INDEX
BHASKARACHARYA COLLEGE OF APPLIED SCIENCE
BSC. (HONS.) POLYMER SCIENCE
SEMESTER-IV/V

SEMESTER –IV

BSc. (Polymer Science)

Bhaskaracharya College of Applied Science

DISCIPLINE SPECIFIC CORE COURSE – 10

CREDIT DISTRIBUTION, ELIGIBILITY, AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
POLYMER TESTING AND SPECIFICATIONS (PTS)	4	2	0	2	Class 12th with Physics, Chemistry, Mathematics	--

Learning objectives

The Learning Objectives of this course are as follows:

- To learn about the fundamentals of polymer testing
- To understand testing standards of polymeric materials on various testing instruments

Learning outcomes

The Learning Outcomes of this course are as follows:

After completing the course, the students

- Perform tests of polymeric materials on testing instruments
- Establish the structure property correlation (mechanical, thermal, optical, electrical) of polymers
- Elucidate stability of various polymers and their properties on the basis of their thermo mechanical transitions.

SYLLABUS OF DSC- 10

THEORY COMPONENT-

UNIT 1: (12 Hours)

TESTING STANDARDS AND MECHANICAL ANALYSIS OF POLYMERS

Principles of standardization, preparation of sample, different standards: BIS and ASTM standards (thermal and mechanical analysis), testing methods, evaluation of errors in polymer testing, correction of errors

a. Short term strengths: tensile, flexural, hardness, impact strength, tear resistance, abrasion, etc.

b. Long term strengths: Creep and fatigue properties, isochronous stress strain curve compression set.

UNIT 2: **(4 Hours)**

ELECTRICAL AND OPTICAL PROPERTIES

Dielectric strength, surface and volume resistivity, electro active properties, Refractive index, Haze and gloss, yellowness index.

UNIT 3: **(6 Hours)**

GAS BARRIER AND ENVIRONMENTAL ASSESSMENT

Permeability to gases and moisture: Standard methods of measuring the permeability of gases, Environment resistance: Cause of deterioration of polymer by aging & weathering, assessment of deterioration, natural and artificial weathering, chemical resistance.

UNIT 4: **(8 Hours)**

THERMAL AND FIRE RESISTANT PROPERTIES

Thermo-mechanical Properties, Melt flow index, thermal conductivity, thermal diffusivity, specific heat capacity, linear thermal expansion, brittleness temperature etc. Burning behaviour, flammability tests (UL-94, limiting oxygen index, critical temperature index, smoke density).

PRACTICAL COMPONENT **(60 Hours)**

- To determine the melt flow index of LLDPE, PP etc.
- To evaluate limiting oxygen index (LOI)/ UL-94 of plastic samples: PVC, PE, PP etc.
- To determine the heat distortion temperature (HDT) & vicat softening point (VSP) of polymers.
- To measure the abrasion resistance of polymer sheets.
- To measure the dielectric strength of polymer films/sheets.
- To determine the coefficient of friction of polymeric samples.
- To determine the Izod impact strength of polymeric samples.

- To determine the environment stress cracking resistance of PE/PP.
- To calculate weight percentage of inorganic and organic ingredients in polymeric compounds.
- Measure the Thermo-mechanical transition.
- Determine the water vapor transition rate for polymeric film.
- Determine the thermal conductivity of a polymer sheet.

ESSENTIAL/RECOMMENDED READINGS

- Shah V., (2007) Handbook of Plastic Testing & Technology, Wiley-Inter science.
- Hylton D., (2004) Understanding Plastic Testing, Hanser publication
- Grellmann W., Seidler S., (2013) Polymer Testing, Hanser publication.
- Willard H.H., Merrit L.L., Dean J.A. (1988) Instrumental method of analysis, Wads worth Publishing Company.
- Seidel, A. (Ed.). (2008). Characterization analysis of polymers. Wiley-Interscience.
- Pethrick, R. A., & Viney, C. (2003). Techniques for polymer organization and morphology characterisation. Wiley.
- Frick. A., Stern. C. , Muralidharan V. (2019) Practical Testing And Evaluation Of Plastics, Wiley,

SUGGESTIVE READINGS

- Berins M. L., (1991) SPI Plastic Engineering Hand book, Springer.
- Ward I.M., Sweeney J., (2004) An Introduction to the Mechanical Properties of Solid Polymers, Wiley.
- Tanaka T., (1999) Experimental Methods in Polymer Sciences, Academic Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 11

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
POLYMER PROCESSING TECHNOLOGY	4	2	0	2	Class 12th with Physics, Chemistry, Mathematics	---

Learning objectives

- To learn about the various processing techniques and their components
- To learn the fundamentals of extrusion and different extrusion processes of thermoplastics.

Learning outcomes

After studying this paper, students will be able to

- Explain the significance of the single screw and multiple screw extruder systems
- Apply the fundamentals of injection and compression molding process and interpret processing variables for upgradation of quality of products

SYLLABUS OF DSC- 11

THEORY COMPONENT-

UNIT 1: (6 Hours)

EXTRUSION

Extrusion process, the extrusion die, classification of extrusion dies: film and sheet extrusion, multi-layer extrusion, Spider die, Pipe and Tube die, offset die, etc. Die swell and die defects

UNIT 2: (10 Hours)

INJECTION & BLOW MOLDING

Principles, material used, injection molding cycle, injection molding machine, some aspects of product quality, reaction injection molding (RIM), blow molding, extrusion blow molding,

injection blow molding, stretch blow molding, blow moulding of PET, trouble shooting operations.

UNIT 3: **(4 Hours)**

THERMOFORMING

Thermoforming process: Principles, materials used, types and applications

UNIT 4: **(4 Hours)**

COMPRESSION & TRANSFER MOLDING

Compression moulding process, transfer moulding process: introduction, material used, types and applications

UNIT 5: **(6 Hours)**

MISCELLANEOUS PROCESSING METHODS

Casting and rotational moulding processes: principles, material used, types and applications
Casting, rotational moulding, machining and joining processes: principles, material used, types and applications

PRACTICAL COMPONENT **(60 Hours)**

- To prepare a polymeric sheet/ specimen by compression molding.
- To prepare polymeric specimens by transfer molding.
- Preparation of polymeric specimens/product by injection molding.
- To process a polymer using extruder and to determine the production rate & residence time
- To prepare polymer film/ membrane by solution casting method.
- To prepare thermo formed polymeric products.
- To cast various products using polyester resin/epoxy resin/latex.
- Industrial/lab visit.

ESSENTIAL/RECOMMENDED READINGS

- Strong A.B., (2005) Plastics: Materials & Processing, Prentice Hall.
- Rosato D.V., Rosato D.V., (2000) Injection Moulding Handbook, CBS Publisher.
- Morton-Jones D.H., (2007) Polymer Processing, Chapman & Hall.
- Griff A. L., (2021) Plastics Extrusion Technology, Creative Media Partners, LLC

- Gogos, C. G., & Tadmor, Z. (2013). Principles of polymer processing. John Wiley & Sons.
- Berins, M. (Ed.). (1991). Plastics engineering handbook of the society of the plastics industry. Springer Science & Business Media.

SUGGESTIVE READINGS

- Chan I. Chung, Hanser Verlag (2000) Extrusion of Polymers: Theory and Practice,
- R. J. Crawford, Rotational Molding of Plastics ABS, Research Studies Press Ltd.
- Crawford R.J., (1998) Plastic Engg, Butterworth-Heinemann.
- J.L. Throne (1987) Thermoforming Hanser Publishers.
- Rosato (1987) Blow Molding Handbook, Hanser Publishers.
- Harper, C. A., & Petrie, E. M. Plastic materials and processes: a concise encyclopedia. 2003.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 12

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
RECYCLING AND WASTE MANAGEMENT	**4**	**2**	**0**	**2**	**Class 12th with Physics, Chemistry, Mathematics**	**-**

Learning objectives

- To introduce the concept of life cycle analysis
- To learn about the solid waste management policies
- To learn about various sources of polymer waste generation and their management
- To understand various waste disposal and treatment methods

Learning outcomes

After studying this paper, students will be able to

- Explain the policies and legislations related to polymeric waste management and their impact on environment
- Apply the 4 R's approach (reduce, reuse, recycle, recover) for solid waste management

SYLLABUS OF DSC-12

THEORY COMPONENT-

UNIT 1: (10 Hours)

INTRODUCTION TO WASTE MANAGEMENT

Introduction to the concept of life cycle analysis, four pillars of LCA, plastic wastes and litter, social and environmental challenges of plastic waste recycling in India, Main features of Plastic waste management regulations in India, sorting techniques and classification (density - float sink and froth floatation methods, selective dissolution, optical, spectroscopic, sorting by melting temperature, triboelectric separator etc.).

UNIT 2: (6 Hours)

CLASSIFICATION OF WASTE MANAGEMENT

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

UNIT 3: (4 Hours)

DISPOSAL AND WASTE TREATMENT TECHNIQUES

Controlled tipping, pulverization, composting, incinerators, pyrolysis, gasification, on-site disposal methods, compacting and baling

UNIT 4: (5 Hours)

THERMOPLASTIC RECYCLING

Recycling of polyolefins, PVC, PET, polystyrene, polyamides (nylon-6 and nylon-6, 6) etc.

UNIT 5: (5 Hours)

WASTE MANAGEMENT OF THERMOSET

Recycling of thermosets, reclaiming of rubber, tire retreading, uses of recycled rubber

PRACTICAL COMPONENT (60 Hours)

- Primary recycling of various waste collected from the environment.
- Secondary recycling of MSW by incorporating and blending the recyclable waste with virgin polymers.
- To study composting of natural/biopolymers.
- Separation of polymer mixture by sink flotation technique.
- Separation of polymer mixture by selective dissolution technique.
- To recover BHET from PET by chemical recycling process
- To recover adipic acid from nylon 66 by chemical recycling technique
- To study the effect of vulcanized rubber at varying ratio (in powder form) on mechanical properties of rubber vulcanizate
- To study the effect of vulcanized rubber at varying ratio (in powder form) on thermal properties of rubber vulcanizate
- To study the effect of vulcanized rubber at varying ratio (in powder form) on physical properties of vulcanized rubber

ESSENTIAL/RECOMMENDED READINGS

- Hawkins W. L., (1984) Polymer Degradation and Stabilization, SpringerLink.
- Reich L., Stivala S. S., (1971) Elements of Polymer Degradation, McGraw-Hill.
- Niti Aayog (2021), Undp Handbook on Sustainable Urban Plastic Waste Management
- Saha N. C., Garg M., Sadhu S. D., Ghosh A. K., (2022) Food Packaging-Materials, Techniques and Environmental Issues, Springer.
- Chandra R., Adab A., (2004) Rubber and Plastic Waste: Recycling, Reuse and Future Demand, CBS Publisher.
- NIIR Board of Consultant and Engineers, (2007) Medical, Municipal and Plastic Waste Management Handbook, National Institute of Industrial Research.
- Goodship V., (2007) Introduction to plastics recycling, Rapra.

SUGGESTIVE READINGS

- Maharana, T., Negi, Y. S., & Mohanty, B. (2007). Recycling of polystyrene. Polymer-Plastics Technology and Engineering, 46(7), 729-736.
- Caillol, S. (2014). Lifecycle assessment and green chemistry: a look at innovative tools for sustainable development. Environmental Impact of Polymers, 65-89.

