Course Structure and curriculum of MSc in Polymer Science and Technology(2021-22)

1st Semester

Sl. No	Subject code	Subject Name	Class Load/Week			Total load	Credit
			L	T	P		
1.	**Polm C101**	**Introduction to Polymer Science and Technology (Core)**	**3**	**1**	**0**	**4**	**4**
2.	**Polm C102**	**Basic Polymer Chemistry (Core)**	**3**	**1**	**0**	**4**	**4**
3.	Polm E101	Polymer Nanotechnology (Elective I)	3	1	0	4	4
4.	Polm E102	Biopolymer (Elective II)					
5.	**CBCS**	**Course from other department**	**4**	**0**	**0**	**4**	**4**
		Theory Subtotal	**16**	**0**	**0**	**16**	**16**
1.	Polm L101	Lab. on Polm C102	0	0	4	4	2
2.	Polm L102	Lab. on Polm C103	0	0	4	4	2
1ST SEMESTER TOTAL							**20**
		Seminar / SkillX					02

2nd Semester

Sl. No	Subject code	Subject Name	Class Load/Week			Total load	Credit
			L	T	P		
1.	**Polm C201**	**Basic Characterization Techniques of Polymers (Core)**	**3**	**1**	**0**	**4**	**4**
2.	**Polm C202**	**Chemistry of Paints and Dyes (Core)**	**3**	**1**	**0**	**4**	**4**
3.	Polm E201	Specialty Polymers for advanced applications (Elective III)	3	1	0	4	4
	Polm E202	Rheology and Mechanical Properties of Polymer (Elective IV)					
4.	**CBCS**	**Course from other department**	**4**	**0**	**0**	**4**	**4**
		Theory Subtotal	**16**	**0**	**0**	**16**	**16**
1.	Polm L201	Lab. on Polm C201	0	0	4	4	02
2.	Polm L202	Lab. on Polm C202	0	0	4	4	02

2ND SEMESTER TOTAL					**20**
Seminar / SkillX					02

3rd Semester

Sl. No	Subject code	Subject Name	Class Load/Week			Total load	Credit
			L	T	P		
1.	**Polm C301**	**Surface Coating (Core)**	**3**	**1**	**0**	**4**	**4**
2.	**Polm C302**	**Biomaterials and 3D printing (Core)**	**3**	**1**	**0**	**4**	**4**
3.	**Polm C303**	**Polymers and Environment (Core)**	**2**	**1**	**0**	**3**	**3**
4.	Polm E301	Research Methodology and Ethics/ Rubber and Textile Technology (Elective V)	3	0	0	3	3
	Polm E302	Industrial Process Management (Elective VI)					
		Theory Subtotal	**14**	**0**	**0**	**14**	**14**
1.	Polm TE301	Term Paper Seminar &Viva-voce	-	-	-	-	06
3RD SEMESTER TOTAL							**20**
		Seminar / SkillX					02

4th Semester

Sl. No	Subject code	Subject Name	Class Load/Week			Total load	Credit
			L	T	P		
1.	Polm P401	Project Final Thesis	-	-	-	-	14
2.	Polm P402	Project Final Viva-voce	-	-	-	-	06
4th SEMESTER TOTAL							**20**
		Seminar / SkillX					02

Total Credits = [20+20+20+20] = 80

Prof. Ajoy Kumar Ray

Prof. Amit Basak

Prof. Amit Roy Chowdhury

Prof. Debabrata Chakrabarty

Dr. Kaushik Singha

Dr. Subhankar Singha

Dr. Prosenjit Saha

Detailed syllabus for POLYMER SCI. & TECHNOLOGY

1st Semester

Polm C101: Introduction to Polymer Science and Technology

Course Outcomes:

CO1: Students will be able to identify suitable polymer(s) for a given application

CO2: Understanding basic concepts of polymer science

CO3: Identifying a suitable chemical bonding in polymers

CO4: Understand Monomer structure and polymerizability

MODULE 1: History of macromolecular science.

Concept of macromolecules. Degree of polymerization, Concept of molecular mass, polydispersity, number average and weight average, viscosity average molecular weight and their statistical equations, molecular weight distribution in linear polymers (step growth and chain polymers), Nomenclature of polymers.

MODULE 2: Basic concepts in polymer science.

