INDEX

BHASKARACHARYA COLLEGE OF APPLIED SCIENCE

B.Sc. (Honours) Polymer Science
Semester-III

Category I

B.Sc. (Honours) Polymer Science
Bhaskaracharya College of Applied Science

DISCIPLINE SPECIFIC CORE COURSE – 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 (if any)
		Lecture	Tutorial	Practical/ Practice		
RUBBER ADDITIVES (DSC-7-RA)	4	3	0	1	PCM	--

LEARNING OBJECTIVES

The Learning Objectives of this course are as follows:

- To enable the students to know about need for additives in compounding of rubber
- To understand the different types of ingredients in compounding.
- To know about property modification by vulcanization
- To enrich knowledge on testing of compounded rubber

LEARNING OUTCOMES

The Learning Outcomes of this course are as follows:

After completing the course, the students

- Will understand concept of rubber compounding.
- Will modify the properties of rubber by incorporation of additives.
- Will develop rubber compound for required end use application.
- Will modify the strength by varying vulcanizing agents.
- Will do testing of rubber and asses quality of rubber compound.

SYLLABUS OF DSC-7

THEORY COMPONENT-

UNIT – I (3 Weeks)

FILLERS AND PROCESSING AIDS

Fillers: Carbon black, Non carbon black, Colors and Pigments,Plasticizers, Process aids, Softeners and Extenders.

UNIT – II (3 Weeks)

OTHER ADDITIVES FOR RUBBERS

Vulcanizing agents (sulphur, peroxide and metal oxide, phenolic curatives, benzoquinone derivatives, bismaleimides), accelerators (benzothiazoles, benzothiazolesulfenamide, dithiocarbamates, amines), lubricants, retarders (pre-vulcanized inhibitor), activators,

UNIT – III (2 Weeks)

ANTIDEGRADATION AND MISCELLEOUS ADDITIVES

Uv stabilizers, Heat stablizers, Antioxidants, Antiozonants- Mechanism of degradation – Mechanism of ozone attack. Special purpose additives: Chemical blowing agents – Flame retardants – Antistatic agent – Abrasives -Integral bonding additives – stiffening agents. antioxidants, thermal), softners, tackifying agents, blowing agents, surface property modifiers etc.

UNIT – IV (3 Weeks)

INDIVIDUAL RUBBER FORMULATIONS

Formulating for natural and synthetic rubbers and typical recipes for a few rubber products, Implications of FDA Regulations - Toxicity and environmental issues.

UNIT – V (4 Weeks)

FORMULATION FOR PERFORMANCE REQUIREMENTS

Compounding to meet different Hardness requirements – Iow compression set – For damping application – Compounding to meet bonding requirements with metals and textiles– Compounding to meet processing – Economics of compounding – Cost estimation.

PRACTICAL COMPONENT- (CREDIT:01, Laboratory Period:30, 15 Classes of 2 Hrs each)

- Mastication of NR on two roll mill
- Mixing of rubber compounds
- Compression moulding of rubber compounds
- Preparation of dry rubber products – play ball
- Preparation of dry rubber products – Hawaii sheet
- Preparation of dry rubber products – M.C Sheet
- Preparation of dispersions for compounding of latex
- Preparation of latex products: i. Hand Gloves ii. Balloon iii. Rubber band iv. Thread
- Compression moulding of fabric/rubber composite
- Preparation of rubber blends

ESSENTIAL/RECOMMENDED READINGS

- John S Dick, Rubber Technology- Compounding and Testing for Performance Hanser Publishers, 2001.
- C. Hepburn, Rubber Technology and Manufacturing, Butterworth-Heinemann, 2009
- Brendon Rodgers, Rubber Compounding- Chemistry and Applications, Taylor and Francies, 2016.

SUGGESTIVE READINGS

- Brydson J.A., (2016) Plastics Materials, Butterworth Heinemann, 8th Edition.
- Roger Brown, Physical Testing of Rubber, Chapman and Hall, 3rd Edition, 1996.