- Klöpffer, W. (Ed.). (2014). Background and future prospects in life cycle assessment. Springer Science & Business Media.
- Dimitris, S., & Achilias, L. (2014). Recent advances in the chemical recycling of polymers (PP, PS, LDPE, HDPE, PVC, PC, Nylon, PMMA). Mater. Recycl. Trends Perspect, 3, 64.
- La Mantia, F. (2002). Handbook of plastics recycling. iSmithers Rapra Publishing.
- Braun, D. (2002). Recycling of PVC. Progress in polymer science, 27(10), 2171-2195.
- Scheirs J., (1998) Polymer Recycling, John Wiley & Sons.
- Blow S., (2000) Handbook of Rubber Technology, Hanser Gardner.
- Bandrup J.E., (1996) Recycling and Recovery of Plastics, Hanser Gardner.

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SEMESTER-V

BSc. (Hons.) Polymer Science

DISCIPLINE SPECIFIC CORE COURSE – 13

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
FIBRE SCIENCE	**4**	**2**	**0**	**2**	**Class 12th with Physics, Chemistry, Mathematics**	**-**

Learning objectives

- To study the basic concepts of natural and synthetic fibres
- To learn about the basic concepts of spinning including melt and solution spinning.
- To understand various parameters affecting spinning, drawing and heat setting of fibre structure and properties

Learning outcomes

After studying this paper, students will be able to

- Explain classification, structure and properties of natural and synthetic fibres
- Manufacture fibre with desired properties.
- Explain the various spinning variables

SYLLABUS OF DSC-13

UNIT 1: (4 Hours)

INTRODUCTION TO FIBRES

Introduction, classification, structural requirements of fibre forming polymers, general properties of fibres such as moisture absorption, fineness (tex, denier), tensile properties (elongation at break, elastic recovery, tenacity etc.)

UNIT 2: **(5 Hours)**

NATURAL FIBRES

Brief introduction to structure, properties and application of naturally occurring fibres: vegetable fibres, animal fibres and mineral fibres

UNIT 2: **(10 Hours)**

FIBER SPINNING PROCESSES

Melt spinning process: Spinning line, spinning manifold, spinning pack and manifold, cooling system, spinning variables, Force balance and heat balance in melt spinning; fibre structure development:

Solution spinning process: dry spinning (dope, spinning process, fibre cross section formation) wet spinning (solution preparation, coagulation, effect of process parameters on coagulation and structure of dry and wet spun fibres)

UNIT 3: **(12 Hours)**

SYNTHETIC FIBRES

Structure, properties and applications of synthetic fibres: viscose rayon, cellulose acetate, nylon 6, nylon – 66, polyester, acrylic, carbon fibre and aramid fibres

PRACTICAL COMPONENT **(60 Hours)**

(Students are required to minimum 6 experiments)

- To determine fineness (denier, tex and count) of given fibre, filaments and yarns.
- To study the cross-sectional view of natural and synthetic fibres and to identify them.
- To study the longitudinal view of natural and synthetic fibres and to identify them.
- To investigate moisture regain of fibres by absorption and desorption method.
- To identify fibres through elemental analysis.
- To identify the fibre through solubility tests.
- To analyze the reaction fibres to heat & flame.
- Analysis of chemical structure of fibres by FTIR and UV spectroscopy.
- To study thermal degradation of fibers through Thermo Gravimetric Analysis TGA method.
- To determine composition of fibres in blends.
- To measure electrical resistance of fibres.
- To measure static electricity a static charge in fibres

- To analyze microscopic properties of fibre.
- Quantitative analysis of cellulose/polyester blends.
- R & D Lab visit

ESSENTIAL/RECOMMENDED READINGS

- Cook J.G., (2009), Hand Book of Textile Fibres, Woodhead Publishing.
- Mishra S. P., (2000), A Text Book of Fibre Science and Technology, New Age International Publisher.
- Sperling L. H., (2013), Introduction to Physical Polymer Science, Wiley, 4th Edition
- Gupta V.B., Kothari V.K., (1997) Manufactured Fibre Technology, 1st Ed Chapman and Hall.
- Vaidya A.A., (1988) Production of Synthetic Fibres, First Edition, Prentice Hall of India.

SUGGESTIVE READINGS

- Morton W.E., Hearle J.W.S., (2008) Physical Properties of Fibres, Woodhead Publishing.
- David S. R., (2000) Structure Formation in Polymeric Fibres, First edition, Hanser Publishers.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 14

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
POLYMER CHARACTERIZATION	**4**	**2**	**0**	**2**	**Class 12th with Physics, Chemistry, Mathematics**	**-**

Learning objectives

- To acquaint the students with the instrumental techniques and their applications in characterization of polymers and polymeric materials
- To determine a chemical property and identify a chemical structure of a polymer.

Learning outcomes

After studying this paper, students will be able to

- Explain the basic principle and application of characterisation techniques.
- Interpret NMR, Raman, Mass and IR–Spectra for characterization of molecular structure of polymeric materials
- Elucidate stability of various polymers and their characterization on the basis of their thermal stability and glass transition temperature

SYLLABUS OF DSC-14

THEORY COMPONENT

UNIT 1: (4 Hours)

INTRODUCTION

Basic principle of spectroscopy, molecular, atomic and electronic spectra, Lambert-Beer's law, Frank-condon principle, electromagnetic radiation and it's properties, interaction of radiation with matter, statistical method of analysis.

UNIT 2: (5 Hours)

SPECTROSCOPIC TECHNIQUES

Principles and applications in structural determination of polymers (functional group, tacticity, molecular structure, purity, unsaturation etc.) by Infra-red spectroscopy, UV-Vis spectroscopy, electron spin resonance (ESR), raman spectroscopy, nuclear magnetic resonance spectrometer (^{1}HNMR).

UNIT 3: **(5 Hours)**

CHROMATOGRAPHY TECHNIQUES IN POLYMER

Paper chromatography, thin layer chromatography, high performance liquid chromatography, gel permeation chromatography (GPC), gas chromatography and size exclusion chromatography.

UNIT 4: **(6 Hours)**

MICROSCOPIC AND X-RAY TECHNIQUES

Optical microscopy, electron microscopy (SEM, TEM, AFM) and XRD: basics principle and applications in polymers characterization, Contact angle and measurement.

UNIT 5: **(6 Hours)**

THERMO-MECHANICAL CHARACTERIZATION

Principle and applications of Thermal gravimetric analysis (TGA), Differential thermal analysis (DTA). Differential scanning calorimeter (DSC), Dynamic mechanical analyser (DMA) and thermal mechanical analyser (TMA) in polymer analysis.

UNIT 6: **(4 Hours)**

MOLECULAR MASS AND MASS SPECTROSCOPY

Mass spectroscopy, Gas chromatography-mass spectrometer (GC-MS): principle and application for determination of molecular mass and chemical structure of polymers.

PRACTICAL COMPONENT **(60 Hours)**

- To verify Lambert-Beer's law by UV-Vis. spectrophotometer.
- Calculate weight percentage of inorganic and organic ingredient in polymeric compound.
- Analyze thermal behaviour of polymers by TGA.
- Quantitative determine of chemical impurities in polymer sample by UV-Vis. spectrophotometer.
- Contact angle and measurement of polymer

- Identification of additives present in a processed polymer by Paper and thin layer chromatography.
- Separation, characterization, and purity determination of polymers by TLC and Paper chromatography.
- Determination of size and particle distribution of additive in polymer sample by optical microscope.
- Determine the size and prepare size distribution curve by microscopy
- Visit of analytical laboratory.

ESSENTIAL/RECOMMENDED READINGS

- Willard H.H., Merrit L.L., Dean J.A. (1988) Instrumental method of analysis, Wads worth Publishing Company.
- Kaushik N.K., Shukla S. K., (2023) Thermal Analysis Techniques and Applications, IK International Pvt. Ltd.
- Skoog D.A, (1997) Principle of Instrumental Analysis, Harcourt College Pub.
- Shah V., (2007) Handbook of Plastic Testing, Technology, Wiley-Inter science.
- Banwell C.N., McCash E.M., (2008) Fundamentals of Molecular Spectroscopy, Fourth Edition, Tata McGraw-Hill.
- Muhammad Malik, Jimmy Mays, Muhammad Raza Shah, (2021) Molecular Characterization of Polymers: A Fundamental Guide, Elsevier.

SUGGESTIVE READINGS

- Tanaka T., (1999) Experimental Methods in Polymer Sciences, Academic Press.
- Silverstein R.M., (1991) Spectrometric identification of organic compounds, John Wiley.
- Macomber R.S., (2008) A complete introduction to NMR spectroscopy, Wiley-inter science.

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DISCIPLINE SPECIFIC CORE COURSE – 15

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
POLYMERS IN PACKAGING	**4**	**2**	**0**	**2**	**Class 12th with Physics, Chemistry, Mathematics**	**-**

Learning objectives

- To learn about the Packaging systems and role of Polymer in packaging
- To acquire knowledge of various types of polymers as packaging materials

Learning outcomes

After studying this paper, students will be able to

- Apprehend the basic concept of packaging and its utilization for desired applications
- Assess the quality of packaging material and packaged product
- Select the packaging material and can design a packaged product

SYLLABUS OF DSC-15

THEORY COMPONENT-

UNIT-1: **(10 Hours)**

PACKAGING SYSTEMS

Types of packaging systems: box, bottle, tetrapack, pouch, shrink, vacuum packaging, controlled atmospheric packaging (CAP), modified atmospheric packaging (MAP), aseptic packaging.

UNIT 2: **(10 Hours)**

POLYMERS IN PACKAGING

Importance of polymers in packaging. Property requirements of Polymers for packaging applications: Structure and process requirements for the required Properties and applications. Properties and applications: PE (LLDPE, LDPE, HDPE, HMHDPE), PP, BOPP PVC, nylons, polyester, polycarbonate, PS, EPS, PVA, Ionomers & Fluoro polymers.

UNIT 3: **(10 Hours)**

TESTING OF POLYMER PACKAGING MATERIAL

Bursting strength, tensile strength, tear strength, puncture test, impact test (drop, falling dart), barrier properties test (water vapour, oxygen), sealing strength., migration & compatibility.

PRACTICAL COMPONENT **(60 Hours)**

- Preparation of packaging films (PP/ HDPE/ LDPE/ LLDPE/PVA)
- To prepare polyester film and find its WVTR.
- Identification of packaging materials with the help of FT-IR, DSC, TGA etc.
- Preparation of laminate films by various methods (heat, solvent, adhesives)
- Determination of physico-mechanical properties (density, bursting strength, tensile strength, tear strength, puncture strength, impact strength etc) of packaging materials.
- Determination of water vapor transmission rate of packaging material.
- To determine the seal strength of packaging materials.
- To determine compatibility of packaging film with the packaged material.
- Industrial visit of packaging industry/plant

ESSENTIAL/RECOMMENDED READINGS

- Robertson G.L., (2012) Food Packaging – Principles and Practice, CRC Press Taylor and Francis Group.
- Paine F.A., Paine H.Y., (1992) A Handbook of Food Packaging, Blackie Academic and Professional
- Sharma S., Aggarwal M., Sharma D., (2019), Food Frontiers, New Delhi Publisher
- N. C. Saha, M. Garg, S. Dey Sadhu, A. K. Ghosh(2022) Food Packaging-Materials, Techniques and Environmental Issues" by published by Springer.
- Garg, M., Meena, P.L., Sadhu, S.D., Alam, T. (2019). Food Packaging: A Practical Guide : Viba Press Pvt. Ltd.

SUGGESTIVE READINGS

- Coles R., McDowell D., Kirwan M.J., (2003) Food Packaging Technology, Blackwell.
- Sukhareva L.A., Yakolev V.S., Legonkova O.A., (2008) Polymers for packaging and containers in the food industry, VSP.