Different ways in classification of polymers depending on – a) The origin (natural, Semisynthetic, synthetic etc.) b) The structure (linear, branched, network, hyperbranched, dendrimer.)

c) The type of atom in the main chain (homochain, hetercohain). d) The formation (condensation, addition). e) Homopolymers, copolymers. f) The behaviour on application of heat and pressure (thermoplastic and Thermosetting). g) The form and application (plastics, fiber. elastomers and resin).

MODULE 3: Chemical bonding in polymers – ionic (ionomers), covalent, coordinate, metallic (Metalocene polymers), hydrogen bonding.

MODULE 4: Monomer structure and polymerizability.

Concept of functionality. Writing the structure of the polymer formed for a given monomer and its classification. Raw materials for monomers with specific example viz. acrylonitrile, vinyl, chloride, methyl methacrylate, isobutylene, isoprene, styrene, hexamethylene diamine and adipic acid, caprolactum, ethylene oxide and sebasic acid, ethylene glycol and terephthalic acid and their Polymerization reactions.

Books recommended:

1) F.W. Billmeyer, Jr. Textbook of polymer science, Wiley- Interscience,N.Y.(1971)
2) Introduction to polymer chemistry, R. Seymour, Wiley –Interscience(1981)

3) Physical chemistry of Macromolecules, by D.D. Deshpande, Vishal publications, (1985)
4) Principles of polymer chemistry by P.J.Flory.
5) Polymer Science –V RGowarikar.
6) Principles of polymerization, G.Odian, Wiley – Interscience(1981)

Polm C102: Basic Polymer Chemistry

Course Outcomes:

CO1: Students will be able to understand the basic concepts in Organic Chemistry

CO2: Understanding basic concepts of Physical Organic Chemistry and Photochemistry

CO3: Identifying and understanding Stereoisomerism

CO4: Applications and Preparations of reagents

MODULE 1: Basic Concepts in Organic Chemistry

Review of basic concepts in organic chemistry: bonding, hybridisation, MO picture, inductive effect, electromeric effect, resonance effect, hyperconjugation, steric effect. Bonding weaker than covalent bonds.

The formalism of curved arrow mechanisms. Practicing of line diagram drawing.

Concept of aromaticity: delocalization of electrons - Hückel's rule, criteria for aromaticity, examples of neutral and charged aromatic systems - annulenes. NMR as a tool for aromaticity. Anti-and homo-aromatic systems - Fullerenes, Carbon nanotubes and Graphene.

Mechanism of electrophilic and nucleophilic aromatic substitution reactions with examples. Arenium ion intermediates. SN1, SNAr, SRN1 and Benzyne mechanisms.

MODULE 2: Physical Organic Chemistry and Photochemistry

Energy profiles. Kinetic versus thermodynamic control of product formation, Hammond postulate, kinetic isotope effects with examples, Hammet equation, Taft equation.

Photoreactions of carbonyl compounds: enes, dienes, dienones and arenes. Norrish reactions of acyclic ketones. Patterno-Buchi reaction. Barton, Di-πmethane and photo Fries rearrangements. Photochemistry of nitro and azo groups.

Topicity and prostereoisomerism, topicity of ligands and faces as well as their nomenclature. NMR distinctionof enantiotopic/diastereotopicligands.

Stereoisomerism: definition based on symmetry and energy criteria, configuration and conformational stereoisomers.

Geometrical isomerism: nomenclature, E-Z notation, methods of determination of geometrical isomers. Interconversion of geometrical isomers.

MODULE 3: Preparations and applications of following reagents: Aluminium tertiary butoxide, BF3, DCC, Ozone, Per benzoic acid, Pt & Pd, Selenium, Per iodic acid, PPA, Di azo acetic ester.