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

DISCIPLINE SPECIFIC CORE COURSE – 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 (if any)
		Lecture	Tutorial	Practical/ Practice		
PLASTIC ADDITIVES (DSC-8-PA)	4	3	0	1	PCM	---

LEARNING OBJECTIVES

The Learning Objectives of this course are as follows:

- To introduce the basics of polymer additives and their significance
- To study different additives and their representative formulations

LEARNING OUTCOMES

The Learning Outcomes of this course are as follows:

After studying this paper, students will be able to

- Understand the role of various compounding additives used for plastics and rubbers
- Describe various steps & variables for mixing and blending of additives
- Utilize understanding of compounding additives and methods for modification of polymer properties

SYLLABUS OF DSC- 8

THEORY COMPONENT-

UNIT – I (4 Weeks)

INTRODUCTION TO ADDITIVES AND COMPOUNDING

Importance of additives and their selection criteria for commercial polymers and technical requirements of additives, limitation of polymer additives, physical behavior of polymer additives (solubility etc.), limitation of polymer compounding, two roll mill, high speed mixer, internal batch mixer, single screw & twin screw extruders

UNIT – II (5 Weeks)

ADDITIVES FOR PLASTICS

Plasticizers, theories of plasticization, types of plasticizer (phthalate, polymeric, hydrocarbon oil, vegetable oil, phosphates trimellitic etc.), methods of incorporation, fillers, introduction, classification, selection criteria (particle size, shape & geometry, packing fraction, hardness and abrasiveness, optical properties), impact of fillers on properties (mechanical properties, thermal properties, moisture content and electrical properties), Foaming agents, blowing agents, stabilizers (UV, heat, antioxidants and light), metal deactivators, Colorants (Dyes and pigments, coloring properties, classification of pigments, inorganic and organic pigments, method of incorporation (dispersion, pre mixing, agglomerate breakdown, compaction and wetting)

UNIT – III (3 Weeks)

ADDITIVES FOR SPECIAL NEEDS

Flame retardants (halogen based, metal oxides, hydrated salts etc.), impact modifiers, lubricants & flow promoters, dry bonding agent and antistatic agents, conductive additives, biodegradation additives

UNIT – IV (3 Weeks)

CASE STUDY

Compounding techniques with illustration of few formulations like:

- Rigid PVC pipes
- Clear bags and flexible films
- Acrylic sheet and display board
- Rubber sole
- Air water hose
- Conveyor belt

PRACTICAL COMPONENT- (CREDIT:01, Laboratory Period:30, 15 Classes of 2 Hrs each)

- Determination of bulk density of fillers.
- Determination of pore size and net size of fillers.
- Determination of thermal stability of polymer stabilized by heat stabilizer.
- Measurement of flash point of a plasticizer.
- Identification of additives using chromatography.
- Determination of the plasticizer and filler content in plastic materials.
- Evaluate the bleeding and blooming properties of an additive.
- Evaluate the effect of fillers/plasticizers on the properties of a plastic/rubber.
- To prepare a PVC masterbatch.
- Identification of a pigment by spot test.
- Estimation of Iodine value of Castor oil
- Determination of DBP value and sieve analysis of Carbon black.

ESSENTIAL/RECOMMENDED READINGS

- Lutz J.T., (2001), Polymer Modifiers and Additives, Marcel Dekker.
- Zweifel H., Amos S.E., (2001) Plastics Additives Handbook, Hanser.
- Gachter R., Muller H., (1987) Plastics Additive Handbook, Hanser Publishers.