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COMMON POOL OF DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)
COURSES OFFERED IN ODD SEMESTERS BY THE DEPARTMENTS

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-1)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
ADVANCED ANALYTICAL TECHNIQUES FOR POLYMERS	4	2	0	2	Class 12th with Physics, Chemistry	---

Learning objectives

The Learning Objectives of this course are as follows:

- To acquaint the students with the advancements in different characterisation techniques (spectroscopy, microscopy and separation), their principle, instrumentation, and applications in characterization of polymeric materials.
- Students will be able to determine a chemical structure, purity, property and functionality in polymer samples.

Learning outcomes

After studying this paper, students will be able to

- Interpret NMR, raman, mass and IR–spectra for characterization of molecular structure of polymeric materials
- Elucidate the morphology, size, homogeneity and distribution of various polymers and polymeric samples
- Acquire the knowledge about separation process of components from polymer mixture and samples.

SYLLABUS OF DSE-1

THEORY COMPONENT-

UNIT 1 (14 Hours)

SPECTROSCOPIC TECHNIQUES

Principles, instrumentation, and applications for structural determination of polymers (functional group, tacticity, molecular structure, purity, unsaturation etc.) using FT-IR, electron spin resonance, Raman, nuclear magnetic resonance (^{13}C NMR).

Mass Spectroscopy: Introduction, basic principles, instrumentation, fragmentation patterns, and interpretation of mass spectra and applications. Basis and application of MALDI-TOF, and ESI-MS in characterisation of different polymers including biopolymer for determination of molecular mass and structures (branching, and chain length).

UNIT 2 (8 Hours)

CHROMATOGRAPHY TECHNIQUES

Introduction to chromatographic methods: thin layer chromatography, column and gas chromatography. Principles, instrumentation and application of Gas liquid Chromatography, High performance liquid chromatography and gel permeation chromatography (GPC) including brief about column, detectors and stationary phases and their significance.

UNIT 3 (8 Hours)

MICROSCOPIC AND MISCELLANEOUS TECHNIQUES

Optical microscopy, electron microscopy (SEM, TEM, AFM) and XPS, XRD: principle, instrumentation and applications (Particle size by Scherrer formula, d-Spacing, Crystal parameter, morphology etc.) for polymers characterization. Different methods used for determination of molecular mass, Particle size analyser, and measurement and importance of zeta potential.

PRACTICAL COMPONENT (60 Hours)

- To identify the functional groups and components in various polymers (homo and co polymers) using FTIR.
- To determination of Reactivity ratio by FTIR.
- To determination of purity of monomers by spectrophotometer
- To determine the cross linking density of a polymer samples by FTIR.
- To analyse the Raman spectra of given polymers(demonstrative).
- Evaluate percentage crystallinity and size of polymeric samples by XRD curve.

- To separate and identify additives in a given polymeric sample by thin layer chromatography.
- To separate and identify the polymeric samples and mixture by TLC.
- To analyze film morphology (homogeneity, distribution and size) by optical microscope.
- To determine the size of polymer/additives particles by particle size analyzer.
- Visit to an analytical laboratory and submit a report.

ESSENTIAL/RECOMMENDED READINGS

- Willard H.H., Merritt L.L., Dean J.A. (1988) Instrumental method of analysis, Wads worth Publishing Company.
- Skoog D.A, (1997) Principle of Instrumental Analysis, Harcourt College Pub.
- Shah V., (2007) Handbook of Plastic Testing, Technology, Wiley-Inter science.
- Banwell C.N., McCash E.M., (2008) Fundamentals of Molecular Spectroscopy, Fourth Edition, Tata McGraw-Hill.
- Maus, A. (2008). Characterization and Analysis of Polymers, Wiley and Sons.
- Malik, A. Mays, J. Shah, M. R. (2021) Molecular Characterization of Polymers: A Fundamental Guide, Elsevier.

SUGGESTIVE READINGS

- Tanaka T., (1999) Experimental Methods in Polymer Sciences, Academic Press.
- Silverstein R.M., (1991) Spectrometric identification of organic compounds, John Wiley.
- Macomber R.S., (2008) A complete introduction to NMR spectroscopy, Wiley-inter science.

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DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-2)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical / Practice		
FIBRE MANUFACTURING TECHNOLOGY	**4**	**2**	**0**	**2**	**Class 12th with Physics, Chemistry**	**---**

Learning objectives

The Learning Objectives of this course are as follows:

- To learn about the basic concepts of spinning including melt and solution spinning.
- To understand various parameters affecting spinning, drawing and heat setting of fibre structure and properties

Learning outcomes

After studying this paper, students will be able to:

- Manufacture fibre with desired properties.
- Demonstrate the various spinning variables.

SYLLABUS OF DSE-2

THEORY COMPONENT-

UNIT 1 (6 Hours)

INTRODUCTION TO FIBRES

Manmade fibres: definition of man-made fibres, brief history of manmade fibres, relative merits and demerits of manmade and natural fibres

UNIT 2: (12 Hours)

MELT SPUN FIBRES

Melt spinning of PP, polyester and nylon-6 and nylon -66, Effect of parameters on structure development in nylon 6, PET, PP, post spinning operations (drawing, necking and heat setting), bulking/texturing

UNIT 3 (12 Hours)

SOLUTION SPUN FIBRES

Cellulose diacetate and triacetate fibres: Unit operations, dope preparation, dry-jet-wet-spinning

Acrylic fibres: Acrylonitrile polymerization (solution, emulsion and aqueous dispersion polymerization), Fibre manufacturing; polymer solubility and dope preparation, wet spinning (fibre extrusion and coagulation, structure of coagulated fibre, tow processing), dry-jet-wet-spinning

Rayon fibres: Viscose rayon process (chemistry and spinning), overview of alternatives to viscose process

Gel spinning of PE, PAN and PVA

PRACTICAL COMPONENT (60 Hours)

- To prepare polypropylene fibre by melt spinning.
- Study of preparation, melt spinning and properties of any one specialized melt spun fibre.
- Melt spinning and cold drawing of nylon 6 using laboratory spinning and drawing machines
- To prepare polyester fibre by melt spinning.
- Solution spinning of acrylic fibre.
- Dry-jet-wet spinning of PAN fibre.
- To characterize a woven fabric with respect to its dimensional properties: thread density, yarn number, yarn crimp, weave, cover factor, areal density, skewness, thickness
- To determine the crease recovery of fabric and observe the effect of loading time and recovery time on crease recovery.
- Drawing and heat setting of fibres.
- Chemical modification of fibres.
- Visit of Industry/R&D organization

ESSENTIAL/RECOMMENDED READINGS

- Gupta V.B., Kothari V.K., (1997) Manufactured Fibre Technology, 1st Ed Chapman and Hall.
- NPTEL course material on Manufactured fibre Technology.

- Macintyre J.E., (2005) Synthetic Fibres: Nylon, Polyester, Acrylic, Polyolefin, Elsevier Science.
- Vaidya A.A., (1988) Production of Synthetic Fibres, First Edition, Prentice Hall of India.

SUGGESTIVE READINGS

- Vaidya A.A., (1988) Production of Synthetic Fibres, First Edition, Prentice Hall of India.
- Kothari V.K., (2000), Textile Fibres: Developments and Innovations, IAFL Publications.
- Nakajima T., (2000) Advanced Fiber Spinning Technology, First Edition, Woodhead Publisher.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-3)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
TYRE TECHNOLOGY	4	2	0	2	Class 12th with Physics, Chemistry	---

Learning objectives

The Learning Objectives of this course are as follows:

- Familiarizing various types of tyres and their components.
- Developing the knowledge of manufacturing techniques of various tyres.

Learning outcomes

The Learning Outcomes of this course are as follows:

After studying this paper, students will be able to

- Apply the knowledge of basic concept of manufacturing technology of tyre
- Demonstrate the designing and compounding of various tyre components.
- Evaluate performance and quality assessment of tyre.

SYLLABUS OF DSE-3

THEORY COMPONENT-

UNIT 1 (8 Hours)

INTRODUCTION AND TYRE MANUFACTURING

Classification: based on construction (pneumatic, radial, bias, cross ply, tube, tubeless, solid), Types of tyre on their uses: Cycle tyre, Car tyre, Light truck tyre, truck tyre, aeroplane tyre, earthmoving machinery tyre, Animal drone vehicles tyre etc. Tyre Components: Tread, sidewall, Bede, Apex, Solder, Inner Liner etc. Mixing (Mixing instruments: two roll mill, kneader, internal mixers), processing (extrusion, calendaring, bead winding), building drum, curing (molding machines etc.)

UNIT 2 (12 Hours)

TYRE DESIGN

Compound design (selection of chemical ingredients); process design (process parameters correlating with properties); product design (constructions), latest advances in materials and technologies

UNIT 3 (10 Hours)

TYRE TESTING

Endurance, groove crack test, plunger test, traction: dry, wet and snow, air permeation, noise test, rolling resistance, drivability, road test, wet braking test, fuel economy test, tread to ply pull out, bead seating test

PRACTICAL COMPONENT (60 Hours)

- To identify the type of rubber by reverse engineering.
- To prepare fabric- rubber coated ply.
- To test mechanical and physical properties of vulcanized rubber.
- To perform air aging properties of rubber and rubber to fabric ply.
- To determine bonding strength of rubber to fabric.

- To calculate abrasion losses of tyre tread.
- To calculate rebound resilience of a rubber.
- Tyre indexing and cut section analysis.
- To evaluate the compression set of a rubber.
- To determine rolling resistance test.
- Industrial Visit of Tyre Industry/ R&D

ESSENTIAL/RECOMMENDED READINGS

- Koutny F., Zling, (2007) Geometry and Mechanics of Pneumatic TIRE, CZE.
- French T., (1989) Tyre Technology, Adam Hilger, New York.
- Mark J.E., Erman B., Eirich F.R., (2005) The Science and Technology of Rubber, Elsevier.

SUGGESTIVE READINGS

- Ford T.L., Charles F.S., (1988) Heavy Duty Truck TIRE Engineering SAE's 34th L. Ray Buckingdale Lecture, SP729.
- Clark S.K., (1971) Mechanics of Pneumatic Tires, National Bureau of Standards, Monograph, US Govt. printing office.
- Gent A.N., Walter J.D., (2006) The Pneumatic TIRE, U.S. Department of Transportation, National Highway Traffic Safety Administration.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-4)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
POLYMER PRODUCT DESIGN	**4**	**2**	**0**	**2**	**Class 12th with Physics, Chemistry**	**---**

Learning objectives

The Learning Objectives of this course are as follows:

- To understand physical properties of polymers required for product design
- To learn about plastic parts such as static and dynamic loaded parts for electrical, optical and mechanical applications (gears, bearings, pipes, seals, couplings and vibration dampers)

Learning outcomes

After studying this paper, students will be able to

- Explain the terminology involved in product design
- Distinguish the moulded hole, insert and undercut
- Describe the processing limitation of product design and stress analysis for product
- Demonstrate the plastic products for load bearing applications
- To do cost estimation of a polymeric product

SYLLABUS OF DSE-4

THEORY COMPONENT-

UNIT-1 **(7 Hours)**

INTRODUCTION TO PRODUCT DEVELOPMENT

Introduction, challenges in development process, distinguishing features in polymer products, polymer product classification, Selection of the right product, Generic development process, Criteria for a successful product process flow chart, identifying customer need and its analysis, Material data bank, comparative analysis, Criterion for material selection, types of polymers and their characteristics

UNIT 2 **(7 Hours)**

STRUCTURAL DESIGN AND DYNAMIC LOADING ON PLASTIC PARTS

Structure and physical properties of polymers, Dynamic load response of polymers, effects of cyclic loading, other forms of stress applied to polymer parts, design for stiffness, stress analysis of polymers, structural design

UNIT 3 **(10 Hours)**

DESIGN PROCEDURE FOR PLASTIC PARTS

Design procedure for plastic parts- Tolerance-Moulded holes-threads-radius- moulded hinges, integral hinge-snap fits Design of plastic structural parts for static loads, design of dynamically

loaded plastic parts, design of plastic parts for electrical applications, design of plastic parts for optical applications.

