Smithers Rapra Technology (2009).
3. SPI Plastic Engineering Handbook by M.L. Berins. Springer-Verlag (1991).
4. An Introduction to the Mechanical Properties of Solid Polymers by I. M. Ward and J. Sweeney, Wiley (2004).

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

Paper C403: Recycling and Waste Management

Unit 1. (10 L)

Definition of plastic wastes and litter, basis for assessing plastic wastes, applications of plastics and their potential as sources of waste. Separation techniques (density - float sink and froth floatation methods, optical, spectroscopic, sorting by melting temperature etc.).

Unit 2. (10 L)

Thermoplastic waste management: 4 R's approach (reduce, reuse, recycle (mechanical and chemical), recover), recycling classification- - primary - secondary - tertiary - quaternary recycling with examples.

Unit 3. (15 L)

Disposal processes and Various waste treatment methods – controlled tipping, pulverization, compositing, Energy from waste –(incinerators- pyrolysis, factors affecting incineration), new developments in thermal disposal of refuse, on-site disposal methods, compacting and baling.

Unit 4. (15 L)

Recycling of Polyolefins, PVC, PET, Polystyrene, Polyamides (Nylon-6 and Nylon-6,6).

Unit 5. (10 L)

Recycling of Thermosets –reclaiming of rubber –pyrolysis, depolymerization of scrap rubber, tyre retreading, uses of recycled rubber.

Practicals:

1. Primary recycling of various waste collected from environment.
2. Secondary recycling of MSW by incorporating and blending the recyclable waste with virgin polymers.
3. To study Composting of natural polymers
4. Preparation of plasticizer from polyester waste.
5. Preparation of curing hardness for epoxy from polyester waste.
6. Preparation of reclaim from tyre waste.

Suggested Readings:

1. Rubber and Plastic Waste: Recycling, Reuse and Future Demand by R. Chandra and A. Adab, CBS Publisher (2004).

2. Medical, Municipal and Plastic Waste Management Handbook by NIIR Board of Consultant and Engineers, National Institute of Industrial Research (2007).

3. Polymer Recycling by J. Scheirs, John Wiley & Sons (1998).

4. Handbook of Rubber Technology by S. Blow, Hanser Gardner (2000).

5. Recycling and Recovery of Plastics by J. E. Bandrup, Hanser Gardner (1996).

6. Introduction to plastics recycling by V. Goodship, Rapra (2007).

Vth SEMESTER

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

Paper C501: Polymer Characterization

Unit 1. (15 L)

Basic principles of spectroscopy, molecular and atomic spectra, Lambert-Bear law, Frank-condon principal, electromagnetic radiation, properties of electromagnetic radiation, interaction of radiation with matter: A classical picture, uncertainty and the question of time scale.

Unit 2. (15 L)

Applications of spectroscopy: IR, UV, ESR, Raman, NMR and mass spectroscopy of polymers.

Unit 3. (10 L)

Chromatography: Thin layer chromatography, high performance liquid chromatography, gel permeation chromatography (GPC), gas chromatography.

Unit 4. (10 L)

Applications of optical microscope, SEM, TEM and XRD in polymers.

Unit 5. (10 L)

Thermal analysis of polymers using DSC-DTA, TGA, DMA etc

Practicals:

1. To Verify Lambert-Beers law by UV-Vis. spectrophotometer.
2. Calculate % amount of Inorganic and organic ingredient in polymeric compound.
3. Analyze the thermal behavior of polymers.
4. To Calculate Percentage Crystallinity of Polymeric Sample by XRD.
5. Identification of polymer components by Chromatography.
6. FTIR and Raman analysis of polymers.

Suggested Readings:

1. Instrumental method of analysis, by Willard et,al., Wadsworth Publishing Company (1988).
2. Principle of Instrumental Analysis, by Skoog et.al., Harcourt College Pub (1997).

3. Handbook of Plastic Testing, Technology, by V. Shah, Wiley-Interscience (2007).
4. Experimental Methods in Polymer Sciences, by T.Tanaka, Academic Press (1999).
5. Spectrometric identification of organic compounds. Silverstein, Robert M. John Wiley (1991).
6. A complete introduction to NMR spectroscopy by Roger S .Macomber, Wiley-Interscience (2008).

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

Paper C502: Speciality Polymers

Unit 1. (30 L)

Preparation, properties and applications of the following polymers

i. Polyether ether ketone resins (PEEK)
ii. Polyamideimide resins (PAI)
iii. Sulphur based polymers (Polysulphone and polyphenylene sulfide)
iv. Polyamide resins
v. Polyetherimide resins (PEI)
vi. Polyester resins
vii. Polycarbonate (PC)
viii. Acetal resins
ix. Polyphenylene oxide (PPO)

Unit 2. (10 L)

Conducting polymers: Synthesis, properties and application of polyaniline, polypyrole and polythiophene.

Unit 3. (10 L)

Biopolymers (Polylactic acid, polycaprolactone, starch, etc.)

Unit 4. (10 L)

Inorganic Polymers (Silicon and Nitrogen containing polymers)

Practicals:

1. To find out conductivity of polymeric sample.
2. To find out Bio-degradability and bio compatibility of polymeric compound.
3. Synthesis of conducting polymers.
4. Preparation of Nylon 6, 10 by interfacial polymerization.
5. Phenol formaldehyde (Resol/Novolac).
6. Urea-formaldehyde preparation.

Suggested Readings:

1. Plastic Materials by J. A. Brydson, Butterworth-heinemann (1999).
2. Engg. Plastics by R. W. Dyson, Blackie, Chapman and Hall, 1990
3. Engg Materials Handbook (Vol. 1 to 3) by ASTM Internaional, USA.
4. Handbook of Biodegradable Polymer by A. J. Domb. Gordon and Breach Science Publishers (1997)
5. High Performance Polymers, their origin and development, by Seymour R. B. and Kirshenbaum G. S, Elsevier (1986).

VIth SEMESTER

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

Paper C601: Polymer Blends and Composites

Unit 1. (15 L)

Methods of blending, the incompatibility problem, methods of compatibilization. Properties of blends (mechanical, morphological, rheology and thermal), comparison between polymer blends, copolymers, grafted copolymers and IPNs

Unit 2. (10 L)

Different types of polymer blends (TPE, elastomeric blends and plastic blends).Characterization of blends by various techniques.