Books recommended:

1. R. Bruckner, Advanced Organic Chemistry: Reaction Mechanisms, Academic Press,2002.
2. F.A. Carey, R.A. Sundberg, Advanced Organic Chemistry, Part A: Structure and Mechanisms, 5th Edn.,Springer,2007.
3. J. Clayden, N. Greeves, S. Warren, P. Wothers, Organic Chemistry, Oxford University Press,2004.
4. T.H. Lowry, K.S. Richardson, Mechanism and Theory in Organic Chemistry, 2ndEdn., Harper & Row, 1981.
5. D. Nasipuri, Stereochemistry of Organic Compounds: Principles and Applications, 3 rdEdn., New AgePub.,2010.
6. D.G. Morris, Stereochemistry, RSC, 2001. 08. E.L. Eliel, S.H. Wilen, Stereochemistry of OrganicCompounds, John Wiley & Sons,1994.
7. N.J. Turro, V. Ramamurthy, J.C. Scaiano, Principles of Molecular Photochemistry: An Introduction,University Science books,2009.
8. N.J. Turro, Modern Molecular Photochemistry, Benjamin Cummings,1978.
9. K.K.R. Mukherjee, Fundamentals of Photochemistry, New Age Pub.,1978.
10. Organic Synthesis based on Name reaction and unnamed reaction, A.Hassner & C. Stummer, Pergamonpress. 2ndedition
11. Advanced Organic Chemistry- Reaction Mechanism & Structure, J.March, John Wiley & Sons. 4thedition
12. Reaction mechanism and reagents in organic chemistry, G. Chatwal, Himalaya publishers.
13. Organic chemistry, warren, oxford university press.

Polm E101: Polymer Nanotechnology

Course Outcomes:

CO1: Students will be able to understand the basic concepts of Amorphous and Nano-crystalline Materials

CO2: Understanding basic concepts of Catalysis

CO3: Identifying and understanding Stereoisomerism

CO4: Applications and Preparations of reagents

MODULE 1: Amorphous and Nano-crystalline Materials

Amorphisation of alloys; Different properties amorphous alloys; metallic glass; Production techniques for amorphous and nano-crystalline materials: vapour deposition techniques, nanoparticles, decomposition of supersaturated solid solutions and glass crystallisation, sol-gelmethods, nanoporous materials; microstructural stability in nanomaterials; colloidal nanoparticles; Catalysis: principles and applications of nano-crystalline materials; mechanical properties and microstructure-mechanical property relationships in nano-crystalline materials.

MODULE 2: Electronic, Opto-electronic and Superconducting Materials

Band theory; Energy band diagrams; Nature of chemical bonds and their relation to crystal structure; Band gap; Fermi level carrier mobility, Extrinsic & intrinsic semiconductors; doping techniques. Optical properties of semiconductors; absorption & emission processes; radiative &non-radiative transitions; photoconducting & non-photoconducting materials materials; Phosphors preparation and applications. Superconductivity, Cooper-pair instability, BCS theory, Josephson Effects, Ginzburg-Landau Theory, Superconductor in magnetic field, Type I and Type II superconductors, flux quantization, d-wave superconductors, high temperature superconductors.

Books Recommended:

1) "The Physics of Polymers, 2'nd Edition, Concepts for Understanding Their Structure and Behavior" G.Strobl, Springer Press1997.
2) Nanomaterials Nanotechnologies and Design, An Introduction for Engineers and Architects, MFAshby

Polm E102: Biopolymers

Course Outcomes:

CO1: Students will be able to understand the basic concepts of Proteins, DNA, Carbohydrates
CO2: Understanding basic concepts of Biomacromolecular structural organization, Nucleotides
CO3: Identifying and understanding DNA/RNA monomer building blocks
CO4: Understand Biodegradable polymers

Proteins (muscles, skin, hair, nails, enzymes), DNA (information storage polymer), Carbohydrates (energy storage, structural components), Biomacromolecular structural organization, Nucleotides: constituents of Nucleic acids, DNA/RNA monomer building blocks, Denaturation of proteins. Biodegradable polymers and polymers from renewable resources and showing their importance in ecological, medical and material applications. It goes out from the processes of the recovery these polymers (biotechnologically, extraction from natural materials) through their modifications according to use.

2nd Semester

Polm C 201: Basic Characterization Techniques of Polymers (Core)

Course Outcomes:

CO1: Students will be able to understand the Importance of Quality control and Characterization of molecular weight

CO2: Understanding basic concepts of Optical properties and analytical tests

CO3: Identifying and understanding Mechanical, Electrical and Flammability Test

CO4: Understand Thermal characterization

MODULE 1: Importance of Quality control and Characterization of molecular weight: Importance of specification & standards in quality control of polymers, Preparation of polymer test specimens and conditioning, determination of Molecular weight by Ultra Centrifugation, Gel Permeation Chromatography. End Group Analysis, Ebulliometry, Cryoscopy, Osmometry, and viscometry.