UNIT 4 **(6 Hours)**

ESTIMATING, COSTING AND ELEMENTS OF COST

Cost estimation, importance of estimation, Costing, importance of costing, Difference between costing and estimation, Importance of realistic estimates, Estimation procedure, Elements of cost, Material Cost, Determination of Material cost, Labour cost, Determination of Labour Cost, Expenses , Cost of Product (Ladder of cost) , Illustrative examples.

PRACTICAL COMPONENT **(60 Hours)**

- Design requirement of Gear: materials, Bearings: Self lubricated plastic materials rubber bearing,
- Design of PVC piping: Raw materials, pipe design, specification and test procedure, manufacturing process
- Product, material, and Process requirement of Car bumper
- Application of reverse engineering in Rubber product design
- To prepare open and closed cell foam.
- To prepare rubber - metal composite products
- To determine mechanical properties of designed products

ESSENTIAL/RECOMMENDED READINGS

- Ulrich, T. K. T. and Eppinger, D.S. (2004), Product design and development, Tata McGraw-Hill, 3rd edition.
- Mahajan, M. (2008) Industrial Engineering and Production Management, Dhanpat Rai Publication.
- Mollay, A.R. (1994) Plastic Part Design for Injection Moulding, Hanser Publishers, Munich Vienna, New York.

SUGGESTIVE READINGS

- Hollins, B. Pugh, S. (1990) Successful product design, Butterworth & Co.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-5)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
POLYMERS IN BIOMEDICAL APPLICATIONS	4	2	0	2	Class 12th with Physics, Chemistry	---

Learning objectives

The Learning Objectives of this course are as follows:

- To acquire knowledge of biocompatibility and biodegradation
- To learn about applications and testing of bio-compatible polymer in tissue engineering

Learning outcomes

After studying this paper, students will be able to

- Explain the basic concepts and requirement of biomedical applications and biocompatibility
- Apply the knowledge of various polymers in biomedical application

SYLLABUS OF DSE-5

THEORY COMPONENT-

UNIT 1 (8 Hours)

BASICS OF BIOMATERIALS

Important features for Biomedical Application: responsiveness, estimations of biodegradation and biocompatibility.

Types of Polymers in Biomedical applications and their Importance, hydrogel, fibres, bio-ceramics, bio-elastomers and membrane

UNIT 2 (10 Hours)

POLYMERS IN BIOMEDICAL APPLICATION

Permanent implants for function-orthopaedics (Internal and External artificial organ), cardio vascular, respiratory patches and tubes, digestive system, genitourinary system, nervous system, orbital (corneal and lens prosthesis)–permanent implant for cosmoses, other applications of engineered material in clinical practices, silicone implants. polymer membranes, polymer skin, polymeric blood

UNIT 3 **(12 Hours)**

MISCELLANEOUS APPLICATIONS (DENTAL, LENSES, DRUG DELIVERY AND TISSUE ENGINEERING)

Contact Lenses, Hard Lenses, Gas Permeable Lenses, Flexible Lenses, Soft Lenses, Hydrogels, Equilibrium Swelling, Absorption And Desorption, Oxygen Permeability, Types of Soft Lenses, Manufacture, Cleaning And Disinfection.

Dental applications, denture bases, crown and bridge resins, plastic teeth, mouth protectors, maxillofacial prosthetic materials, restorative material, polyelectrolyte based restoratives, sealants, adhesives, dental impression and duplicating materials, agar, algmater elastomers.

Introduction to drug delivery, polymers in controlled drug delivery, dressing strips, polymer drug vessels, core shell and nanogels, tissue engineering, uses of cellulose, chitosan and alginate

PRACTICAL COMPONENT **(60 Hours)**

- Evaluate the biocompatibility of polymeric samples.
- Determination of the degradation behavior of polymers such as thermal, hydrolytic etc.
- Preparation of membranes and measurement of their absorption behavior.
- Preparation and characterization of dental cement.
- Prepare a hydrogel and characterization.
- Prepare jaw by powdered silicone rubber
- To find out biocompatibility of polymer products by enigmatic test
- Determination of mechanical strength of polymers.
- To find out hydro degradation of artificial bone.
- To prepare porous membranes.

ESSENTIAL/RECOMMENDED READINGS

- Park, J. B. (2003) Bio-materials, An Introduction, CRC Press.

- Tiwari A., Tiwari A., (2013) Nanomaterials in drug delivery, Imaging and Tissue Engineering, Wiley.
- Pilla S., (2011) Handbook of Bioplastics and Biocomposites Engineering Applications, Wiley.

SUGGESTIVE READINGS

- Ratner B.D., Hoffman A.S., (1996) An Introduction to Materials in Medicine, Academic Press.
- Saltzman W.M., (2001) Drug delivery: Engineering principles for drug therapy, Oxford University Press.
- Kalia S., Averous L., (2011) Biopolymers: Biomedical and Environmental Applications, John Wiley & Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-6)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
CONDUCTING POLYMERS	4	2	0	2	Class 12th with Physics, Chemistry	---

Learning objectives

The Learning Objectives of this course are as follows:

- To impart knowledge of structure and electrical properties of conducting polymers.
- To learn about applications of conducting polymers.

Learning outcomes

The Learning Outcomes of this course are as follows:

After studying this paper, students will be able to

- Perform the synthesis and doping in conducting polymers.
- Analyze and demonstrate the properties of conducting polymers

SYLLABUS OF DSE-6

THEORY COMPONENT-

UNIT 1 (8 Hours)

BASIC ASPECTS OF CONDUCTING POLYMERS

Historical background, band structure, band alignment, conduction mechanism, theory of electrical conduction in conducting polymers

UNIT 2 (10 Hours)

SYNTHESIS OF CONDUCTING POLYMERS

Chemical, electrochemical and mechanical synthesis of polyaniline, polypyrrole, polythiophene. Doping and its effects on properties of conducting polymers

UNIT 3 (12 Hours)

PROPERTIES & APPLICATIONS OF CONDUCTING POLYMERS

Electrical properties, resistance, impedance, capacitance, magnetic properties and optical properties of different conducting polymers. Applications of conducting polymers in electronic devices, sensors, rechargeable batteries, solar cells, light emitting devices, biomedical devices, organ transplant, artificial mussels and EMI shielding etc.

PRACTICAL COMPONENT (60 Hours)

- Synthesis of polyaniline, polypyrrole and polythiophene by chemical polymerizations.
- Synthesis of conducting polymers by electro chemical polymerizations.
- To improve electrical conductivity of PANI by chemical doping.
- Evaluation of mechanical properties of conducting polymer films/sheets.
- Determination of the thermal properties of conducting polymers.
- To prepare a molded sheet of conducting polymers.
- To manufacture molded conducting device
- To study the effect of doping of Polypyrrole

- To measure the electrical conductivity and resistivity of conducting polymer films/sheets.
- To design and demonstrate the conducting polymer based devices i.e light emitting devices, chemical sensor and solar cell.

ESSENTIAL/RECOMMENDED READINGS

- Chandrasekhar P., (1999) Conducting Polymers, fundamentals and applications: A practical approach, Springer.
- Nalwa H.S., (1997) Handbook of Organic Conductive Molecules and Polymers: Conductive polymers: synthesis and electrical properties, Vol. 2, Wiley.
- Skotheim T.A., Elsenbaumer R.L., Reynolds J.R., (2007) Handbook of Conducting Polymers, CRC Press.
- Batrinescu, G., Constantin, L. A., Cuciureanu, A., & Constantin, M. A. (2016). Conductive polymer-based membranes. Conducting Polymers.
- Fernandez O.T., (2015) Conducting Polymers, Royal Society of Chemistry.
- Almeida L.C., (2013) Conducting Polymers: Synthesis, Properties & Applications, Nova Publishers.
- Gupta, R. K. (Ed.). (2022). Conducting Polymers: Chemistries, Properties and Biomedical Applications. CRC Press.

SUGGESTIVE READINGS

- Dyson, R. W., (1982) Speciality polymers Chapman and Hall publications.
- Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.
- Sołoducho, J., & Cabaj, J. (2016). Conducting polymers in sensor design. Conducting Polymers. Rijeka: Intech, 27-48.
- Otero, T. F. (2016). Conducting Polymers: Bioinspired Intelligent Materials and Devices. Royal Society of Chemistry.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-7)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical / Practice		
BIO-BASED AND BIODEGRADABLE POLYMERS	**4**	**2**	**0**	**2**	**Class 12th with Physics, Chemistry**	**---**

Learning objectives

The Learning Objectives of this course are as follows:

- To gain knowledge of biopolymers and their isolations
- To acquire knowledge on structure and properties of biopolymers
- To understand the basic applications of various biopolymers

Learning outcomes

After studying this paper, students will be able to:

- Explain the applications of bio-based and biodegradable polymers
- Distinguish and analyse biopolymers
- Evaluate the strength and properties of polymers

SYLLABUS OF DSE-7

THEORY COMPONENT-

UNIT 1 (12 Hours)

BASICS TO BIOPOLYMERS & NATURAL MACROMOLECULES

Introduction to the concept of Bio Based Polymers and Biodegradable Polymer. Significance, classifications, properties and applications of biopolymers and natural polymers such as Starch, cellulose, chitosan, gelatine, protein, fatty acids, lipids, aliphatic polyesters (PLA, PHB), cellulose

UNIT 2 (8 Hours)

PROCESSING

Isolation, processing of biopolymers: composite formation, blending and solvent casting

UNIT 3 (10 Hours)

APPLICATIONS

Applications of biopolymers in packaging, biomedical testing and devices, agriculture: soil conditioning and micro-nutrient delivery

PRACTICAL COMPONENT (60 Hours)

- To determine the molecular weight of biopolymers.
- Isolation of starch from wheat/rice/potato
- Isolation of gelatin from natural resources.
- To prepare Poly(lactic acid).
- To prepare a chitosan based composite for biomedical applications.
- To prepare blends of natural polymers and find out miscibility
- Develop a biodegradable film by solution casting of biopolymers.
- Estimate the biodegradability by soil burial test.
- Evaluate swelling index, porosity, hardness of a film.
- Estimate the water vapor transmission rate of a biopolymeric film.

ESSENTIAL/RECOMMENDED READINGS

- Byrom D., (1991) Biomaterials: Novel Materials from Biological Sources, First Edition, Macmillan Publishers Ltd.
- Bastioli C., (1987) HandBook of Biodegradable polymers, Rapra Technology.
- Niaounakis M., (2015) Biopolymers: Processing and Products, First Edition, Elsevier Inc.

SUGGESTIVE READINGS

- Johnson R.M., Mwaikambo L.Y., Tucker N., (2003) Biopolymers, Rapra Technology.
- Pilla S., (2011) Hand Book of Bioplastics & Biocomposites for Engineering Applications, Wiley.
- Alexander S., (2003) Biopolymers, Vol. 1, Wiley.