Unit 3. (5 L)

Introduction and classification of composites, selection criteria for polymer matrices for composites.

Unit 4. (15 L)

Fabrication techniques: Prepreg technology, injection and compression moulding, vacuum bag moulding, hand-lay up process, spray-up technique, filament winding process, fiber placement process, pultrusion, reaction transfer molding, laminating techniques, expansion processes, radiation processes, coating processes, fabrication processes: adhesion, cohesion and mechanical processes & FRPs.

Unit 5. (15 L)

Design of composite products: Basic design practice – material considerations, product considerations and design considerations.

Practicals:

1. To prepare polymer blends by melt, solution and latex blending.
2. To find out Compatibility of blends by loop compatibility tester.
3. Preparation of laminates.
4. Preparation of composites with various fillers and various filler loading.
5. Mechanical properties of blends and composites.

Suggested Readings:

1. Polymer Blends Volume 1 & 2, by D. R. Paul and C. B. Bucknall, Wiley-Interscience (2000).
2. Polymer Blends by Lloyd M. Robeson, Hanser Gardner Pubns (2007).
3. Polymer Blends Volume 1 & 2, by D. R. Paul and Seymour Newman, Academic Press (1978).
4. Polymer Blends Handbook Vol 1 & 2 by L. A. Utracki, Kluwer Academic Pub (2003).

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

Paper C602: Fiber Science and Rubber Technology

Unit 1. (10 L)

Introduction – classification and terminology of fibres, salient features of fibre forming polymers and their properties. Basic structure of a fibre. General properties of a fibre such as moisture absorption, tex, denier, tenacity, elongation at break and elastic recovery.

Unit 2. (10 L)

Naturally occurring fibres – Vegetable fibres, animal fibres and mineral fibres.

Unit 3. (10 L)

Man made and synthetic fibres –properties and uses of viscous rayon, cellulose acetate, nylon – 66, polyester, acrylic, carbon fibre and aramid fibres.

Unit 4. (15 L)

Physical properties of raw rubber and mastication. Theories and phenomena of vulcanization, rheocurve of compounded rubber, mechanism of sulphur vulcanization with and without accelerators, theories of non sulphur vulcanization, properties of vulcanized rubber.

Unit 5. (15 L)

Natural rubber and synthetic rubber, styrene-butadiene rubber, polybutadiene rubber, ethylene propylene diene rubber, butyl rubber, nitrile rubber, neoprene, silicone rubber, fluorocarbon rubber.

Practicals:

1. Determination of tensile strength, modulus, elongation at break, tear strength, abrasion resistance, heat build-up resilience, hardness, flex resistance for rubber compounds.
2. Determination of curing time on physical properties of NR compound.
3. Identification of fibres through solubility tests.
4. Identification of fibres by chemical methods
5. Analysis of reaction of fibres towards heat & flame.
6. To determine viscosity using Mooney viscometer.

7. Qualitative analysis of Cellulose –Polyester blends.

8. Distinguish POY & FDY polyester filament yarn based on extensibility & shrinkage behavior.

10. Determination of Twist, elongation, TEX, Tenacity, Denier, and count of yarn, fiber & filament.

Suggested Readings:

1. Hand Book of Rubber Technology by Smith and Martin, CBS Publisher, (2007).
2. The Science and Technology of Rubber by J. E. Mark, B. Erman and F.R. Eirich, Elsevier Academic Press (2005).
3. Hand Book of Textile Fibers, by J. G. Cook, WoodheadPublishing Volume 1 (1984) and & Volume 2 (2009).
4. Hand Book of Rubber Technology by S. Blow, Hanser Gardner (2000).
5. Understanding Textiles by Collier and Tortora, Prentice Hall (2009).
6. Physical Properties of Fibers by Morton & Hearle, CRC Press (2008).

GE 1- 4: Generic Electives

(Any one paper per semester in semesters 1- 4)

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

GE: Paper 1- Basics of Polymer Science

Unit 1. (10 L)
Introduction – Historical development, Basic concept and definitions, classification of polymers (Natural vs Synthetic), Polymer structure (a)Linear, Branched and Cross-linked (b) Amorphous or crystalline (c) Homopolymer or Copolymer (d) Fibres, Plastics or Elastomers, Configuration and conformation of polymers. Chemical bonding and Polymer structure, entanglements, random chain model and rms end-to-end distance.

Unit 2. (10 L)
Morphology of crystalline polymers : Crystal structure of polymers, Morphology of polymer crystals grown from solution, Morphology of polymer crystallized from melt, crystallinity and polymer properties.

Unit 3. (10 L)
Properties of polymers (physical, thermal, flow & mechanical properties).

Unit 4. (10 L)
Thermal transitions in polymers- Molecular motion and Glass transition temperature (T_g), theoretical treatment of glass transition(free volume theory and WLF equlation) and measurement of T_g. Factors affecting the glass transition temperature. Crystalline melting point and its determination

Unit 5. (10 L)
Structure-property relationships in homopolymers , Structure-property relationships in copolymers, Molecular weight of polymers (M_n, $\bar{M}_w$ etc.), molecular weight distribution and determination of molecular weight.

Unit 6. (10 L)
Polymers in solution – solubility behavior of polymers, low mol. weight polymer mixture, Flory Huggins theory, properties of dilute solutions.

Practical – Polymer I:

- Determination of Shoftening Behaviour of Polymers

- To determine the melting point of crystalline polymers.
- To check the solubility of the given polymeric sample in different solvents.
- Determination of molecular weight by solution viscosity.
- Determination of molecular weight by end group analysis.
- Chemical identification of polymers
    - Unsaturation
    - Testing of functional groups (associated with polymers)

Suggested Readings:

1. Plastics Materials by J. A. Brydson, Butterworth Heinemann (1999).

2. Polymer Science and Technology of Plastic and Rubber by P. Ghosh, Tata Mcgraw Hill (1990).

3. Polymer Science by Gowarikar V.R., New Age International Publishers Ltd. (1986).

4. Molecular Weight Distribution in Polymer by L.H. Peebles, Wiley Interscience, N.Y. (1971).

5. Textbook of Polymer Science by Fred W. Billmeyer, Wiley, India (2007).

6. Polymer Crystillization, by Schultz, American Chemical Society (2001).

7. Polymer Chemistry, by Seymour R. B. and Carraher, Marcel Dekker (2000).

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

GE: Paper 2- Chemistry of Polymers

Unit 1. (5 L)
Criteria for polymer synthesis. Classification of polymerization processes.