SUGGESTIVE READINGS

- Mascia L., (1974) The Role of Additives in Plastics, Edward Arnold Publishers Ltd., U.K.
- Murphy J., (2001) Additives for Plastics Handbook, Second Edition, Elsevier Advanced Technology, Oxford.
- Gerard J. F., (2001) Fillers and Filled Polymers, Wiley-VCH verlag GmbH

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DISCIPLINE SPECIFIC CORE COURSE – 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 (if any)
		Lecture	Tutorial	Practical/ Practice		
POLYMER DEGRADATION (DSC-09-PD)	**4**	**3**	**0**	**1**	**PCM**	**-**

LEARNING OBJECTIVES

The Learning Objectives of this course are as follows:

- To familiarize with the utility and importance of polymer degradation
- To learn about the conditions and the reactions of degradation of polymers

LEARNING OUTCOMES

The Learning Outcomes of this course are as follows:

After studying this paper, students will be able to

- Explain the factors responsible for degradation
- Understand the handling of various polymers without affecting the properties
- Evaluate degradation of polymers by various methods

SYLLABUS OF DSC-9

THEORY COMPONENT-

UNIT – I (4 Weeks)

CONCEPT OF DEGRADATION

Introduction to degradation, classification of degradation based on

a. Pattern of degradation:
   i. Random degradation
   ii. Side chain degradation
   iii. Chain end degradation

b. Cause of degradation (mechanism, factors affecting thermal degradation, example)
   i. Thermal degradation
   ii. Oxidative degradation
   iii. Degradation by radiation
   iv. Mechanical degradation
   v. Chemical degradation
   vi. Biological degradation

UNIT – II (7 Weeks)

DEGRADATION OF A FEW THERMOPLASTICS

Different types of degradation patterns with mechanism of the polymers:

- Polyolefins (PE and PP)
- PVC

- Polyamides
- PMMA
- Cellulose
- Polyacrylonitrile (PAN)
- Polystyrene (PS)
- PET

UNIT – III (2 Weeks)

DEGRADATION OF ELASTOMERS

i. PU **ii.** Natural rubber **iii.** SBR

UNIT – IV (2 Weeks)

QUANTITATIVE AND QUALITATIVE EVALUATION OF DEGRADATION

Degradation studies using DSC, TGA

PRACTICAL COMPONENT- (CREDIT:01, Laboratory Period:30, 15 Classes of 2 Hrs each)

- To study biodegradation of polymers.
- To study mechanical degradation of polymers and its effect on properties.
- To study thermal degradation of polymers under various conditions.
- To study thermal analysis of a given polymer by DSC/ TGA.
- To study photo-degradation of PVC.
- To evaluate chemical degradation of PET.
- To determine environmental stress cracking resistance of polymers.
- To evaluate chemical degradation of Nylon 66.
- To study epoxidation of Natural Rubber Latex.
- To study the effect of degradation on properties like: Mechanical strength, hardness, solubility, viscosity etc.

ESSENTIAL/RECOMMENDED READINGS

- Pesce W.J., (2007) Encyclopaedia of Polymer Science and Technology, Wiley.
- Turi E.A., (1997) Thermal Characterization of Polymeric Materials, Academic Press.
- Glaser, J. A. (2019). Biological degradation of polymers in the environment (Vol. 1, p. 13). London, UK: IntechOpen.
- Gilbert, M. (2017). Cellulose plastics. In Brydson's Plastics Materials (pp. 617-630). Butterworth-Heinemann.
- Krasowska, K., Heimowska, A., & Rutkowska, M. (2015). Environmental degradability of polyurethanes. Thermoplastic Elastomers—Synthesis and Applications; IntechOpen: London, UK, 75-94.

SUGGESTIVE READINGS

- Hamid S.H., Amin M.B., (1992) Handbook of Polymer Degradation, Marcel Dekker.
- Ehrenstein G.W., Riedel G., Trawiel P., (2004) Thermal analysis of plastics, Hanser.

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DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE-1)

COMMON POOL OF DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE) COURSES OFFERED IN ODD SEMESTERS 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		
ADVANCED ANALYTICAL TECHNIQUES (DSE-01-AAT)	**4**	**2**	**0**	**2**	**12Th science**	**---**

LEARNING OBJECTIVES

The Learning Objectives of this course are as follows:

- To acquaint the students with the modern instrumental techniques and their applications in characterization of polymeric materials
- Students will be able to determine a chemical property and identify a chemical substance in a polymer.