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DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-8)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
ENGINEERING DRAWING & MOLD DESIGN	4	3	0	1	Class 12th with Physics, Chemistry	---

Learning objectives

- To understand the various planes of work pieces
- To learn about the various mold and their components
- To acquaint with the concepts of mold & die design and their key features

Learning outcomes

The Learning Objectives of this course are as follows:

After studying this paper, students will be able to

- Explain about the graphics design
- Apply design features in structure of injection molds
- Apply design features in structure of extrusion dies

SYLLABUS OF DSE-8

THEORY COMPONENT-

UNIT 1 (18 Hours)

INTRODUCTION & PROJECTIONS OF PLANES, POLYHEDRA SOLIDS AND SOLIDS OF REVOLUTION

Introduction of Drawing instruments, sheet layouts lines, lettering and Dimensioning scales, various types of projections, First and Third angle systems of orthographic projections. Projection of Points in different quadrants: parallel to one reference plane, inclined to one plane but perpendicular to the other, inclined to both reference planes. Projections of Polyhedra Solids and Solids of Revolution – in simple positions with axis perpendicular to a plane, with

axis parallel to both planes, with axis parallel to one plane and inclined to the other, Projections of sections of Prisms, Pyramids, Cylinders and Cones.

UNIT 2: (12 Hours)

MOLD DESIGNING AND MAKING

Materials selection for mold and die, mold making processes: casting, electro deposition, cold hobbing, pressure casting, spark machining. Tool room machines and their application: CNC machines-CNC EDM-CNC, Milling- CNC. Basis structure and feed system of mould: core, cavity, runner, gates, bolster, and cooling unit.

UNIT 3: (15 Hours)

EJECTION SYSTEM & UNDER CUTS

Ejector grid, ejector plate assembly, ejection techniques, ejection from fixed half and sprue pullers, Form pin, split cores, side cores, stripping internal undercuts, molds for threaded components. Daylight molds–general, undercut, formin, double & triple daylight mold

PRACTICAL COMPONENT (30 Hours)

- Lines, lettering & Dimension (Sketch Book): Scale-representative Fraction, Plan scale, Diagonal Scale, Vernier scales (In sheet), comparative Scale, & scale of chords (Sketch Book)
- Geometric conception, caners used in drawing practice. Conic Section: Construction of Ellipse, Parabola & Hyperbola by different methods (In sheet)
- Construction of cycloid, Epicycloids, Hypocycloid and Involutes (In sheet) Archimedean and Logarithmic spiral, (Sketch book)
- Type Projection, Orthographic Projection: First Angle and third Angle Projection (Sketch Book)
- Projection of Straight lines, different position of straight lines, methods for determining True length, true inclinations and Traces of straight lines (Four problems in sheet and three problems in Sketch Book)
- Projection of Planes: Different positions of Plane lamina like.: - Regular polygon, circle three of planes (Four problems in Drawing sheet and three problems in Sketch Book).
- Demonstration software used in mold and die design (Auto CAD, solid works, etc.)

- To design and validate well labelled mold from clay/POP/resin and prepare plastic products.
- Demonstration of Lathe, milling, CNC and wire cutting machine
- Tool room/industrial visit

ESSENTIAL/RECOMMENDED READINGS

- Engineering Drawing, Basant Agarwal & CM Agrawal, Tata McGraw Hill.
- Engineering Drawing Geometrical Drawing, P.S. Gill, S.K. Katara & Sons.
- Engineering Drawing, Dhanarajay A Jolhe, Tata McGraw Hill.
- Pye R.G.W., (2000) Injection mould design, Affiliated East West Press Pvt. Ltd.
- Strong A.B., (2005) Plastics: Materials & Processing, Prentice Hall.
- Rosato D.V., Rosato D.V., (2000) Injection Moulding Handbook, CBS Publisher.

SUGGESTIVE READINGS

- Engineering Drawing, N.D. Bhatt, Charotar Publishing House Pvt. Ltd.
- Morton-Jones D.H., (2007) Polymer Processing, Chapman & Hall.
- Crawford R.J., (1998) Plastic Engg, Butterworth-Heinemann.
- Rees H., (1995) Mould Engineering, Hanser Publisher.

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DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-9)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
POLYMER PHYSICS	**4**	**2**	**0**	**2**	**Class 12th with Physics, Chemistry**	**---**

Learning objectives

- To learn about the conformations of polymer chains.
- To understand the morphology of crystalline and amorphous polymers.

Learning outcomes

After studying this paper, students will be able to

- Apply concepts of polymer physics.
- Classify polymers on the basis of physical properties.
- Determine crystal structure of polymers.

SYLLABUS OF DSE-9

THEORY COMPONENT-

UNIT 1 (12 Hours)

FUNDAMENTALS OF POLYMER PHYSICS

Potential energy and conformational energy of molecules, conformations and configurations, tacticity, isomeric states and isomerism in polymers, stereoisomerism, geometric isomerism, Random coils and average end to end distance, more realistic chains, excluded-volume effect, chain flexibility and the persistence length.

UNIT 2 (10 Hours)

REGULAR CHAINS AND CRYSTALLINITY

Regular and irregular chains, Polymers with 'automatic' regularity, Polydienes, Helical molecules, Determination of crystal structures by X-ray diffraction, Crystal structures of some common polymers (PE, PP, PET, Nylons, PVC)

UNIT 3 (8 Hours)

MORPHOLOGY AND MOTION

Introduction, degree of crystallinity, Experimental determination of crystallinity. Crystallites: fringed-micelle model, Chain-folded crystallites, Extended-chain crystallites, Non-crystalline regions and polymer macro-conformations:, Lamellar stacks, Spherulites and other polycrystalline structures, Concept of chain orientation, orientation in amorphous and crystalline polymers, Uniaxial and biaxial orientation practical significance, Optical microscopy of spherulites, Light scattering by spherulites.

PRACTICAL COMPONENT (60 Hours)

- To determine density of fibres by Density Gradient Column.
- To develop and study the growth of PP spherulites in different crystallization conditions.
- To study the morphology of the given fibre sample by Infrared spectroscopy.
- Interpretation crystallization and isothermal crystallization of polymers by DSC thermogram
- To determine crystallinity and orientation in polymers by XRD
- To determine the d-spacing in a given polymer sample by XRD.
- Morphological study of polymers by optical microscopy and interpretation of optical micrograph.
- Interpretation of molecular weight distribution curve/chromatogram
- To study Tyndall effect in polymer solution.
- To study the effect of crystallinity on mechanical properties of fibres.
- R&D Lab Visits

ESSENTIAL/RECOMMENDED READINGS

- Sperling L.H., (1993) Introduction to Physical Polymer Sciences, J. Wiley N.Y.
- Crompton R.T., (1989) Molecular Motions in High Polymers, Pergamon Press N.Y.
- Hiemenz, P. C., & Lodge, T. P. (2007). Polymer chemistry. CRC press.

SUGGESTIVE READINGS

- Crompton T.R., (1989) Analysis of Polymers, Pergamon Press N.Y.
- Ward I.M., (1979)Mechanical Properties Of High Polymers, John Wiley.

Note: **Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-10)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
MATERIAL SCIENCE	4	3	0	1	Class 12th with Physics, Chemistry	---

Learning objectives

- To introduce the fundamentals of material science especially dielectric materials, semiconducting materials and nanomaterials
- To impart knowledge of different types of materials, their properties and applications

Learning outcomes

After studying this paper, students will be able to

- Explain the structure, function, properties of various materials
- Apply the knowledge of smart materials for desired applications

SYLLABUS OF DSE-10

THEORY COMPONENT-

UNIT 1: (15 Hours)

BASICS OF MATERIALS STRUCTURE

Amorphous and crystalline structure, 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, single and polycrystalline materials, imperfections in crystalline solids magnetism, intrinsic and extrinsic semiconductors, dielectric properties, absorption and transmission of electromagnetic radiation.

UNIT 2: **(15 Hours)**

ADVANCED MATERIALS

Ferroelectric, piezoelectric, optoelectronic, semiconducting behaviour, lasers and optical fibres, photoconductivity and superconductivity, nanomaterials (synthesis, properties and applications), biomaterials, shape memory alloys, Ceramics: structure, properties, processing and applications of traditional and advanced ceramics.

UNIT 3: **(15 Hours)**

METALS AND ALLOYS

Solid solutions, solubility limit, intermediate phases, intermetallic compounds, iron-iron carbide phase diagram, heat treatment of steels, cold, hot working of metals, recovery, recrystallization and grain growth. Microstructure, properties and applications of ferrous, non-ferrous alloys and polymer alloy

PRACTICAL COMPONENT **(30 Hours)**

- To check the hardness of composite materials by rockwell hardness tester.
- To determine % composition of metals, fillers etc.
- Thermogravimetric analysis of different Polymers (Using TGA)
- Determination of degradation profile and filler content of a polymer (using TGA).
- Study of mechanical stress v/s strain behavior of a polymer (tensile and flexural)
- Determination of impact strength of a polymer by izod method.
- Determination of impact strength of a polymer by charpy method.
- To determine magnetic properties of materials.
- To determine mechanical properties (strength, modulus) of materials.
- Preparation of advanced polymer composite material for different applications (packaging and biomedical).
- To prepare safety glass and evaluate its properties.

ESSENTIAL/RECOMMENDED READINGS

- Shackelford J.F., (2010) Materials Science And Engineering Handbook, Third Edition CRC Press.
- Mittemeijer E.J., (2011) Fundamentals of Materials Science: The Microstructure–Property Relationship Using Metals as Model Systems, Springer.
- Sedha R.S., Khurmi R.S., (2004) Materials Science, S. Chand.

SUGGESTIVE READINGS

- Kakani S.L., Kakani A., (2006) Material Science, New Age International.
- Yao J., Zhou Z., Zhou H., (2019) Highway Engineering Composite Material and its Application, Springer.

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DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-11)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
SMART MATERIALS	4	3	0	1	Class 12th with Physics, Chemistry	---

Learning objectives

- Overview of smart materials, Piezoelectric Ceramics, Piezo-polymers, Magnetostrictive Materials, Electroactive Polymers, Shape Memory polymers.
- To learn the fundamentals of electro and magneto rheological fluids, thermally responsive polymers, modelling of smart materials, introduction to composite smart materials and smart hydrogels.

Learning outcomes

After studying this paper, students will be able to

- Explain polymer based smart materials
- Demonstrate applications of smart materials.

SYLLABUS OF DSE-11

THEORY COMPONENT-

UNIT 1: (15 Hours)

INTRODUCTION

Smart materials and structures: components and classification of smart structures, single crystals vs polycrystalline systems, common smart materials and associated stimulus-response, application areas of smart systems, piezoelectric materials- piezoelectric effect, parameter definitions, piezoceramics, piezopolymers, piezoelectric materials as sensors, actuators and bimorphs.

UNIT 2: (15 Hours)

SMART POLYMERS

Thermally responsive polymers, electroactive polymers microgels (synthesis, properties and applications), protein-based smart polymers, ph-responsive and photo-responsive polymers, self-assembly, molecular imprinting using smart polymers, approaches to molecular imprinting, drug delivery using smart polymers

UNIT 3: (15 Hours)

SMART HYDROGELS

Synthesis, fast responsive hydrogels, molecular recognition, smart hydrogels as actuators, controlled drug release, artificial muscles, hydrogels in microfluidics. smart systems for space applications: elastic memory composites, smart corrosion protection coatings, self-healing materials, sensors, actuators, transducers, deployment devices, molecular machines.