MODULE 2: Optical properties and analytical tests: Refractive index, haze, gloss, density, water absorption, moisture analysis, sieve analysis, apparent density, melting point, Shrinkage, Melt Flow Index test, Particle size, Density, and bulk factor.

MODULE 3: Mechanical, Electrical and Flammability Test: Introduction, Hardness, Tensile strength, Compression strength, Flexural strength, Impact strength, Dielectric strength, Dielectric constant, dissipation factor, Insulation resistance and arc resistance, Ignition properties, Oxygen index test and smoke generation tests.

MODULE 4: Thermal characterization

TGA, DTA, DSC, TMA, Heat deflection temperature, Vicat softening temperature, thermal conductivity thermalexpansion, brittleness temperature, surface and volume resistance.

Chemical and Weathering Properties: Immersion test, Stain resistance test, Solvent stress cracking resistance test, Environmental stress cracking resistance test, Accelerated weathering test, Outdoor weathering of polymers.

Books Recommended:

1. Handbook of plastics test method, R. P. Brown, Longman Scientific andTechnical.
2. Handbook of plastics testing technology, Vishu Shah, John Wiley & Sons, NewYork.
3. Instrumental methods of Analysis, Will and Merritt, CBS Publisher, NewDelhi.
4. Principles of Instrumental Analysis, Douglas A. Skoog, F. James Holler and Timothy A.Nieman,

Polm C202: Chemistry of Paints and Dyes (Core)

Course Outcomes:

CO1: Students will be able to understand the Importance of Colourants
CO2: Understanding basic theories of color and constitution
CO3: Identifying and understanding General Introduction of Paint industry
CO4: Understand Source and composition of oils

MODULE1: Colourants

Origin of colour in organic molecules. Chromatic and achromatic colors. Red shift, blue shift, hyperchromic effect, solvatochromism, halochromism. Beer-Lambert's law, absorptivity, oscillator strength, and half band width.

MODULE 2: Early theories of color and constitution - empirical correlations between the chemical structures and their color. Chromophores, auxochromes, distribution rules, chromogens. $n \rightarrow \pi^*$, donor acceptor, acyclic and cyclic polyene, and cyanine type chromogens.

Resonance theory of color, failures of resonance theory. Steric effects in electronic absorption spectra – some general considerations.

MODULE 3: Paints

General Introduction of Paint industry, definition of Paints, varnishes and lacquers their constitutions and functions. General classification of surface coating, mechanism of film formation.

MODULE 4: Source and composition of oils, non –glyceride, component of oils, classification, extraction and refining of oils,Chemical reactions of oils, like oxidation, hydrolysis, glyceralysis, saponification etc, and their evaluation, characterization of oils.

Function of additives, additives for solvent-thinned coating like wetting, and dispersing agents, anti-settling and bodying agents, anti-skinning agents, anti-flooding agents etc, additives for latex paints like surface – active agents, antifoam agents, emulsifier, thickening agents, preservatives coalescing agents etc.

Books Recommended:

1. Chemistry of Synthetic Dyes and Pigments, Lubs H. A., Robert E Krieger Publishing Company, NewYork,1977
2. Chemistry of Synthetic Dyes – Vol I, Venkataraman, K., Academic Press,1952
3. Chemistry of Synthetic Dyes – Vol III, Venkataraman, K., Academic Press,1972

4. Colour and Chemical Constitution of Organic Dyes, Griffiths J., Academic Press,1976

Polm E201: Speciality Polymers for advanced applications

Course Outcomes:
CO1: Students will be able to understand liquid crystalline polymers and their classification
CO2: Understanding conducting polymers
CO3: Identifying and understanding heat resistant polymers
CO4: Applications of polymers in miscellaneous specialty

MODULE 1: LIQUID CRYSTALLINE POLYMERS (LCPS) Concept of liquid crystalline (LC) phase, liquid crystalline polymers and their classification. theories of liquid crystallinity, characteristics of LC state and LCPs, blends of LCPs, applications of LCPs.

MODULE 2: CONDUCTING POLYMERS Theory of conduction, band theory, requirements for polymer to work as conductor, types of conducting polymers - doping of polymeric systems, Polyaniline, Polyacetylene, Polypyrrole, organometallic polymers – Photo conducting polymers- Polymers with Piezo, ferro and pyro electric properties.