Unit 2. (15 L)
Basic methods of polymerization and their mechanism: Addition, condensation, mass (bulk), suspension, emulsion and solution processes.

Unit 3. (15 L)
Concept of functionality, Carother's equation and its applications in polymerization reactions. Polymer formation by step growth polymerization and chain growth polymerization and their kinetics. Mayo's equation, auto-acceleration, inhibition and retardation. Copolymerization , Zeigler-Natta catalysts and polymerization.

Unit 4. (25 L)
Brief introduction to the preparation, structure, properties and applications of the following polymers:

a) Polyolefins (PE,PP)
b) Polystyrene and its copolymers
c) Poly(vinyl chloride)
d) Acrylic polymers
e) Fluoropolymers (PTFE,PCTFE,PVF)
f) Aliphatic polyamides
g) Unsaturated polyester resins
h) Phenol formaldehyde resins
i) Polymers from amines
j) Polyurethanes
k) Epoxides

Practical - Polymer II:

- Preparation of thermosetting resins.
- Suspension polymerisation of styrene/MMA.

- Emulsion polymerisation of butyl acrylate.
- Bulk and solution polymerisation of methyl methacrylate/styrene.
- Preparation and testing of epoxy resins.
- Copolymerisation of styrene & MMA and determination of reactivity ratios.

Suggested Readings:

1. Principles of Polymerization, by G.Odian, Wiley – Interscience (1981).

2. Plastics Materials by J. A. Brydson, Butterworth-heinemann (1999).

3. Principles of Polymer Chemistry by P.J. Flory, Asian Books Private Limited (2006).

4. Organic Chemistry of Synthetic High Polymers, by Robert W. Lenz, Interscience Publisher (1967).

5.Polymer Chemistry, by Seymour R. B. and Carraher, Marcel Dekker (2000).

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

GE: Paper 3- Polymer Testing and Characterization

Unit 1. (20 L)

Spectroscopy- Basic principal, Lambert bears law, Principle and applications of UV-Vis and IR spectroscopy in Polymer Science.

Unit 2. (20 L)

Thermal and mechanical analysis of polymers- Stress- strain curve, measurement of Tensile, Flexural Impact, tear and abrasion resistance of polymeric materials, Creep and fatigue properties. Thermal properties: Thermal conductivity, thermal diffusivity, specific heat capacity, linear thermal expansion, heat distortion temperature, vicat softening point, low temperature flexibility etc.

Unit 3. (20 L)

Flow and Optical properties: Melt flow index, Optical properties: Gloss, haze, refractive index, degree of yellowness etc.

Practical - Polymer IV

1. Measure the M.F.I of polymers.
2. Determination the LOI & Smoke density of polymeric samples.
3. Determination the H.D.T and Vicat softening temperature.
4. Measurement of abrasion resistance of polymer samples.
5. Determination the coefficient of friction and Izod impact of polymer sample.
6. Determination of environment stress cracking resistance of PE/PP
7. Determination of Hardness of plastics

Suggested Readings:

1. Handbook of Plastic Testing, Technology, by V. Shah, Wiley-Interscience (2007).
2. Polymer Testing, by W. Grellmann and S. Seinder, HANSER Publisher, 1961

3. Rubber Technology Handbook, by Martin and Smith, Smithers Rapra Technology (2009).
4. SPI Plastic Engineering Handbook, by M.L. Berins. Springer-Verlag(1991).
5. Introduction to the Mechanical Properties of Solid Polymers by Ward and Sweeney, Wiley (2004).

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

GE: Paper 4- Polymer Modifiers and Waste Management

Unit 1. (5 L)
Importance of additives and their selection criteria for commercial polymers.

Unit 2. (15 L)
Additives for plastics and their mechanism of function:

a) Stabilizers
b) Fillers
c) Plasticizers
d) Lubricants
e) Flame retardants
f) Cross linking agents

Unit 3. (15 L)
Additives for rubbers and their mechanism of function:

a) Vulcanizing agents and retardants
b) Accelerators
c) Activators
d) Fillers
e) Softeners
f) Colors and pigments

Unit 4. (5 L)
Illustration of few formulations and their compounding procedures.

Unit 5. (10 L)
Plastics waste management: 4 R's approach (reduce, reuse, recycle (mechanical and chemical), recover), recycling classification- - primary - secondary - tertiary - quaternary recycling with examples. Energy from waste – incinerators-pyrolysis, factors affecting incineration.

Unit 6. (10 L)

Plastics waste management: Disposal of plastic waste and litter – role of plastics in the collection of refuse; disposal process – controlled tipping, pulverization, compositing, incineration; air pollution, new developments in thermal disposal of refuse, on-site disposal methods, compacting and baling.

Practical - Polymer III:

1. Determination of gravity of fillers.
2. Determination of bulk density of fillers.
3. Identification of additives.
4. Secondary recycling of MSW by incorporating and blending the recyclable waste with virgin polymers.

Suggested Readings:

1. Polymer modifiers and additives, by Lutz, Marcel Dekker (2001).
2. Chemistry and Technology of Polymer Additives, by Al- Malaika, Elsevier Applied Science (1999).
3. Plastic materials, by J. Brydson, Butterworth-heinemann (1999).
4. Handbook of Rubber Technology, by Martin and Smith, CBS Publisher (2007).
5. Polymer Science and Technology: Plastic, Rubber Blends and Composites, by P. Ghosh, Tata Mcgraw Hill (1990)
6. Rubber and Plastic Waste: Recycling, Reuse and Future Demand by R. Chandra and A. Adab, CBS Publisher, (2004)

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

GE: Paper 5- Product Manufacturing and Processing

Unit 1. (15 L)
Injection moulding: Principles, the moulding cycle, the injection moulding machine, some aspects of product quality, reaction injection moulding (RIM).