PRACTICAL COMPONENT (30 Hours)

- To determine the elastic properties of polymers.
- To determine % swelling of a hydrogel.
- To determine the sensing power of a sensor.
- To prepare corrosion resistance coatings.
- To test the corrosion inhibition of materials.
- To prepare electroactive microgel.
- To prepare polymer for artificial muscles and study its behaviour with pH change.
- To determine the flexural strength of epoxy/ polyester composite.
- To synthesise and test water absorption behaviour of hydrogel.
- To prepare a polymer based photo sensor.

ESSENTIAL/RECOMMENDED READINGS

- Leo D.J., (2007) Engineering Analysis of Smart Material Systems, Wiley.
- Addington M., Schodek D.L., (2005) Smart Materials and New Technologies in Architecture, Elsevier.
- Otsuka K., Wayman (Eds.) C.M., (1998) Shape Memory Materials, Cambridge University Press.
- Gandhi, M.V., Thompson B. S., (1992) Smart Materials and Structures, Chapman & Hall.
- Schwartz, M., (2006) New Materials, Processes, and Methods Technology, CRC Press.

SUGGESTIVE READINGS

- Ball, P., (1997) Made to Measure: Materials for the 21st Century, Princeton University Press.
- Galaev, I., Mattiasson, B., (Eds.), (2008) Smart Polymers: Applications in Biotechnology and Biomedicine, 2nd ed, CRC Press.
- Yui, N., Mrsny, R. J., Park, hK., (Eds.), (2004) Reflexive Polymers and Hydrogels: Understanding and Designing Fast Responsive Polymeric Systems, CRC Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-12)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
AUTOMOBILE APPLICATIONS OF POLYMERS	**4**	**3**	**0**	**1**	**Class 12th with Physics, Chemistry**	**---**

Learning objectives

- To know various sources of materials used in automobiles.

- To learn about polymeric materials significance in automobiles structural and mechanical components.
- To study about rubber components used in automobiles.

Learning outcomes

After completing this course, the students

- Explain the knowledge about requirements of automobile industry.
- Apply the polymeric (plastic) components in automobile interior and exterior parts.
- Determine the rubber components used in automobile parts.

SYLLABUS OF DSE-12

THEORY COMPONENT-

UNIT 1: **(8 Hours)**

INTRODUCTION TO AUTOMOTIVE COMPONENTS AND MATERIALS

History of automobile industry, need for polymers, advantages and limitations of polymers, competition between plastics, composites and other materials, processing, designing with plastics, selection criteria of material.

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UNIT 2: **(10 Hours)**

POLYMERS IN THE INTERIOR OF THE VEHICLE

Interiors, dominance of polymeric components, Fashion and function, Plastics surfaces (Texture and fogging), Plastic structure and panel application (Sandwich concept, Instrumental panel, other sensitive panels), Structural and mechanical components (Seating, Door and window furniture, steering wheel, airbags, seat belts, pedals, instrumental and others).

UNIT 3: **(10 Hours)**

POLYMERS IN THE EXTERIOR OF THE VEHICLE

Exteriors: Body panels and structure – Painting problems – Bumpers – Other exteriors: Grills, Spoilers, Mirrors, Door handles, Wheel trim, Road wheels, Sun roof components, Windscreen wiper assemblies.

UNIT 4: **(10 Hours)**

ENGINE, POWERTRAIN AND CHASSIS

The engine compartment, cooling system, under bonnet structure, transmission, engine hang on parts, engine interior, composite engine, suspension, steering, brakes, fuel tanks, electrics: battery boxes, circuitry, lighting and instrumentation, electronics.

UNIT 5: (7 Hours)

RUBBER PRODUCTS

Rubber mounts, spring, seals, O-ring, rubber to metal bonding components, coupling hoses, brake lining, disc brakes.

PRACTICAL COMPONENT (30 Hours)

- To prepare EPDM profile for windshield and door seal.
- To prepare bumper material and test its impact strength.
- To prepare O'Rings/gaskets material for sealing applications
- To manufacture automobile carpet/leather and test its mechanical and physical properties.
- To prepare laminated material for radiator pipe
- To manufacture carbon fibre-epoxy composite for high strength applications
- To prepare plastic joint and test its strength.
- To find out scratch resistance of a coated automobile part.
- To prepare composite for railway breaker
- To analyze flexural strength of jumping rod.
- Industrial Visit

ESSENTIAL/RECOMMENDED READINGS

- Maxwell, J,. (1994) “Plastics in the Automotive Industry”, SAE internationals, Woodhead Publication, England.
- Mann, D., (1999) “Automotive Plastics and Composites Worldwide Markets and Trends” to 2007, 2nd Edition , Elsevier advanced technology.
- Ashby, M. F., Shercliff, H., Cubon, D., (2007) “Materials Engineering Science, Processing and Design”, Butterworth Publications.
- Brian, C., Patrick, G., and Colin J., (2007) Automotive Engineering: Light Weight, Functional and Novel Materials, Taylor & Francis.

- Groover, M. P., (2005) Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 2nd edition, John Wiley & Sons.
- Stauber, R., Vollrath, L. (2007) Plastics in Automotive Engineering: Exterior Applications, Hanser publications.
- Marur, S., (2011) Plastics Application Technology for Safe and Lightweight Automobiles.

SUGGESTIVE READINGS

- Callister, W. D., (2005) Materials Science and Engineering an Introduction, 6th edition, John Wiley & Sons.
- Yamagata, H., (2005) The Science and Technology of Materials in Automotive Engines, Yamaha Motor Co. Ltd., Japan Woodhead Publishing Limited.
- Davies, G., (2003) Materials for Automobile Bodies, Butterworth-Heinemann Publications.
- Koronis, G. Silva, A., (2018) Green Composites for Automotive Applications, Woodhead Publishing Series in Composites Science and Engineering.
- Sehanobish, K., (2009)"Engineering Plastics and Plastic composites in Automotive Applications", SAE internationals, Warrendale.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-13)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
POLYMERS IN ENERGY APPLICATION	4	2	0	2	Class 12th with Physics, Chemistry	---

Learning objectives

The Learning Objectives of this course are to:

- Make students familiar with use of advanced polymers for energy applications
- Learn about the manufacturing of fuel cells

- Understand polymer properties related to energy components

Learning outcomes

After studying this paper, students will be able to

- Select the polymers for energy applications
- Explain working process of lithium ion batteries and fuel cell

SYLLABUS OF DSE-13

THEORY COMPONENT-

UNIT 1: (6 Hours)

INTRODUCTION

Importance and need of energy storage, modes of energy transmission, batteries, thermal, mechanical storage, hydrogen, pumped hydropower, flywheels, role of polymer in energy storage applications. environmental and sustainability issues.

UNIT 2: (8 Hours)

ENERGY STORAGE DEVICES BASED ON POLYMERS

Introduction, principal, methodology & working: photovoltaics, supercapacitors, lithium-ion batteries: PVAc based polymer blend electrolytes for lithium batteries, preparation of solid polymer electrolytes based batteries, perovskite-type composite polymer electrolytes, PPO-type composite polymer electrolytes, sulfide-type polymer electrolytes, solid polymer electrolytes with ionic liquid, solid polymer electrolytes with cellulose.

UNIT 3: (8 Hours)

FUEL CELLS

Hydrogen generation & storage, fuel cells, principles and nanomaterials design for; proton exchange membrane fuel cells (PEMFC), sulfonated poly (ether-ether ketone)s, sulfonated poly(aryl ether) for PEMFC and direct methanol fuel cell (DMFCs). Polymer composite membrane role (cation/anion/proton-exchange membranes) in bio-electrochemical systems – construction and performance of MFCs.

UNIT 3: (8 Hours)

POLYMER NANOCOMPOSITES FOR RENEWABLE ENERGY STORAGE SYSTEMS

Solar cells: Types, functioning, mechanism, materials for solar cell and structure design, Concept of solar cells with organic quantum dots, Quantum dots (polymer multiple & molecular multiple quantum dots), polymer-inorganic hybrid solar cells, hybrid conjugated polymer-inorganic semiconductor composites, semiconducting polymer-based bulk heterojunction solar cells, current trends and future status.

PRACTICAL COMPONENT (60 Hours)

- To prepare methanol fuel cell.
- To design low, medium and high-temperature fuel cell.
- Preparation of proton exchange by membrane fuel cell.
- Preparation of hydrogen fuel cell.
- To prepare quantum dots grown by molecular layer deposition for photovoltaics.
- Synthesis of polymer multiple quantum dots.
- To test the efficiency of solar cell.
- Demonstrate the working principle of solar cell.
- To prepare PVAc based polymer blend electrolytes.
- To test the energy storage of Lithium batteries.

ESSENTIAL/RECOMMENDED READINGS

- Deborah, D.L., Chung, (2002) "Composite Materials", Springer.
- Sun, S. S., Sariciftci, N. S., (2005) "Organic Photovoltaics", CRC press-Taylor & Francis.
- Mohammad, F., (2007) "Specialty Polymers: Materials and Applications", I. K. International Pvt Ltd.
- Chanda, M. Roy, S. K., (2008) "Industrial Polymers, Specialty Polymers", and Their Applications, CRC Press.
- Ram K. Gupta, R. K., (2022) "Conducting Polymers for Advanced Energy Applications", CRC Press.
- Thangadurai, T. D., Nandhakumar, M., Thomas, S., Nzihou, A., (2022) "Polymer Nanocomposites for Energy Applications", Wiley.

SUGGESTIVE READINGS

- Malaika, S. Al, Wilkie, C. A., Golovoy, A., (2001) "Specialty Polymer Additives", Wiley.
- Dyson, R. W., (1982) "Speciality polymers", Chapman and Hall publications.

- Ise, N., Tabushi, I., (1983) "An Introduction to Speciality Polymers", CUP Archive.
- Inamuddin, Ahamed M. I., Boddula, R., Altalhi, T., (2022) "Polymers in Energy Conversion and Storage".
- Kroschwitz, J. I. (2003) "Encyclopedia of polymer science and technology", John Wiley.
- Mark, H. F. (2013). "Encyclopedia of polymer science and technology", John Wiley & Sons.

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DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-14)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
3D PRINTING OF POLYMERS	4	3	0	1	Class 12th with Physics, Chemistry	---

Learning objectives

- Impart students to the fundamentals of various 3D Printing techniques for application to various industrial needs.
- Students will be able to convert part files into STL format and will understand the method of manufacturing of liquid based, powder based and solid based techniques.

Learning outcomes

The Learning Objectives of this course are as follows:

After studying this paper, students will be able to

- Use software tools for 3D printing
- Prepare 3D printed modules
- Construct products using LOM and FDM technologies

SYLLABUS OF DSE-14

THEORY COMPONENT-

UNIT 1: **(15 Hours)**

BASICS OF 3D PRINTING TECHNOLOGIES

Introduction to 3D printing, advantages. commonly used terms, process chain, 3D modeling, classification of 3D printing process (comparing different 3D printing technologies, including FDM, SLA, SLS, and MJ.), applications to various fields.

UNIT 2: **(15 Hours)**

MATERIALS FOR 3D PRINTING

Comparing the different material types available for 3D Printing product, including PLA, ABS, PETG, TPE, nylon, PC, as well as 8 exotic filaments that are not focussed on physical properties.