MODULE 3: HEAT RESISTANT POLYMERS Requirements for heat resistance, determination of heat resistance, synthesis, structure-propertyrelationships, applications of heat-resistant polymers like polyamides, polyimides

and its derivatives, polyquinolines, polyquinoxalines, Polymers for high temperature resistant-PBT, PBO, PBI, PPS, PPO, PEEK, Fluro polymers

MODULE 4: PHOTOSENSITIVE POLYMERS AND POLYMERS AS COATING ADDITIVES

Photosensitive polymers - synthesis, curing reactions, applications in various fields. Photo resist for semiconductor fabrication. Membranes, their types, methods of casting and their applications. Polymer as coating additives - types,synthesis, requirements for polymer to work as coating additives and applications

MODULE 5: POLYMERS IN MISCELLANEOUS SPECIALTY APPLICATIONS

Polymers in agricultural applications: green houses, control release of agricultural chemicals, seed coatings, etc., polymers in construction and building applications, polymer concrete, polymeric materials used in telecommunication and power transmission applications, polymer composites inaerospace.

Shape memory polymer, Polymers responding to various stimuli such as heat, light, pressure, fluids/chemicals etc.

Polymers in telecommunications and power transmission: Polymers as insulators electrical breakdown strength, capacitance, dielectric loss and cable attenuation, submarine cable insulation, low fire risk materials, polymersin power transmission, optical fibre telecommunication cables.

Polymer concrete, polymer impregnated concrete, ultra-high modulus fibers, polymers for biomedical application, polymeric bindersfor rocket propellants, polymer supported reagents.

Books recommended:

1. Faiz Mohammad, Specialty Polymers: Materials and Applications, I.K. International Pvt Ltd,2008
2. Johannes Karl Fink, Hand book of Engineering and Specialty Polymers, John Wiley & Sons, Vol.2,2011
3. Manas Chanda, Salil K. Roy, Industrial Polymers, Specialty Polymers, and their Applications, CRCPress,2008
4. Norio Ise, IwaoTabushi, An Introduction to Speciality Polymers, Cambridge University Press, 1983foodapplications.
5. Robert William Dyson, Speciality Polymers, 2nd ed., Springer verlag,2011
6. Smart Polymers: Applications In Biotechnology And Biomedicine by Igor. Galaev, BoMattiasson
7. Smart polymers for bioseparation and bioprocessing by Igor Yu Galaev, Igor Galaev, BoMattiasson
8. Encyclopedia of Polymer Science & Engineering H.F. Mark (Ed) John Wiley & Sons, New York (1989)RelevantVolumes

Polm E202: Rheology and Mechanical Properties of Polymer (Elective II)

Course Outcomes:
CO1: Students will be able to understand reheology and mechanical properties of polymers
CO2: Understanding mechanical models
CO3: Identifying and understanding the glassy state and the glass transaction
CO4: Applications of strain behavior of elastomers

Reheology and mechanical properties of polymers: - Introduction to Reheology, Newton's and Hooks laws, reheological response of materials, the ideal fluid, non-Newtonian Fluids, time dependent fluids, power law models. Viscous flow, Relationship between stresses and stain, viscoelastisity, Mechanical models – Maxwell and voigt Boltzmann's superposition principles. Kinetic theory of rubber elasticity. The glassy state and the glass transaction, dynamic mechanical testing, relaxation spectrum, frequency dependent visco-elastic behavior stress – strain behavior of elastomers, the mechanical properties of crystalline polymers.

Books Recommended:

1) Plastic technology by patten, W. J., D. Bavaporwala, Bombay.

2) Polymer plastics technology and Engineering Vol. II Naturaman, L.M. Dekkar (1979)
3) Polymer science and material science H.B. Vol. I & II by Jenkins, A.D. North Holland publishingco., Amsterdam, London.
4) Principles of polymer processing by Fenner R.T., Chemical publishing N.Y. (1979)
5) Principles of polymer chemistry by P.J.Flory
6) Polymer science by Govarikar V.R. and others, Wiley Eastern (1986).
7) Outline of paint Technoogy, W MMorgsn.
8) Paints, Coatings and solvents –DieterStoye.