Unit 2. (15 L)
Blow moulding: Blow moulding principles, extrusion blow moulding, injection blow moulding, stretch blow moulding, blow moulding of PET.

Unit 3. (15 L)
Thermoforming: Principles, types and applications. Compression and transfer moulding: Introduction, thermosetting compounds, compressing moulding process, transfer moulding.

Unit 4. (15 L)
Miscellaneous processing methods – casting and rotational moulding.

Practical - Polymer IV:

1. Compounding of additives in roll-mill with fillers and reinforcing agents.
2. Compression moulding
3. Injection moulding
4. Extrusion on single screw and twin screw extruders.
5. Thermoforming.
6. Casting of membrane

Suggested Readings:

1. Plastics: Materials & Processing by A. B. Strong, Prentice Hall (2005).
3. Injection Moulding Handbook, Dominick, V. Roato and Donald. V. Rosato, CBS Publisher (2000)
4. Polymer Processing by Morton and Jones, Chapman & Hall (2007)
5. Plastic Engg. by R. J. Crawford, Butterworth-heinemann (1998).
6. Polymer Processing Principles and Design by Baird and Collias, Wiley-

Interscience (1998).
7. Plastic Processing Data Handbook by D. V. Rosato and D. V. Rosato, Springer Netherlands (2001).

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

GE: Paper 6: Materials Science

Unit 1. (15 L)

Structure: Crystalline structure of materials, unit cells and space lattices, x-ray diffraction of crystal structures, miller indices of planes and directions, packing geometry in metallic, covalent and ionic solids. Concept of amorphous, single and polycrystalline materials. Crystal growth techniques. Imperfections in crystalline solids.

Unit 2. (15 L)

Solid solutions, solubility limit, phase rule, phase diagrams, intermediate phases, intermetallic compounds, **Ceramics:** Structure, properties, processing and applications of traditional and advanced ceramics.

Unit 3. (20 L)

Advanced Materials and Tools: Smart materials, exhibiting ferroelectric, piezoelectric, optoelectric, semiconducting behavior, lasers and optical fibers, photoconductivity and superconductivity, nanomaterials – synthesis, properties and applications, biomaterials, superalloys, shape memory alloys.

Unit 4. (10 L)

Magnetic Properties: Origin of magnetism in metallic and ceramic materials, paramagnetism, diamagnetism, ferromagnetism, antiferro magnetism, magnetic hysterisis.

Practicals

1. To check hardness of Metal, Ceramics, composites by Rockwell hardness tester.
2. To determine % composition of metals, fillers etc.
3. To determine magnetic properties of materials.
4. To determine mechanical properties of materials.

1. Preparation of advanced material for biological applications.
2. To prepare safety glass.

Suggested Readings:

1. Materials Science And engineering Handbook, Third Edition by James F. Shackelford, CRC Press, New York, (2010).
2. Fundamentals of Materials Science: The Microstructure–Property Relationship Using Metals as Model Systems by Mittemeijer, Eric J, Springer, (2011).
3. Materials Science and Engineering an Introduction, by William D. Callister, Jr. and David G. Rethwisch, (1940).
4. Material Science by S. L. Kakani and Amit Kakani New Age International, (2006).

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

GE: Paper 7- Biomedical Applications of Polymers

Unit 1. (10 L)

Basics of biomaterials: Concept of biocompatibility, responsiveness, degradation, estimations of degradation and biocompatibility, technically important form of polymers: Hydrogel, bioceramics, bioelastomers, and membrane.

Unit 2. (10 L)

Physico-chemical properties of biomaterials: mechanical (elasticity, yield stress, ductility, toughness, strength, fatigue, hardness, wear resistance), tribological (friction, wear, lubricity), morphology and texture, porosity, adsorption, physical (electrical, optical, magnetic, thermal), chemical and biological properties.

Unit 3. (10 L)

Polymers used as Biomaterials: Silicone rubber, dacron, poly (methyl methacrylate), polyurethanes, cellulose, properties and applications.

Unit 4. (10 L)

Organ Transplants: Properties of polymers for organ transplant, different polymers used for organ transplant e.g. dental cement, orthopedic, skin, artificial kidney etc.

Unit 5. (10 L)

Tissue Engineering: Regeneration, important polymers used in tissue engineering, cellulose, chitosen and alginate.

Unit 6. (10 L)

Drug Delivery: Introduction to drug delivery, polymers in controlled drug delivery, dressing strips, polymer drug vessels, core shell and nanogels.

Practical

1. Evaluate the biocompatibility of polymeric samples.
2. Determine the degradation behavior of polymers such as thermal, hydrolytic etc.
3. Prepare membranes and measure absorption behavior.
4. Preparation and characterization of dental cement.
5. Prepare a hydro gel and characterization.
6. Determine the mechanical strengths of polymers.

Suggested Readings:

1. Nanomaterials in drug delivry, Imaging and Tissue Engineering by Ashutosh Tiwari and Atul Tiwari, Wiley (2013).
2. Handbook of Bioplastics and Biocomposites engineering applications by Srikanth Pilla, Wiley (2011).
3. Biomaterials Science, An Intoduction to Materials in medicine, Eds. B. D. Ratner and A. S. Hoffman, Academic Press, New York, (1996).
4. Drug delivery – Engineering principles for drug therapy, Editor: Saltzman W. M. Oxford University Press, USA (2001).
5. Biopolymers: Biomedical and Environmental Applications by Susheel Kalia and Luc Averous, John Wiley & Sons (2011).

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

GE: Paper 8: Fibres and Rubbers

Unit 1. (10 L)

Introduction – classification and terminology of fibres, salient features of fibre forming polymers and their properties. Basic structure of a fibre. General properties of a fibre such as moisture absorption, tex, denier, tenacity, elongation at break and elastic recovery.

Unit 2. (10 L)

Naturally occurring fibres – Vegetable fibres, animal fibres, mineral fibres.

Unit 3. (10 L)

Man made and synthetic fibres –properties and uses of viscous rayon, cellulose acetate, nylon – 66, polyester, acrylic, carbon fibre and aramid fibres.