UNIT 3: **(15 Hours)**

3D PRINTING TECHNOLOGY

Laminated object manufacturing (LOM): Models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

Fused deposition modelling (FDM): Models and specifications, process, working principle, applications, advantages and disadvantages, case studies, practical demonstration

PRACTICAL COMPONENT **(30 Hours)**

- Manufacturing of additives by selective laser Sintering (SLS)
- To prepare fibre by FDM
- Manufacturing of Polyamide products by powder bed fusion
- Product manufacturing by extrusion 3D printing process (fusion, deposition, modelling)
- Direct ink writing of 3D functional materials
- To manufacture polymer products by Multi jet fusion
- To prepare photoreactive polymeric materials by material jetting.
- To prepare the shoe sole by 3D printing.
- To prepare filament by FFF (fused filament fabrication)
- Preparation the elastomeric thread by 3 D printing technology

ESSENTIAL/RECOMMENDED READINGS

- Chua C.K., Leong K.F. and LIM C.S, (2010) Rapid prototyping: Principles and Applications, World Scientific publications, 3rd Ed.

- Pham, D.T. and Dimov, S.S. , (2001) Rapid Manufacturing, Springer.
- Wohlers, T., (2000) Wohlers Report 2000, Wohlers Associates, 2000

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SUGGESTIVE READINGS

- Jacobs, P. F., (1996) " Rapid Prototyping and Manufacturing"–, ASME Press.
- Gibson, I., Rosen D., Stucker B., 2014) Additive Manufacturing Technologies, Springer, 2nd Ed.

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DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-15)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
RESEARCH METHODOLOGY IN POLYMER SCIENCE	4	3	0	1	Class 12th with Physics, Chemistry	---

Learning objectives

- To understand some basic concepts of research and its methodologies
- To learn research problem and parameters
- To learn about preparation a project proposal
- To study components of research paper, report and thesis

Learning outcomes

After studying this paper, students will be able to

- Select a particular research method.
- Apply research skills in qualitative and quantitative data analysis and presentation.
- Write the research paper, project and thesis with advanced critical thinking skills.

SYLLABUS OF DSE-15

THEORY COMPONENT

UNIT 1: (10 Hours)

RESEARCH METHODS

Identification and selection of the research problem, Literature survey for required information, Search engines (Scopus, Science direct, Web of science, Google scholar) for scientific information, Encyclopaedia, Reference books, abstraction of a research paper – drawing inferences from data, - qualitative and quantitative analysis, Reference, Management Software like Zotero/Mendeley, Software for paper writing and formatting like chem draw, origin,

LaTeX and MS Office. Developing a research plan, Format of research proposal: individual research proposal and institutional proposal.

UNIT 2: (10 Hours)

Research TOOLS, Paper and report writing

Correct usage of technical language and scientific peer network, ethics with respect to science and research, intellectual honesty and research integrity, scientific misconduct: falsification, fabrication and plagiarism (FFP), redundant publications: duplicate and overlapping publication, salami slicing, selective reporting and misrepresentation of data. Thesis and Paper writing, General format, page and chapter formation. Analysis and presentation of data, Statistical test: choosing and using suitable statistical tests. The use of quotation - footnotes - tables and figures - referencing - appendices - revising the paper or thesis - editing and evaluating and the final product - proof reading - the final types copy.

Thesis and Paper writing: Format of thesis- title, abstract, introduction, objectives, methods, results, tables, figures, graphs, discussion, summary, acknowledgement, in-text citations, reference list, and appendix. Presentation skill, them of conferences and workshops - Oral presentation skills – Post presentation of research outcome, Abstracts, Proceedings of technical deliberation - Publication in journals, conference proceedings and in book or as book chapters.

Research article & Research Proposals

Components of research article - Title, abstract, key words, introduction, citations, introduction, objectives, methods, results, tables figures, graphs, discussion summary, and references. Instruction to authors by journal for writing a research paper. Components of proposal document- Title, aim, research background, project outline, research methodology & budgeting, time schedule, deliverables and references.

UNIT 3: (15 Hours)

PUBLICATION ETHICS

Publication ethics: definition, introduction and importance, Best practices / standard setting initiatives and guidelines COPE (Committee on publication ethics), conflicts of interest, publication misconduct: definition, concept, problems that lead to unethical, behaviour and vice-versa, types, violation of publication ethics, authorship and contributor ship, identification of publication misconduct, complaints and appeals, predatory publishers and journals. Software for detection of Plagiarism determining the mode of action, literature survey, mode of approach of actual investigation.

PRACTICAL COMPONENT (30 Hours)

- Literature survey (scopus, sciencedirect, elsevier, scifinder etc.)
- Report writing
- Reference writing using softwares like Endnote, Mendley etc.
- Drawing of chemical structures using software like chem draw etc.
- Poster making
- Paper writing
- Graphical representation using excel, origin etc.

ESSENTIAL/RECOMMENDED READINGS

- Kothari, C. K. Garg, G.(2018) Research Methodology: Methods and Techniques, New Age International, 4th Edition,
- Rajaraman V., (2008) Computer Oriented Numerical Methods, Prentice Hall of India.
- Jain M. K., Iyengar S. R. K. and Jain R.K., (2007) Numerical Methods for Scientific and Engineering Computation, New Age International.

SUGGESTIVE READINGS

- Bhattacharya D. K., (2009) Research Methodology, Excel Books India.
- Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., (2002) An introduction to Research Methodology, RBSA Publishers.
- Kothari, C.R., (1990) Research Methodology: Methods and Techniques. New Age International. 418p.
- Sinha, S.C. and Dhiman, A.K., (2002). Research Methodology, Ess Ess Publications. 2 volumes.
- Trochim, W.M.K., (2005). Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
- Wadehra, B.L., (2000). Law relating to patents, trade marks, copyright designs and geographical indications. Universal Law Publishing.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES OFFERED BY THE DEPARTMENTS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
BASICS OF POLYMER SCIENCE	**4**	**2**	**0**	**2**	**Class 12th with Physics, Chemistry**	**---**

Learning objectives

The Learning Objectives of this course are as follows:

- To familiarize with the structure of polymers will be introduced to students.
- To acquaint students with knowledge of molecular weight determination and polymer solubility

Learning outcomes

After studying this paper, students will be able to

- Distinguish crystalline and amorphous states of polymers
- Correlate polymer flexibility with the glass transition temperature
- Illustrate structure-property relationship of polymers
- Apply mathematical formulae to depict polymer solution properties

SYLLABUS OF GE-1

THEORY COMPONENT-

UNIT – I (10 Hours)

Introduction and classification of polymers, configuration and conformation of polymers, nature of molecular interaction in polymers, entanglement, various structures of copolymers such as linear branched and cross-linked copolymers, Polymer solutions, solubility parameter, solution viscosity, polymer solubility, thermodynamics of polymer solutions

UNIT – 2 **(10 Hours)**

Physical properties, stress–strain behaviour, mechanical properties (tensile, flexural, impact, fatigue, hardness, creep, abrasion), introduction to flow & glass transition temperature (T_g) and its measurement of T_g, factors affecting the glass transition temperature

UNIT – 3 **(10 Hours)**

Nature and structure of polymers – structure-property relationships, Molecular weight of polymers (*M*n, *M*w etc.), polydispersity, molecular weight distribution and determination of molecular weight by viscosity, end group analysis, cryoscopy, ebulliometry, light scattering & ultracentrifugation methods

PRACTICAL COMPONENT **(60 Hours)**

- Chemical identification of polymers: Functional groups (associated with polymers).
- Determination of molecular weight by solution viscosity/end group analysis.
- To check the solubility of the given polymeric sample in different solvents.
- To determine the melting point of crystalline polymers.
- Determination of heat deflection temperature & vicat softening point of polymers.
- Determination of Acid value of acrylic acid
- Estimation of hydroxyl value by PVA and Cyclohexanol
- Determination of epoxy equivalent weight of the epoxy resin.
- Determination of saponification value of oil.
- Study of three component systems.

ESSENTIAL/RECOMMENDED READINGS

- Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.
- Ghosh P., (2010) Polymer Science and Technology: Plastics, Rubbers, Blends and Composites Tata McGraw-Hill.
- Gowarikar V.R., (2019) Polymer Science, New Age International Publishers Ltd, 3rd Edition
- Billmeyer F.W., (2007) Textbook of Polymer Science, Wiley, India.
- Shah V., (1998) Handbook of Plastics Testing Technology, Wiley interscience publications.

SUGGESTIVE READINGS

- Schultz J.M., (2001) Polymer Crystallization, American Chemical Society.
- Seymour R.B., Carraher C.E., (2000) Polymer Chemistry, Marcel Dekker.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-2)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
ADVANCED ANALYTICAL TECHNIQUES	4	2	0	2	Class 12th with Physics, Chemistry	---

Learning objectives

The Learning Objectives of this course are as follows:

- To acquaint the students with the advanced instrumental techniques and their applications in characterization of polymeric materials.

Learning outcomes

After studying this paper, students will be able to

- Elucidate surface morphology of polymeric materials
- Determine crystallinity of various polymers and their characterization on the basis of their thermal stability and glass transition temperature

SYLLABUS OF GE-2

THEORY COMPONENT-

UNIT – I **(8 Hours)**

Basic principle of spectroscopy, molecular and atomic spectra, Lambert-Beer's law, Frank-condon principle, electromagnetic radiation and it's properties, interaction of radiation with matter, statistical method of analysis

UNIT – 2 **(8 Hours)**

Principles and applications in structural determination of polymers (functional group, tacticity, molecular structure, purity, unsaturation etc.): Infra-red spectroscopy, UV-Vis spectroscopy, electron spin resonance, raman, nuclear magnetic resonance spectrometer

UNIT – 3 **(8 Hours)**

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

UNIT – 4 **(6 Hours)**

Optical microscopy, electron microscopy (SEM, TEM, AFM) and XRD: basics and applications (size, morphology, crystallinity etc.) in polymers characterization

PRACTICAL COMPONENT **(60 Hours)**

- Study of UV stabilization of polymer samples by UV-visible spectrophotometer.
- Calculate weight percentage of inorganic and organic ingredients in polymeric compounds.
- Determination of K-value of PVC.
- Quantitative determination of impurities by UV-Vis. spectrophotometer.
- Characterization of Filler Content /Ash Content of common polymers by Thermogravimetric Analysis, (TGA).
- Identification of additives in a processed polymer by chromatography.
- Interpretation of FTIR, NMR and Raman spectra of polymers.

ESSENTIAL/RECOMMENDED READINGS

- Willard H.H., Merritt L.L., Dean J.A. (1988) Instrumental method of analysis, Wads worth Publishing Company.
- Skoog D.A, (1997) Principle of Instrumental Analysis, Harcourt College Pub.
- Shah V., (2007) Handbook of Plastic Testing, Technology, Wiley-Inter science.

- Banwell C.N., McCash E.M., (2008) Fundamentals of Molecular Spectroscopy, Fourth Edition, Tata McGraw-Hill.

SUGGESTIVE READINGS

- Tanaka T., (1999) Experimental Methods in Polymer Sciences, Academic Press.
- Silverstein R.M., (1991) Spectrometric identification of organic compounds, John Wiley.
- Macomber R.S., (2008) A complete introduction to NMR spectroscopy, Wiley-inter science.

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GENERIC ELECTIVES (GE-3)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
POLYMER AND ENVIRONMET	4	2	0	2	Class 12th with Physics, Chemistry	----

Learning objectives

The Learning Objectives of this course are as follows:

- To give understanding of basics of care to be taken while handling polymer products.
- To know the Safety and hazardous of their manufacturing processes.
- To impart Knowledge of the subject will help students to see the environmental impact of plastic and resin.
- To understand the current benefits and concerns surrounding the use of plastics and look to future priorities, challenges and opportunities.