LEARNING OUTCOMES

The Learning Outcomes of this course are as follows:

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 of various polymers
- Acquire the knowledge about separation of components from polymer mixture

SYLLABUS OF DSE-1

THEORY COMPONENT-

UNIT 1 (7 Weeks)

SPECTROSCOPIC TECHNIQUES

Principles and applications of structural determination of polymers (functional group, tacticity, molecular structure, purity, unsaturation etc.) using FT-IR, electron spin resonance, raman, nuclear magnetic resonance (^{1}H NMR, ^{13}C NMR).

Mass Spectroscopy: introduction, basic principles, instrumentation, fragmentation patterns, nitrogen rule, McLafferty rearrangement, interpretation of mass spectra and applications, MALDI-TOF, ESI-MS and methods for determination of molecular mass (principles and applications in polymer characterization).

UNIT 2 (4 Weeks)

CHROMATOGRAPHY TECHNIQUES

Introduction to chromatographic methods: TLC, column and gas chromatography, principles, instrumentation, GC column, detectors and stationary phases and applications, hyphenated techniques (GC-MS). Liquid chromatography LC/HPLC, gel permeation chromatography (GPC)

UNIT 3 (4 Weeks)
MICROSCOPIC AND MISCELLANEOUS TECHNIQUES

Optical microscopy, electron microscopy (SEM, TEM, AFM) and XRD: basics and applications (size, morphology, crystallinity etc.) for polymers characterization. Particle size analyzer, zeta potential, etc.

PRACTICAL COMPONENT- (CREDIT:02, Laboratory Period:60, 15 Classes of 4 Hrs each)

- To identify the functional groups in various polymers using FTIR.
- To analyze the NMR spectra of a given polymer.
- To analyze the raman spectra of given polymers.
- Evaluate percentage crystallinity of polymeric samples by XRD.
- To separate additives in a given polymeric sample by chromatography.
- To separate a polymeric mixture by TLC.
- To analyze film morphology by compound/electron/Atomic Force microscope.
- To determine the size of polymer/additives particles by particle size analyzer.
- To study the polymers tacticity using NMR.
- Visit to an analytical laboratory.

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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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 (DSE-02-FMT)	4	2	0	2	12Th science	---

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

The Learning Outcomes of this course are as follows:

After studying this paper, students will be able to

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

SYLLABUS OF DSE-2

THEORY COMPONENT-

UNIT 1(3 Weeks)

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: (6 Weeks)

MELT SPINNING

Melt spinning process: Crystallization in spin line, stress induced crystallization, melt spinning of PP, polyester and nylon-6 and nylon -66, effect of process parameters on structure and properties of melt spun filament.

UNIT 3 (6 Weeks)

SOLUTION DRY & WET SPINNING

Dry spinning of cellulose acetate, acetylation of cellulose, dope preparation and spinning of cellulose diacetate and triacetate, dry spinning of acrylic, significance and types of co-monomers used during polymerization of acrylonitrile (PAN)

Wet spinning of acrylic fibre and viscose rayon, formation of structure in viscose, influence of various additives and temperature of the regeneration bath on the process and properties of viscose rayon

PRACTICAL COMPONENT- (CREDIT:02, Laboratory Period:60, 15 Classes of 4 Hrs each)

- To prepare polypropylene fibre by melt spinning.
- Melt spinning of Nylon 6/66.
- To prepare polyester fibre by melt spinning
- Solution spinning of acrylic fibre.
- Dry 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
- Identification of dyestuff on different substrates
- 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.

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.

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.