Unit 4. (15 L)

Physical properties of raw rubber and mastication. Theories and phenomena of vulcanization, rheocurve of compounded rubber, mechanism of sulphur vulcanization with and without accelerators, theories of non sulphur vulcanization, properties of vulcanized rubber.

Unit 5. (15 L)

Natural rubber and synthetic rubber, styrene-butadiene rubber, polybutadiene rubber, ethylene propylene diene rubber, butyl rubber, nitrile rubber, neoprene, silicone rubber, fluorocarbon rubber.

Practicals:

1. Determination of tensile strength, modulus, elongation at break, tear strength, abrasion resistance, heat build-up resilience, hardness, flex resistance for rubber compounds.
2. Determination of curing time on physical properties of NR compound.
3. Identification of fibres through solubility tests.
4. Identification of fibres by chemical methods
5. Analysis of reaction of fibres towards heat & flame.
6. To determine viscosity using Mooney viscometer.

7. Qualitative analysis of Cellulose –Polyester blends.

8. Distinguish POY & FDY polyester filament yarn based on extensibility & shrinkage behavior.

10. Determination of Twist, elongation, TEX, Tenacity, Denier, and count of yarn, fiber & filament.

Suggested Readings:

1. Hand Book of Rubber Technology by Smith and Martin, CBS Publisher, (2007).
2. The Science and Technology of Rubber by J. E. Mark, B. Erman and F.R. Eirich, Elsevier Academic Press (2005).
3. Hand Book of Textile Fibers, by J. G. Cook, WoodheadPublishing Volume 1 (1984) and & Volume 2 (2009).
4. Hand Book of Rubber Technology by S. Blow, Hanser Gardner (2000).
5. Understanding Textiles by Collier and Tortora, Prentice Hall (2009).
6. Physical Properties of Fibers by Morton & Hearle, CRC Press (2008).

SEC 1-2: Skill Enhancement Courses

(any one paper per semester in semesters 3- 4)

(2 L/Week) (Total Credits -2)

SEC: Paper 1: Biopolymers

Unit 1. (5 L)

Biopolymers, classifications of biopolymers based on chemical structure, application and functions.

Unit 2. (15 L)

Biopolymers: Starch, cellulose, chitosan, gelatine, keratin, fatty acids, lipids, aliphatic polyesters (PLA, PHB), cellulose and its esters and cellulose-regenerating processes.

Unit 3. (5 L)

Biodegradability: Natural biodegradable polymer, synthetic and modified biodegradable polymers, testing methods of biodegradability of biopolymers.

Unit 4. (5 L)

Use of biomaterials for manufacture of plastic films, blends, various types of films and their applications.

Suggested Readings:

1. Polymer Chemistry by Seymour and Carraher's, Sixth Edition, Hardcover (2003)
2. Biomaterials –novel materials from biological sources by D. Byrom - Stockton press.
3. Hand Book of Biodegradable polymers by Catia Bastioli, - Rapra Tech.(1987).
4. Surface modification of biomaterials: Methods analysis and applications by R Williams - Woodhead Publishing Series in Biomaterials (2010).
5. Biopolymers by R.M. Johnson, L.Y. Mwaikambo and N. Tucker, Rapra Technology (2003).
6. Hand Book of Bioplastics & Biocomposites for Engineering Applications by Srikanth Pillai, Wiley (2011)
7. Biopolymers by Steinbuechel Alexander Vol. 1-10 Wiley (2003).

2h L/Week or
(4h Lab/Week) (Total Credits -2)

SEC: Paper 2: Estimation of polymers and polymeric compounds

Unit 1. (10 L)

Quantitative and qualitative estimation of the basic raw materials such as fillers, plasticizers, initiators, inhibitors, antioxidants and heat stabilizers etc. used in polymer industries. Determination of purity of solvents, monomers and other auxiliaries.

Unit 1. (10 L)

Determination physical properties such as boiling point, melting point, viscosity, refractive index, specific gravity, swelling index and gel content of polymer materials.

Unit 1. (10 L)

Analysis of Polymer Compounds: Iodine value, Carbon black content, Free sulphur content, Total inorganic content, Silica content. hydroxyl value, acid value, flash point.

Suggested Readings:

1) Rubber Analysis: Polymers, Compounds and Products. by M. J. Forrest, Rapra Tech. Ltd. (2001).
2) Analysis of Rubber and Rubber-like Polymers. by M.J. Loadman, Springer, (2012).
3) Characterization and Analysis of Polymers edited by Arza Seidel, Willey (2008).
4) Molecular Characterization and Analysis of Polymers edited by John M. Chalmers, Robert J. Meier, Elsevier (2008).

(2 L/Week) (Total Credits -2)

SEC: Paper 3: Wire and Cable Technology

Unit 1. (5 L)

Introduction to Insulator, semiconductor and conductor, classification wire and cables (eg. Electric, telecommunication etc.), cable characteristics.

Unit 2. (10 L)

General properties of cable insulating materials:

i) Electrical: Volume and surface resistivity, break down voltage, dielectric constant, dielectric loss etc.

ii) Thermal: Heat resistance, permissible temperature, effect of overloading on the life of an electrical appliances and thermal conductivity

iii) Chemical: Solubility, chemical resistance, weatherability

iv) Mechanical and physical: Mechanical strength, porosity, density, brittleness, mouldability.

Unit 3. (5 L)

Factors affecting the electrical, thermal, chemical and mechanical properties of cable insulating materials. Selection of cable insulating materials

Unit 4. (10 L)

1. Polymers for cable insulation and sheathing (eg. CM, CSM, HDPE, LDPE, PVC, NBR, PTFE, EPDM, EVA, EMA etc.)

Suggested Readings:

1) Polymers for wire and cables- changes within an industry, by Keith Cousins, Smithers Rapra Publishing, (2000).
2) The History of Electric wire and Cables, by R. M. Black, (1983).
3) Hand book of Rubber Technology by Smith and Martin, CBS Publishers (2007).

(2 L/Week) (Total Credits -2)

SEC: Paper 4: **Footwear Technology**

Unit 1. (10 L)

Shoe Soles: Soling requirements, soling materials, compounding and processing. Individual soling compounding-PVC, thermoplastic rubber, polyurethane, ethylene vinyl acetate, etc.