3rd Semester

Polm C301:

Course Outcomes:
CO1: Students will be able to understand Surface chemistry
CO2: Understanding surface preparations
CO3: Identifying and understanding the auger electron spectroscopy
CO4: Understand nanoparticles stabilization

MODULE 1: Surface Coating

Surface chemistry I: Surface Phenomena, Gibbs adsorption isotherm, types of adsorption isotherms, solid-liquid interfaces, contact angle and wetting, Methods of surface tension and contact angle measurements Young Laplace, Kelvin Equation and implications of wetting, Nanostructure influence on wetting Lotus effect, rose petals and birds Marangoni effect, solid-gas interface, physisorption and chemisorption, Freundlich, derivation of Langmuir and BET isotherms, surface area determination. Kinetics of surface reactions involving adsorbed species, Langmuir-Hinshelwood mechanism, Langmuir-Rideal mechanism, Rideal-Eleymechanism.

MODULE 2: Surface chemistry II:

Surface Films, Langmuir-Blodgett films, self-assembled mono layers, collapse pressure, surface area and mechanism of heterogeneous catalysis, phase transfer catalysis. Chemical analysis of surfaces: Surface preparations - spectroscopic surface characterization methods, electron spectroscopy, ion scattering spectrometry, secondary ion scattering microscopy (SIMS) - Auger electron spectroscopy - instrumentation and application. Electron stimulated micro analysis, scanning probe microscopes.

Surfactants, detergency and foams, Micellization, self-assembly, liquid crystals, Emulsion, micro emulsion,flotation, Adhesion, biofouling, adhesives, gecko effect, self-cleaning

Electric double layer, zeta potential, electrophoresis and electroosmosis DLVO theory, colloids and nanoparticles stabilization

Books Recommended

1) P. W. Atkins, Physical Chemistry, 6th Edn., Oxford University Press,1998.
2) D. McQuarie, and J. D. Simmen, Physical Chemistry, 1st Edn., University Science,1998
3) Physical chemistry of the surfaces, A.W. Adamson and A.P. Gast, John Wiley, 6th edition, 1997, NewYork.
4) Adsorption and Catalysis, D.K. Chakraborty, 1st edition, 1992, Narosa, NewDelhi.
5) Surfactants and Polymers in aqueous solution, Krister Holmberg, Bo J¨onsson, Bengt Kronberg andBj¨ornLindman, 2002, John Wiley,Sussex.

Polm C302: Biomaterials and 3D printing

Course Outcomes:
CO1: Students will be able to understand biomaterials, clinical implications of biomaterials development
CO2: Understanding polymers as biomaterials
CO3: Identifying and understanding the Medical devices, medical device development
CO4: Understand Solid based systems

MODULE 1: Introduction to classes of materials used in medicine, world-wide market for biomaterials, clinical implications of biomaterials development. Types of materials-inert, toxic, bioactive, natural materials - collagen, biopolymers etc. Introduction to biocompatibility, requirements and standards, cell-material interaction, testing of

biomaterials, in vitro assessment, in vivo assessment of tissue compatibility, testing of bloodmaterials interaction, animal models.

MODULE 2: Polymers as biomaterials, silicones, polyurethanes, polyvinyl chloride, polyethylenes, ultra-high molecular weight polyethylene, polyacrylates, polyether ether ketone, water soluble polymers, hydrogels, bio-adhesives, diffusion principles, polymers for controlled drug delivery applications, polysaccharides, poly(orthoesters), polyanhydrides, aminoacid derived polymers, polyphosphazenes, bacterial polyesters, etc. Concepts of polymer composites, composites - reinforcing systems-fabrication, mechanical properties, dental filling composites, fibrous and particulate composites in orthopedic implants. Biomimetic materials, nanoscale materials/engineering; bioactive/bioresponsive materials, polymer scaffolds, principles of tissue engineering.

MODULE 3: Medical devices, medical device development, material choice, device design, extracorporeal devices, oxygenators, intravenous catheters, stents, polymeric implants, heart valves, total artificial heart, cardiac pace makers, vascular grafts, artificial kidney, dialysis membranes, hard tissue implants, orthopedic implants, fractureplates, intramedullary devices, spinal fixation, joint replacements, bone cement, soft tissue replacements, wounddressing, artificial skin, sutures, contact lenses, tissue adhesives, maxillofacial implants, ear and eye implants, controlled drug delivery systems, biosensors, gloves, condoms, urinary catheters, intrauterine systems, cosmetic implants. Regulation and standards for quality, FDA, EU-medical directives, GMP, GLP, ISO, CE marking etc. Degradation of polymers in biological environments, biodegradable polymers, polylactic acid, polyglocolic acid,polylactic acid co-glycolic acid, polycaprolactone, hydrolysis, enzymatic degradation. Surface modification techniques, plasma modifications, coating methods. Sterilization, methods, dry heat, steam, ethylene oxide, gamma ray, effect of sterilization on polymers, importance of packaging, shelf-life.