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 (DSE-03-TT)	**4**	**2**	**0**	**2**	**12Th science**	**---**

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 knowledge of basic concept of manufacturing technology of tyre
- Understand designing and compounding of various tyre components
- Evaluate testing and quality assessment of tyre

SYLLABUS OF DSE-3

THEORY COMPONENT-

UNIT 1 (4 Weeks)

INTRODUCTION AND TYRE MANUFACTURING

Classification: based on construction (pneumatic, radial, bias, cross ply, tube, tubeless, solid), Mixing (Mixing instruments: two roll mill, kneader, internal mixers), processing (extrusion, calendaring, bead winding), building drum, curing (molding machines etc.), mold

UNIT 2 (6 Weeks)

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 (5 Weeks)

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- **(CREDIT:02, Laboratory Period:60, 15 Classes of 4 Hrs each)**

- 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

- Clark S.K., (1971) Mechanics of Pneumatic Tires, National Bureau of Standards, Monograph, US Govt. printing office.
- French T., (1989) Tyre Technology, Adam Hilger, New York.

SUGGESTIVE READINGS

- Ford T.L., Charles F.S., (1988) Heavy Duty Truck TIRE Engineering SAE's 34th L. Ray Buckingdale Lecture, SP729.
- Gent A.N., Walter J.D., (2006) The Pneumatic TIRE, U.S. Department of Transportation, National Highway Traffic Safety Administration.
- Mark J.E., Erman B., Eirich F.R., (2005) The Science and Technology of Rubber, Elsevier.
- Koutny F., Zling, (2007) Geometry and Mechanics of Pneumatic TIRE, CZE.

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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 (DSE-04-PPD)	**4**	**2**	**0**	**2**	**12Th science**	**---**

LEARNING OBJECTIVES

The Learning Objectives of this course are as follows:

- To learn physical properties of polymers required for product design
- To design 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

The Learning Outcomes of this course are as follows:

After studying this paper, students will be able to

- Demonstrate the response of polymers for various loads.
- Apply the knowledge to develop plastic products.
- Develop the design for polymer products in engineering applications.

SYLLABUS OF DSE-4

THEORY COMPONENT-

UNIT-1 (5 Weeks)
INTRODUCTION

Introduction to structure and physical properties of polymers, stress – strain behaviour of polymers, effect of fillers on properties of polymers, stress analysis of polymers, structural design of beams, plates and other structural members.

UNIT 2(5 Weeks)
CHARACTERISTICS OF PRODUCT DESIGN

Dynamic load response of polymers, effects of cyclic loading, other forms of stress applied to polymer parts, design for stiffness, processing limitations on polymers product design. Material and process interaction and the effects on the performance of plastic parts and the resulting design limitations, performance in service and environmental exposure.

UNIT 3 (5 Weeks)
PRODUCT DESIGN TECHNIQUES

Design procedure for plastic parts- basic principles-shrinkage-flash lines-undercuts-suggested wall thickness-draft-tolerance-moulded holes-threads radius- moulded hinges-integral hinge-snap fits – product design thumb rules – case studies and product design. 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.

PRACTICAL COMPONENT- **(CREDIT:02, Laboratory Period:60, 15 Classes of 4 Hrs each)**

- To prepare a poly styrene sheet with in-situ polymerization.
- To prepare open and closed cell foam.
- To prepare laminates such as epoxy, polyester and epoxy-polyester.
- To prepare a PMMA sheet using bulk polymerizations.
- To join polymer products by molding.
- Preparation of polymer products by different processing techniques.
- To study the post curing of rubber
- To prepare a composite mouse pad
- To prepare rubber - metal composite products
- To determine mechanical properties of designed products

ESSENTIAL/RECOMMENDED READINGS

- Levy S. & Dubois J.H., (1977) Plastic Product Design Engineering Hand Book, Van Nostrand Reinhold Co., New York.
- Miller E., Plastics Products Design Hand Book, Marcel Dekker,