Unit 2. (10 L)

Adhesives: Soling adhesives and types of adhesives, adhesion principle, adhesive selections, Heel covering; sole attaching, neoprene, PU, hot melt and liquid curing adhesives, adhesion problems. Coated fabrics: PVC, PU coated fabric.

Unit 3. (5 L)

Soles Materials: Molded and pre fabricated units, individual solings – rubbers, vulcanized rubbers, nylons, polyesters, PVC, thermoplastic rubbers, PU, EVA.

Unit 4. (5 L)

Processing Technology: Injection moulding, sponge moulding, direct molded shoes, thermoplastic moulding, polyurethane injection moulding, insert moulding, HF flow moulding.

Suggested Readings:

1. Footwear Materials & Process Technology, A. J. Harvey, Shoe Trades Publishers (1982).

2. Modern Footwear Materials & Process, W E Cohn, Fairchild Publicatins, (1969).

3. Introductin to Modern Footwear Technology, B. Venkatappaiah, B. Sita Publishers (1997).

DSE: Discipline Specific Elective

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

DSE: Paper 1- Conducting Polymers

Unit 1. (10 L)

Basic of conducting polymers- Band structure, electrical conductions, resistance, capacitance and impedance of conducting polymers

Unit 2. (15 L)

Synthesis of conducting polymers- Chemical polymerizations, electro-chemical polymerizations of polyaniline, polypyrole, polythiophene etc, effect of chemical doping on properties of conducting polymers

Unit 3. (15 L)

Blends of conducting polymers-nanoblends/Composites of polyaniline, polyaniline derivatives and their blends, comparison of the morphological and conductivity characteristics of polyaniline blends, blends of polythiophene, blends of polypyrrole,

Unit 4. (10 L)

Compositions of conducting polymers-properties and applications of conducting polymer compositions, Bio-components matrices and effect of compositions

Unit 5. (10 L)

Applications- Electronic devices, Chemical sensors, Solar cells, Light emitting devices, Biomedical devices, bio-system, organ transplant, artificial mussels etc.

Practicals:

1. Synthesis of conducting polymers such as polyaniline, polypyrole, polythiophene etc,
2. Prepare film/ sheet of conducting polymers
3. Determination mechanical properties of conducting polymer films/sheet.
4. Testing thermal properties of conducting polymers
5. Testing the electrical properties of conducting polymer films/ sheet.

Suggested Readings:

1. Conducting Polymers, fundamentals and applications: A practical approach by Prasanna Chandrasekhar, Springer (1999).

2. Handbook of Organic Conductive Molecules and Polymers: Conductive polymers: synthesis and electrical properties, Hari Singh Nalwa, Wiley (1997).
3. Handbook of Conducting Polymers by Terje A. Skotheim, Ronald L. Elsenbaumer, John R. Reynolds , Taylor & Francis Group (2007).

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

DSE: Paper 2- Fibre Manufacturing Technology

Unit 1. (5 L)

Introduction to manmade fibres: Definition of made fibres, brief history of manmade fibres, relative merits and demerits of manmade and natural fibres.

Unit 2. (15 L)

Conversion of polymers into fibre: Basic production systems of the man made fibre. Concept of melt spinning, dry spinning and dry jet wet spinning process. Factors influencing selection of a particular process for fibre formation. Relative merits and demerits of melt, dry and wet spinning processes. Effect of parameters on fibre breakage and fiber structure. Spin ability and factors affecting chain length. Variables of spinning. Different components of spinning process, i.e., extruder, gear pump, filters, manifold, spinning head, quenching chamber, winders. Quenching/solidification techniques.

Unit 3. (10 L)

Melt spinning: Raw material, technology of polymerization and extrusion of polyester, nylon -6, nylon 66 and polypropylene. Effect of process parameters on structure and properties of melt spun filament. Characteristic features of PET, polyamide and polypropylene spinning.

Unit 4. (10 L)

Solution dry spinning: Dry spinning of cellulose acetate. Acetylation of cellulose. Dope preparation and spinning of cellulose diacetate and triacetate. Dry spinning of acrylic. Significance and types of co-monomers used during polymerization of acrylic.

Unit 5. (10 L)

Solution wet spinning: Wet spinning of viscose rayon. Formation of structure in viscose and thermoplastic fibres. Influence of various additives and temperature of the regeneration bath and their influence on the process and properties of viscose rayon.

Unit 6. (10 L)

Drawing and heat setting of fibres: Introduction to drawing and heat setting in thermoplastic fibres. Concept of neck drawing. Effect of drawing conditions on the structure and properties of fiber. Effect of heat setting parameters on the structure and properties of fiber.

Practicals:

1. Melt spinning of Nylon 6 and 66.
2. Solution spinning of Acrylic fiber.
3. Preparation of PP tape by extruders.
4. Heat seating of Fibers.
5. Thermal analysis of fibers.
6. Chemical modifications of fibers.

Suggested Readings:

1. Production of Synthetic Fibres by A A Vaidya, 1st Ed., Prentice Hall of India, New Delhi, (1988).

2. Manufactured Fibre Technology by V B Gupta and V K Kothari, 1st Ed., Chapman and Hall, London, (1997).

3. Synthetic Fibres by J. E. Macintyre, Wood Head Fiber Science Series, UK, (2003).

4. Textile Fibers: Developments and Innovations by V K Kothari, IAFL Publications, New Delhi (2000).

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

DSE: Paper 3- Paints, Coatings and Adhesives

Unit 1. (15 L)

Introduction, function and properties of adhesives, mechanical interlocking, adsorption and surface reaction. Surface topography, wetting and setting, thermodynamic work of adhesion, influence of constitution on adhesion, interfacial bonding, and surface preparation of adherents. Types of adhesives (Structural, elastomeric and pseudo plastic based).

Unit 2. (15 L)

General information, paints composition, selection and water solubility, interface-surface treatment, properties manufacturer of paints and uses of paints.

Unit 3. (15 L)

Definition and importance of coating, raw materials and composition of coating, manufacture of coatings, criteria and type of coatings.

Unit 4. (15 L)

The technology for preparation of paints, coatings and adhesives and their use in different fields, coating operations.