MODULE 4: Introduction, Prototyping fundamentals, Historical development, Advantages of AMT, commonly used terms, process chain, 3D modelling, Data Conversion, and transmission, Checking and preparing, Building, Post processing, RP data formats, Classification of AMT process, Applications to various fields
Liquid based systems: Stereo lithography apparatus (SLA): Models and specifications, process,working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications,advantages and disadvantages, case studies. Solid ground curing (SGC): Models and specifications, process, working, principle, applications, advantages and disadvantages, case studies.

MODULE 5: Solid based systems: Laminated object manufacturing (LOM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies.Fused Deposition Modeling (FDM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies
Powder Based Systems: Selective laser sintering (SLS): Models and specifications, process, working principle,applications, advantages and disadvantages, case studies. Three-

dimensional printing (3DP): Models and principles of bioprinting (layer-by-layer), different applications for 3D-printing and bioprinting in the life sciences, process going from an idea to a final 3D-printed object

Books recommended:

1. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen and Jack E. Lemons, Biomaterials Science, Anintroduction to Materials Science, 2nd Edn, Elsevier Academic Press, London,2004.
2. J. Park and R.S.Lakes, Biomaterials An Introduction, 3rd Edn., Springer Science, New York,2007.
3. F.Silver and C. Doillon, Biocompatibility, Interactions of biologicals and Implantable MaterialsVolume
   1. Polymers, VCH Publishers, New York,1989.
4. Shalaby W. Shalaby, Biomedical Polymers, designed to degrade systems, Hanser Publishers, New York,1994.

5. D.L.Wise et al. Eds., Encyclopedic handbook of Biomaterials and Bioengineering, Part A. Materials &part B. Applications, Volume 1 &2,., Marcel Dekker Inc., New York,1995.
6. Chua C.K., Leong K.F. and LIM C.S Rapid prototyping: Principles an Applications, World Scientificpublications, 3rdEd.,2010
7. D.T. Pham and S.S. Dimov, "Rapid Manufacturing", Springer,2001
8. Terry Wohlers, " Wholers Report 2000", Wohlers Associates,2000
9. Paul F. Jacobs, " Rapid Prototyping and Manufacturing"–, ASME Press,1996
10. Ian Gibson, Davin Rosen, Brent Stucker "Additive Manufacturing Technologies, Springer, 2nd Ed,2014.

Polm C303: Polymers and Environment

Course Outcomes:
CO1: Students will be able to understand Applications to atmospheric and radiation
CO2: Understanding The ecological importance of biodegradable polymers
CO3: Identifying and understanding the Biopolymers and nonotechnologies
CO4: Applications of biodegradable polymers

MODULE 1: Fundamental course on polymers to monitor environmental systems; Applications to atmospheric andradiation, weather, air quality, hydrological, water quality, terrestrial ecosystems, and aquatic ecosystems; Sensors technology and polymers, operation principles, calibration, and maintenance; Biodegradable polymers in new technologies, biomaterials.

MODULE 2: The ecological importance of biodegradable polymers and polymers from renewable resources, carbon footprint. LCA of biodegradable polymers and legislative, methods of biodegradability and ecotoxicity testing. Applications of biodegradable polymers in agriculture and packaging, certification of products and progresive technologies.