SUGGESTIVE READINGS

- Malloy R. A., (1994) Plastic Part Design for Injection Moulding, Hanser Pub., Munich Vienna NY.
- Belofsky H., (1995) Plastics Product Design and Process Engineering, SPE, Hanser Publication, Munich Vienna NY.
- Freekly P.K. & Payne A. R., Theory and Practice of Engineering with Rubber.
- Hepburn B. and Raynolds R.J.W. , Elastomers, Criteria for Engineering Design.
- Beck R.D., Plastic Product Design, Van Nostrand Reinhold 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 (DSE-05-PBA)	**4**	**2**	**0**	**2**	**12Th science**	**---**

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

The Learning Outcomes of this course are as follows:

After studying this paper, students will be able to

- Understand 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 (4 Weeks)

BASICS OF BIOMATERIALS

Concept of biocompatibility and biodegradability, responsiveness, estimations of degradation and biocompatibility. Importance of biomaterials: hydrogel, fibres, bio-ceramics, bio-elastomers and membrane

UNIT 2 (5 Weeks)

POLYMERS AS BIOMATERIALS

Sources, properties and applications: polyamides, polyesters, carbohydrates, natural gums, polyurethanes, polylactic acid, alginates, silicone.

UNIT 3 (6 Weeks)

BIOMATERIALS FOR ORGAN TRANSPLANTS & DRUG DELIVERY

Properties and uses of polymers for organ transplant e.g. dental cement, orthopedic, skin, artificial kidney etc., basic concept of tissue engineering, uses of cellulose, chitosan and alginate
Introduction to drug delivery, polymers in controlled drug delivery, dressing strips, polymer drug vessels, core shell and nanogels

PRACTICAL COMPONENT- (CREDIT:02, Laboratory Period:60, 15 Classes of 4 Hrs each)

- 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

- 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.

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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 (DSE-06-CP)	4	2	0	2	12Th science	---

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

- Understand synthesis and requirement of doping in polymers.
- Analyze properties of conducting polymers

SYLLABUS OF DSE-6

THEORY COMPONENT-

UNIT 1(4 Weeks)

BASIC ASPECTS OF CONDUCTING POLYMERS

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

UNIT 2 (5 Weeks)

SYNTHESIS OF CONDUCTING POLYMERS

Chemical and electrochemical polymerizations: polyaniline, polypyrrole, polythiophene etc.; doping and its effects on properties of conducting polymers

UNIT 3(6 Weeks)

PROPERTIES & APPLICATIONS OF CONDUCTING POLYMERS

Electrical properties, resistance, impedance, capacitance, magnetic properties and optical properties

Electronic devices, sensors, rechargeable batteries, solar cells, light emitting devices, biomedical devices, bio-system, organ transplant, artificial mussels and EMI shielding etc.

PRACTICAL COMPONENT- **(CREDIT:02, Laboratory Period:60, 15 Classes of 4 Hrs each)**

- Synthesis of polyaniline, polypyrrole and polythiophene by chemical polymerizations.
- Synthesis of conducting polymers by electro chemical polymerizations.
- To improve electrical conductivity of PANI by 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 light emitting devices for conducting applications.

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.

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.
- Gupta, R. K. (Ed.). (2022). Conducting Polymers: Chemistries, Properties and Biomedical Applications. CRC Press.

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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 (DSE-07-BBP)	**4**	**2**	**0**	**2**	**12Th science**	**---**

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

COURSE LEARNING OUTCOMES:

After studying this paper, students will be able to

- Gain knowledge of biopolymers applications
- Characterize and analyze biopolymers

SYLLABUS OF DSE-7

THEORY COMPONENT-

UNIT 1 (6 Weeks)

BASICS TO BIOPOLYMERS & NATURAL MACROMOLECULES

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

PROCESSING (4 Weeks)

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

UNIT 3 (5 Weeks)

APPLICATIONS

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

PRACTICAL COMPONENT- (CREDIT:02, Laboratory Period:60, 15 Classes of 4 Hrs each)

- 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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