Practicals:

1. Formulation of paints (water and solvent based).
2. To find out adhesive strength by Peel Test method.
3. Adhesive formulation and compounding.
4. Measurement of Wettability of adhesives.
5. Measurement of resin/paint viscosity by Ford cup 4 and Brookfield viscometer.

Suggested Readings:

1. Outline of Paint Technology by W. M. Morgan, CBS Publisher (2000).
2. Paints, Coatings and Solvents by D. Stoye, Wiley-VCH (2008).
3. Adhesion and Adhesives Technology by A. V. Pocius, H. Carl, Hanser-Verlag (2002).

4. Coatings of polymers and plastics by R. A. Ryntz, P. V. Yaneff, Marcel Dekker (2003).
5. Adhesion aspects of polymer coatings by K.L. Mittal, VSP (2003).

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

DSE: Paper 4- Polymeric Nanomaterials

Unit 1. (10 L)

Introduction to general aspects of nanostructured materials, e.g. nanocomposites, block copolymers, interaction parameter. Phase behaviour morphology and phase diagrams, microphase separation transition.

Unit 2. (15 L)

Preparation, structure and properties of nanoreinforcing agents: eg. nanoclays, POSS, carbon nanostructures and nanoparticles.

Unit 3. (10 L)

Effect of factors such as loading, dispersion and percolation, influence of size, shape and diameter of nanotubes, functionalization of nanoparticles and nanoplatelets.

Unit 4. (15 L)

Structural and morphological characterization

- Morphology of crystalline polymers.
- Nanostructure development in semicrystalline polymer during deformation by X-ray scattering & diffraction technique.
- Nanostructure of two component amorphous block copolymers: Effect of chain architecture.

Unit 5. (10 L)

Polymer nanocomposites: Technical challenges and understanding of interfacial dynamics using LJ Potential and many body problems approach. Applications of polymeric nanomaterials.

Practicals:

1. Particle size analysis of nanofillers.
2. Preparation of polymer nanocomposites by solution & melt compounding.
3. Determination of mechanical properties of nanocomposites.
4. Characterization of nanocomposites by optical microscope, SEM, TEM, DSC, DMA, TGA etc.
5. Determination of electrical properties of nanocomposites.

Suggested Readings:

1. Polymer Nanocomposites by J.H. Koo, McGraw-Hill (2010).
2. Polymeric Nanocomposites-Theory and Practice by S. N. Bhattacharya, Hanser Gardner (2008).
3. Mechanical Properties of Polymer based on Nanostructure and Morphology by G. H. Michler and F. J. Balta, CRC Press (2005).
4. Introduction to Nanotechnology by- C. Papoose, F. J. Owens, Wiley, John & Sons (2003).
5. Nanocrystalline Materials by S.C. Tjong, Elsevier Science (2006).

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

DSE: Paper 5- Tyre Technology

Unit 1. (20 L)

Tyre classification: Solid tyre, pneumatic tyre, radial tyre, bias and bias belted tyre and tubeless tyre.

Unit 2. (20 L)

Tyre design, tyre mechanics, caracas design, contour shape, cord path and their characteristics. Cord tension. load capacity of tyre, stresses in tyre, tread design, bead design.

Unit 3. (20 L)

Tyre manufacturing: Tyre building drum, cure finishing. Tyre testing. laboratory test, proving ground, inspection of tyre, earth moving tyres & ADV tyre.

Practicals:

1. To tested mechanical properties of vulcanized rubber: a) Tensile strength b) Elongation at break %, c) Hardness d) Tear strength.
2. To perform oil and air aging properties of rubber and rubber to fabric ply.
3. To determined bonding strength of rubber to fabric and rubber to metal ply .
4. To calculate abrasion loss of tyre tread.

Suggested Readings:

1. Heavy Duty Truck Tire Engineering SAE's 34th L. Ray Buckingdale Lecture, by T. L. Ford and F. S. Charles, SP729 (1988).
2. Engineering Data Book, "Over-The-Road Truck Tyres," The Goodyear Tyre & Rubber Company (2001).
3. The Science and Technology of Rubber by J. E. Mark, B. Erman, F.R. Eirich, Elsevier (2005).

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

DSE: Paper 6- Packaging Technology

Unit 1. (15 L)

Introduction, definition, importance, scope of packaging, packaging materials, origin of packaging materials, types, properties, advantages & disadvantages of packaging materials.

Unit 2. (10 L)

Types of packaging, box, bottle, tetra, pouch, shrink, vacuum, gas, controlled atmosphere packaging (CAP), modified atmosphere packaging (MAP), aseptic etc.

Unit 3. (15 L)

Polymers in packaging, LLDPE, HDPE, HMHDPE, PP-Properties and applications, PVC packaging, nylon packaging, polyester packaging, polycarbonate and PS and expanded polystyrene.

Unit 4. (10 L)

Packaging techniques, Thermoforming in packaging, co-extrusion, extrusion-stretch blow molding, LDPE, BOPP films.

Unit 5. (10 L)

Performance properties of packaging materials, bursting strength, tensile strength, tearing strength, drop test, puncture test, impact test etc.

Practicals

1. To Identification of polymeric package material by using FT-IR, DSC and TGA.
2. Determination of bursting strength, tensile strength, tearing strength, drop test strength, puncture test strength, impact strength etc.
3. Determination of water vapor transmission rate of packaging material
4. To tested sealing strength integrity of packaging materials

Suggested Readings:

1. Food Packaging Principles and Practice by Gordon L. Robertson, CRC press (2005).
2. A Handbook of Food Packaging by Paine F. A. and Paine H. Y., Blackie Academic and Professional (1992).

3. Food Packaging – Principles and Practice by Robertson G. L., CRC Press Taylor and Francis Group (2012).
4. Food Packaging Technology by Coles R, McDowell D., Kirwan M. J., Blackwell (2003).
5. Food Packaging – Principles and Practice by Robertson G. L., CRC Press Taylor and Francis Group (2012).
6. Polymers for packaging materials for preservation of food stuffs by L. A. Sukhareva, V. S. Yakolev, O. A. Legonkova, (2008).