Learning outcomes

After studying this paper, students will be able to

- Explain the basics of environmental and safety issues in the chemical industry.
- Apply the safety in handling monomer and resins

- Demonstrate the final product of polymer in environment after use and its waste management

SYLLABUS OF GE-3

THEORY COMPONENT-

UNIT – 1 **(10 Hours)**

Health and safety, Plastics in the society, Plastics in the environment, Plastic waste management, Plastic waste in the marine and terrestrial environment, Plastic material degradation, regulations for hazardous chemicals in articles/plastic products, coated articles. Separation techniques of plastic wastes (density, float sink and froth floatation methods, optical, spectroscopic, sorting by melting temperature etc.).

UNIT – 2 **(10 Hours)**

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 **(10 Hours)**

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. Recycling of Polyolefins, PVC, PET, Polystyrene, Polyamides (Nylon-6 and Nylon-6,6). Recycling of Thermosets –reclaiming of rubber –pyrolysis, depolymerization of scrap rubber, tyre retreading, uses of recycled rubber.

PRACTICAL COMPONENT (60 Hours)

- Primary recycling of plastic waste collected from the environment.
- Secondary recycling of MSW by incorporating and blending the recyclable waste with virgin polymers.
- To study composting of natural/biopolymers.
- Separation of polymer mixture by sink flotation technique.
- Separation of polymer mixture by selective dissolution technique.

- Recovery of BHET from PET by chemical recycling process
- Recovery of Adipic Acid from Nylon 66 by chemical recycling technique
- To study the effect of vulcanized rubber at varying ratio (in powder form) on mechanical properties of rubber vulcanizate
- Preparation of plasticizer from polyester waste.
- Preparation of reclaim from tyre waste.

ESSENTIAL/RECOMMENDED READINGS

- Chandra, R., & Adab, A. (1994). Rubber & Plastic Waste: Recycling, Reuse and Future Demand. CBD Publishers.
- Scheirs, J., & Long, T. E. (Eds.). (2005). Modern polyesters: chemistry and technology of polyesters and copolyesters. John Wiley & Sons.

SUGGESTIVE READINGS

- Blow, S. (1998). Handbook of Rubber Technology.
- Brandrup, J., Bittner, M., Michaeli, W., & Menges, G. (1996). Recycling and Recovery of Plastics, Hanser. Gardner, München.
- Goodship, V. (2007). Introduction to plastics recycling. iSmithers Rapra Publishing.
- Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.
- Ehrenstein G.W., Riedel G., Trawiel P., (2004) Thermal analysis of plastics, Hanser.

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GENERIC ELECTIVES (GE-4)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
BIOMEDICAL APPLICATIONS OF POLYMERS	**4**	**2**	**0**	**2**	**Class 12th with Physics, Chemistry**	**----**

Learning objectives

- To acquire knowledge of biopolymer and biodegradation
- To gain knowledge of applications and testing of biopolymers

Learning outcomes

After studying this paper, students will be able to

- Explain basic concepts and requirement of biomaterials and biocompatibility
- Apply the knowledge of various biomaterials for a desired bio-application

SYLLABUS OF GE-2

THEORY COMPONENT-

UNIT – 1 **(6 Hours)**

BASICS OF BIOMATERIALS

Concept of biocompatibility and biodegradability, responsiveness, estimations of degradation and biocompatibility, Important biomaterials: hydrogel, fibres, bio-ceramics, bio-elastomers and membranes

UNIT – 2 **(8 Hours)**

POLYMERS AS BIOMATERIALS

Polyester and polysaccharides, natural gums, biodegradable polymers, polymers and hydrogels

UNIT – 3 **(8 Hours)**

BIOMATERIALS FOR ORGAN TRANSPLANTS AND TISSUE ENGINEERING

Properties and applications of polymers for organ transplant e.g. dental cement, orthopaedic, skin, artificial kidney etc., basic concepts of tissue engineering, important polymers for tissue engineering: cellulose, chitosan and alginates

UNIT – 4 **(8 Hours)**

DRUG DELIVERY AND WOUND CARE

Introduction to drug delivery, polymers in controlled drug delivery, dressing strips, polymer drug vessels, core shell and nanogels, polymers for antimicrobial activity, bio-conjugates

PRACTICAL COMPONENT (60 Hours)

- Evaluate the biocompatibility of polymeric samples.
- Determination of the degradation behavior of polymers such as thermal, hydrolytic degradation etc.
- Preparation of membranes and measurement of absorption behavior.
- Preparation and characterization of dental cement.
- Preparation of a hydrogel and its characterization.
- Determination of tensile strength of biopolymers.
- Determine the swelling rate of biopolymers
- Preparation of nanogel and find its water absorption
- preparation and characterization of membrane for skin transplant

ESSENTIAL/RECOMMENDED READINGS

- Tiwari A., Tiwari A., (2013) Nanomaterials in drug delivery, Imaging and Tissue Engineering, Wiley.
- Pilla S., (2011) Handbook of Bioplastics and Biocomposites Engineering Applications, Wiley.
- Ratner, Buddy D., Allan S. Hoffman, Frederick J. Schoen, and Jack E. Lemons. "Biomaterials science: an introduction to materials in medicine." San Diego, California (2004): 162-4.
- Park, J. B., & Bronzino, J. D. (2002). Biomaterials: principles and applications. crc press.

SUGGESTIVE READINGS

- Ratner D., Hoffman A.S., (1996) An Introduction to Materials in Medicine, Academic Press.
- Saltzman W.M., (2001) Drug delivery–Engineering principles for drug therapy, Oxford University Press.
- Kalia S., Averous L., (2011) Biopolymers: Biomedical and Environmental Applications, John Wiley & Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-5)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
POLYMERS FOR PACKAGING	4	2	0	2	Class 12th with Physics, Chemistry	----

Learning objectives

- To learn about the basic necessities and importance of packaging
- To acquire knowledge of various types of packaging materials

Learning outcomes

After studying this paper, students will be able to

- Apply the basic concepts of packaging and its utilization for desired applications
- Evaluate the quality of packaging material and packaged product

SYLLABUS OF GE-5

THEORY COMPONENT-

UNIT – 1 **(6 Hours)**

PACKAGING SYSTEMS

Types of packaging systems: box, bottle, tetra, pouch, shrink, vacuum, gas, controlled atmosphere packaging (CAP), modified atmosphere packaging (MAP), and aseptic packaging

UNIT – 2 **(8 Hours)**

POLYMERS IN PACKAGING

Properties and applications: LLDPE, LDPE, HDPE, HMHDPE, PP, PVC, nylons, polyester, polycarbonate, PS, EPS, PLA, PVA and Starch

UNIT – 3 **(8 Hours)**

PACKAGING PROCESS TECHNIQUES

Preparation of packaging materials by thermoforming, co-extrusion, extrusion-stretch blow molding, injection molding, BOPP films

UNIT – 4 **(8 Hours)**

TESTING OF POLYMER PACKAGING MATERIAL

Bursting strength, tensile strength, tear strength, puncture test, impact test (Drop, falling dart), permeability test (water vapour, oxygen), biodegradability, sealing strength

PRACTICAL COMPONENT **(60 Hours)**

- To identify packaging materials with the help of FT-IR, DSC, TGA etc.
- Determination of physico-mechanical properties (density, burst strength, tensile strength, tear strength, puncture test strength, impact strength etc).
- Determination of water vapor transmission rate of packaging material.
- To test sealing strength integrity of packaging materials.
- To check biodegradability of packaging material.
- Preparation biodegradable packaging film
- Determination of water vapor transmission rate of packaging material.
- To test seal strength integrity of packaging materials.
- To check biodegradability of packaging material.
- To determine compatibility of film.

ESSENTIAL/RECOMMENDED READINGS

- Robertson G.L., (2005) Food Packaging Principles and Practice, CRC press.
- Paine F.A. and Paine H.Y., (1992) A Handbook of Food Packaging, Blackie Academic and Professional.
- Sharma S., Aggarwal M., Sharma D., (2019), Food Frontiers, New Delhi Publisher
- N. C. Saha, M. Garg, S. Dey Sadhu, A. K. Ghosh(2022) Food Packaging-Materials, Techniques and Environmental Issues" by published by Springer.
- Garg, M., Meena, P.L., Sadhu, S.D., Alam, T. (2019). Food Packaging: A Practical Guide : Viba Press Pvt. Ltd.

SUGGESTIVE READINGS

- Robertson G.L., (2012) Food Packaging–Principles and Practice, CRC Press.

- Coles R, McDowell D., Kirwan M.J., (2003) Food Packaging Technology, Blackwell.
- Sukhareva L.A., Yakolev V.S., Legonkova O.A., (2008) Polymers for packaging materials for preservation of foodstuffs, VSP.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-6)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
POLYMERS FOR ELECTRICAL AND ELECTRONIC APPLICATIONS	**4**	**2**	**0**	**2**	**Class 12th with Physics, Chemistry**	**----**

Learning objectives

- To learn about basic concepts of polymer electrical and electronic properties
- To gain knowledge of electrical and electronics applications of polymers

Learning outcomes

After studying this paper, students will be able to

- Synthesize a conducting polymer for a specific application
- Apply the knowledge of properties of polymers required for electrical and electronics applications

SYLLABUS OF GE-6

THEORY COMPONENT-

UNIT – 1 **(6 Hours)**

INTRODUCTION TO POLYMERS

Petro polymers, conducting polymers, biopolymers, composites, Band diagram, processing of polymers, doping (chemical and ion), advantages and disadvantages of conducting polymers, limitations

UNIT – 2 **(8 Hours)**

PREPARATION OF CONDUCTING POLYMERS

Synthetic methods: chemical, electrochemical, photochemical etc. (polyaniline, polypyrrole, polythiophene, polyacetylene, etc.), methods to enhance the processability of conducting polymers

UNIT – 3 **(8 Hours)**

PROPERTIES

Dielectric strength, dielectric loss, charge storage capacity, electrical conductivity, heat capacity, magnetism, hysteresis loop, shape memory, mechanical properties, EMI shielding

UNIT – 4 **(8 Hours)**

ELECTRONIC APPLICATIONS

Semiconducting organic materials, polymer based electronic devices, organic field effect transistor, organic transistors, plastic solar cell, light emitting diode, supercapacitor, sensors etc.

PRACTICAL COMPONENT **(60 Hours)**

- Preparation of conducting polyaniline and measurement of their conductivity.
- Preparation of polypyrrole and measurement of their conductivity.
- Preparation of polythiophene and measurement of their surface resistivity.
- Preparation and testing of conducting polymers for sensor applications.
- Measurement of multilayer insulation of a thin film.
- Measurement of dielectric strength of a polymer film.
- Measurement of mechanical properties of insulating cable
- Preparation polymer sample and analyzed its dielectric strength
- Preparation of a conducting polymer nanocomposites.
- Preparation polymeric semiconductor

ESSENTIAL/RECOMMENDED READINGS

- Skotheim T.A., Elsenbaumer R.L., Reynolds J.R., (1998) Handbook of conducting polymers, Vol. 1 and Vol. 2, Marcel Dekker.
- Nalwa H.S., (1977) Organic Conductive Molecules and Polymers, John Wiley & Sons.
- Bredas J.L., Silbey R., (1991) Conjugated Polymers: The Novel Science and Technology of Highly Conducting and Nonlinear Optically Active Materials, Kluwer Academic Publishers.
- Bikales M., Menges O.B., (1986) Encyclopedia of Polymer science and Engineering, Second Edition, Vol.5, John Wiley & Sons.

SUGGESTIVE READINGS

- Lyons M.E.O., (1994) Electroactive polymers, Plenum Press.
- Margolis J., (1993) Conducting Polymers and Plastics, Chapman & Hall.

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