MODULE 3: Biopolymers and nonotechnologies, active packaging. Definition of Biopolymers and types of biopolymers, definition of bioplastics, Types of bioplastics, such as starch based, cellulose based plastics and some aliphatic polyesters (PLA, PHB), polyamides

Polm E 301: Research Methodology and Ethics

Course Outcomes:
CO1: Students will be able to understand foundation of research
CO2: Understanding review of literature
CO3: Identifying and understanding the field work
CO4: Understand statistical analysis of data

MODULE 1:

Foundation of Research:

What is Research, Objectives of Research, Scientific Research, Research and Theory Conceptual and Theoretical Models, Research Process, Problem definition, Research Questions, Research design, Approaches toResearch, Importance of reasoning in research.
Types of Research: Classification of Research, Descriptive vs. Analytical Research, Applied vs. Fundamental Research, Quantitative vs. Qualitative Research, Conceptual vs. Empirical Research, Exploratory vs. Confirmatory Research, Experimental vs Theoretical Research, Surveys, Case Study, Field Studies, Understanding Theory, Building and Validating Theoretical Models.

MODULE 2: Review of Literature: Significance for Reviewing Literature, What to Review and its Purpose, Literature Search Procedure, Sources of Literature, Tools for identifying literatures, Note Taking, Role of libraries in Information Retrieval, Referencing, Indexing and abstracting services, Citation indexes. Research formulation and design: Selection of a Problem for Research, Formulation of the Selected Problems, Hypothesis Formation, Measurement, Research Design/Plan.b Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments. Methods of data collection: Meaning and Importance of Data, Sources of Data, Use of Secondary Data, Methods of Collecting Primary Data, Observation Method, Simulation. Tools for data collection: Types of Data, Construction of Schedules and Questionnaires, Measurement of Scales and Indices, Pilot Studies and Pre-tests.

MODULE 3: Field work: The Nature of Field Work, Selection and Training of Investigators, Sampling Frame and Sample Selection, Field Operation, Field Administration. Processing of Data: Editing, Classification and Coding,

Transcription, Tabulation.Numerical and Graphical Data Analysis: Sampling: Sampling Techniques or Methods, Choice of Sampling Techniques, Sample Size, Sampling and Non-Sampling Errors, Observation, Surveys, Inferential Statistics, and Interpretation of Results.

MODULE 4: Statistical Analysis of Data: Measures of Central Tendency, Measures of Dispersion, Measures of Association/Relationship, Regression and Correlation Analysis, Hypothesis Testing (For Proportion and Means), Test of Significance. Preparation of Dissertation and Research Papers: Types of Research Papers, Planning of Writing, Research Report Format, Principles of Writing, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References, Citation and listing system of documents.

Polm E 302: Industrial Management

Course Outcomes:
CO1: Students will be able to understand man power planning
CO2: Understanding motivation and productivity
CO3: Identifying and understanding the union management perspective
CO4: Understand dynamics of conflict and collaboration, workers' participation and management

MODULE 1: MAN POWER PLANNING

Need – objectives – planning for future – manpower planning process- projecting manpower supply and demand at organizational level – developing manpower strategy - recruitment selection and induction – process of recruitment – selection tests – placement induction – orientation – training and development – training – management development – retraining – evaluation of training programme.

MODULE 2: MOTIVATION AND PRODUCTIVITY

Issuesinmanagingpeople–Maslow'sneedhierarchy–socialneedsandproductivity– hygieneandmotivators
– motivational climate – demotivation – cases – performance appraisal – job performance and performancemeasurement – validity and reliability – methods – problems in Indian context – career planning – responsibility
– process of career planning and development – advantages and limitations.

MODULE 3: UNION MANAGEMENT PERSPECTIVE

Approaches to industrial relations – public policies – major events in international issues– perspectives forIndia
– trade with development and functions – growth of trade unions – development – functions – structure –leadership and management in the trade union.

MODULE 4: DYNAMICS OF CONFLICT AND COLLABORATION

Process of conflict – types of conflict – interpersonal conflict – managing inter group relations and conflict –industrial conflict resolution – consultation- collective bargaining – types of bargaining – new collective bargaining –negotiation skills – trends in collective bargaining.

MODULE 5: WORKERS PARTICIPATION AND MANAGEMENT

Concept, strategies and practices –models in workers' participation management – design and dynamics ofanticipative forms – case studies– case study analysis – synthesis

Books recommended

1. C.B. Memoria and S.Memoria, Dynamics of Industrial Relations in India, Himalaya Publishing co.,Bombay, 1985
2. C.B. Memoria, Personnel Management, Himalaya Publishing Co., Bombay,1985.
3. H.C. Lucas Jr., Information System Concepts for Management, McGraw Hill, Kogakusha,1978.Robbins, The Management of Human Resource, Prentics, Hall, New Jersey,1982