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

DSE: Paper 7- Fabrication of Polymeric Products

Unit 1. (15 L)

FRP Laminates: Introduction, FRP processing methods contact moulding hand lay up, spray up method vacuum bag & pressure bag moulding, filament welding, centrifugal casting, pultrusion, matched die moulding laminates, definition of terms high, pressure laminating process, types of machinery, impregnation systems – decorative and industrial laminates, continuous high pressure laminating process, application.

Unit 2. (15 L)

Cellular Plastics: Introduction process to create foam in resins mechanical foaming, chemical foaming, physical foaming proceses to shape and solidify foams low pressure foam moulding, high pressure foam moulding, RIM extrusion foaming, casting foams, steam chest moulding structural foam moulding applications.

Unit 3. (10 L)

Machinery & joining of Plastics: Introduction – Importance of machining methods viz. cutting, drilling, blending, filling, etc. Joining principles cohesion principle, adhesion principle- solvent cementing, DOP cementing, welding, vibration welding, hot plate welding, ultrasonic welding, adhesive bonding examples: Mechanical fasteners.

Unit 4. (10 L)

Casting Processes: Dip casting, slush casting, continuous casting, cell casting, processes and applications. Calendering – Types of calendaring systems.

Unit 5. (10 L)

Coating Processes: Roller coating, powder coating, fluidized bed coating, electrostatic spray coating, processes and applications. Other Secondary Processes: Printing, painting, hot stamping, in mould decoration, electro plating and vacuum metallising, decorating.

Practicals

1. To Prepare unit cell products such as close and open cell
2. To prepare rubber-fabric play and composite by calendaring.
3. To prepare powder cotes such as epoxy, polyester and epoxy-polyester type.
4. To Prepare PMMA sheet using bulk polymerizations

5. To repair polymer products by different processing techniques.
6. RTM handling

Suggested Readings:

1. Plastics Finishing and Decoration by Donatar Satar, Van Nostrand Reinhold company, New York (1986).

2. Decorating Plastics by James M. Margolis, Hanser Publishers, New York (1986).

3. Manufacturing of polymer Composites by B. T. Astrom, Chapman and Hall, London (1995).

5. Plastics Processing Data Book by Donal V.Rosato and Dominick V.Rosato, Van Nostrand Reinhold, New York (1990).

6. Plastics: Materials and Processing by A. Brent Strong, Practice- Hall, New Jersey, (1996).

7. Joining Plastics in Production by M.N.Watson, The Welding Institute, Cambridge, (1988).

(4 h L/Week)
(4 h Lab/Week) (Total Credits -6)

DSE: Paper 8- Polymers in Biomedical Applications

Unit 1. (10 L)

Basics of biomaterials: Concept of biocompatibility, responsiveness, degradation, estimations of degradation and biocompatibility, technically important form of polymers: Hydrogel, bioceramics, bioelastomers, and membrane.

Unit 2. (10 L)

Physico-chemical properties of biomaterials: mechanical (elasticity, yield stress, ductility, toughness, strength, fatigue, hardness, wear resistance), tribological (friction, wear, lubricity), morphology and texture, porosity, adsorption, physical (electrical, optical, magnetic, thermal), chemical and biological properties.

Unit 3. (10 L)

Polymers used as Biomaterials: Silicone rubber, dacron, poly (methyl methacrylate), polyurethanes, cellulose, properties and applications.

Unit 4. (10 L)

Organ Transplants: Properties of polymers for organ transplant, different polymers used for organ transplant e.g. dental cement, orthopedic, skin, artificial kidney etc.

Unit 5. (10 L)

Tissue Engineering: Regeneration, important polymers used in tissue engineering, cellulose, chitoson and alginate.

Unit 6. (10 L)

Drug Delivery: Introduction to drug delivery, polymers in controlled drug delivery, dressing strips, polymer drug vessels, core shell and nanogel.

Practical

7. Evaluate the biocompatibility of polymeric samples.
8. Determine the degradation behavior of polymers such as thermal, hydrolytic etc.
9. Prepare membranes and measure absorption behavior.
10. Preparation and characterization of dental cement.
11. Prepare a hydro gel and characterization.
12. Determine the mechanical strengths of polymers.

Suggested Readings:

6. Nanomaterials in drug delivry, Imaging and Tissue Engineering by Ashutosh Tiwari and Atul Tiwari, Wiley (2013).
7. Handbook of Bioplastics and Biocomposites engineering applications by Srikanth Pilla, Wiley (2011).
8. Biomaterials Science, An Intoduction to Materials in medicine, Eds. B. D. Ratner and A. S. Hoffman, Academic Press, New York, (1996).
9. Drug delivery – Engineering principles for drug therapy, Editor: Saltzman W. M. Oxford University Press, USA (2001).
10. Biopolymers: Biomedical and Environmental Applications by Susheel Kalia and Luc Averous, John Wiley & Sons (2011).

(4 L/Week)
(4 h Lab/Week)
(1 Presentation /Week) (Total Credits -6)

DSE: Paper 7- Fabrication of Polymeric Products

Unit 1. (15 L)

FRP Laminates: Introduction, FRP processing methods contact moulding hand lay up, spray up method vacuum bag & pressure bag moulding, filament welding, centrifugal casting, pultrusion, matched die moulding laminates, definition of terms high, pressure laminating process, types of machinery, impregnation systems – decorative and industrial laminates, continuous high pressure laminating process, application.

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Cellular Plastics: Introduction process to create foam in resins mechanical foaming, chemical foaming, physical foaming proceses to shape and solidify foams low pressure foam moulding, high pressure foam moulding, RIM extrusion foaming, casting foams, steam chest moulding structural foam moulding applications.

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Machinery & joining of Plastics: Introduction – Importance of machining methods viz. cutting, drilling, blending, filling, etc. Joining principles cohesion principle, adhesion principle- solvent cementing, DOP cementing, welding, vibration welding, hot plate welding, ultrasonic welding, adhesive bonding examples: Mechanical fasteners.

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Unit 2. (10 L)

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Polymers used as Biomaterials: Silicone rubber, dacron, poly (methyl methacrylate), polyurethanes, cellulose, properties and applications.

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4. Drug delivery – Engineering principles for drug therapy, Editor: Saltzman W. M. Oxford University Press, USA (2001).
5. Biopolymers: Biomedical and Environmental Applications by Susheel Kalia and Luc Averous, John Wiley & Sons (2011).