

DR. A. P. J. ABDUL KALAM TECHNICAL UNIVERSITY
LUCKNOW, UTTAR PRADESH



SYLLABUS & EVALUATION SCHEME WITH SYLLABUS

FOR

B. TECH. 4th YEAR

PLASTIC ENGINEERING

AS PER

AICTE MODEL CURRICULUM
[Effective from the Session: 2025-26]

**B. Tech Plastic Engineering
Evaluation Scheme
Effective Session 2025-26**

		SEMESTER- VII												
S. No.	Code	Subject	Learning Mode	LTP			Evaluation Scheme						Total	Credit
				L	T	P	CT	TA	Total	PS	TE	PE		
1	BPE701	Polymer Composites	Offline	3	-	-	20	10	30	-	70	-	100	3
2	BPE071 to BPE074	Departmental Elective-IV	Offline	3	-	-	20	10	30	-	70	-	100	3
3	BOEP**	Open Elective-II	Offline/ MOOCs	3	0	0	20	10	30	-	70	-	100	3
4	BPE751	Polymer Composites Lab	Offline	0	0	2	-	-	-	50	-	50	100	1
5	BPE752	Mini Project or Internship Assessment*		0	0	4	-	-	-	100	-	-	100	2
6	BPE753	Project-I		0	0	10	-	-	-	150	-	-	150	5
7	BPE754	Startup and Entrepreneurial Activity Assessment#		0	0	4	-	-	-	100	-	-	100	2
		Total		9	0	20							750	19
		PC- Program Core *The Mini Project or internship (5-6 weeks) conducted during summer break after VI semester and will be assessed during VII semester. #The Startup and Entrepreneurial Activity Assessment will be done in 7 th semester under which a student will have to <u>undergo a startup/entrepreneurship activity of at least 60 hours till 6th semester</u>												

Departmental Electives

	Specialization -1	Specialization -2	Specialization -3	Specialization -4
	BPE071	BPE072	BPE073	BPE074
Departmental Elective-IV	Polymers for Energy Storage Applications	Biomedical Plastics	Conducting Polymers	Polymer Structure Property relationship

SEMESTER- VIII														
S. No	Code	Subject	Learnin g Mode	Periods			Evaluation Scheme						Total	Credit
				L	T	P	CT	TA	Total	PS	TE	PE		
1	BOEP**	Open Elective-III	MOOCs	3	0	0	20	10	30		70		100	3
2	BOEP**	Open Elective-IV	MOOCs	3	0	0	20	10	30		70		100	3
3	BPE851	Project-II		0	0	18				100		350	450	10
		Total		6	0	18	24						650	16

Subject Code: BPE701	Polymer Composites	L T P : 3 0 0	Credits: 3
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Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understand the concepts of polymer composites and their applications	K2
CO-2	Understand of theories of composite formation and mechanism of load transfer	K2
CO-3	Acquire knowledge of various techniques for compounding thermoplastics.	K2
CO-4	Understand the process of manufacture of fiber reinforced plastics	K2
CO-5	Acquire knowledge of testing & characterization of composites	K2

UNIT I

Introduction to composite materials

Classification - advantages - polymer composites. Thermosetting and thermoplastic matrix materials – Reinforcements-Types and Forms-particulate, flake, fibrous etc.- coupling agents-Principles of composite reinforcement. Effect of reinforcement on composite properties.

UNIT II

Theory of composite materials

Calculation of composite properties- mechanism of load transfer, minimum and critical fibre content, critical fibre length- Rule of mixtures – Halpin -Tsai - equation.

UNIT III

Compounding of Thermoplastics

Twin screw extrusion, compression moulding- compounding of polyolefins, polystyrene and styrene copolymers, engineering polymers, wood floor and natural fiber filled plastics, compounding lines, post compounding operations.

UNIT IV

FRP processing

Important methods - hand layup, spray up, filament winding, compression moulding, injection moulding, resin, transfer moulding, reaction injection moulding, pultrusion,

Miscellaneous Methods

Machinery, operation, advantages and disadvantages.

UNIT V

Characterization of Composites

Control of particle/fibre and porosity content, particle/fibre distribution, Interfacial Reaction of matrix-reinforcing component, Coating of reinforcing component, Strength analysis

Testing Quality control & end use of Composites

Testing for mechanical, electrical, thermal, optical and chemical properties, Determination of shelf life and gel time – Non-destructive testing methods.

Application of composite

Marine, chemical, railways, electrical and electronic industry, space structures, Robotics.

Text Books:-

1. J.A.Brydson, "Plastics materials", Butterworth- Heinemann - Oxford, 6th Ed., 1995.
2. S.T.Peters, "Handbook of Composites", Chapman & hall, 2nd Edition 1998.

References:-

1. G Lubin, "Hand Book of Composites", 2nd Ed, Van Nostrand Reinhold, New York, 1982.
2. F.L. Matthews and R.D. Rawlings, 'Composite materials: engineering and science', Chapman and Hall, 1994.
3. P.K. Mallick, 'Composites Engineering Handbook', Marcel Dekker Inc.NY., 1997.
4. D. Hull and T. W. Clyne, "An introduction to Composite Materials 2nd Ed", Cambridge, 1996
5. Astrom; B.T, Manufacture of Polymer Composites, Chapman and Hall, London(1997).

Subject Code: BPE751	Polymer Composites Lab	L T P : 0 0 2	Credits: 1
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Course outcomes: The students will be able to		Blooms Taxonomy
CO1	Understand the principles and techniques of polymer composite fabrication, including Hand Lay-Up, Compression Molding, Injection Molding, and Extrusion.	K1
CO2	Apply composite fabrication techniques to create polymer composite sheets, rods, and films using various methods.	K3
CO3	Analyze mechanical and thermal properties of composites using tests like tensile, impact, DSC, and TGA to assess material performance.	K4
CO4	Evaluate polymer composite quality through mechanical, thermal, and morphological tests, including SEM for fiber-matrix interaction.	K6
CO5	Design and create polymer composite systems by selecting suitable fabrication methods and materials to optimize performance.	K6

Study of the following

Sl.No.	Name of the Experiment
1	Fabrication of FRP Composite by Hand Lay-Up Method
2	Manufacturing of Composite Sheet by Compression Molding
3	Preparation of Fiber Reinforced Samples by Injection Molding
4	Fabrication of Bi-layer Film by Blown Film Extrusion
5	Manufacturing of Composite Rods by Twin Screw Extrusion
6	Extrusion of Filled Polymer Strips (Single Screw Extruder)
7	Development and Characterization of Polymer Composite Films
8	Mechanical Testing of Fabricated Composites
9	Thermal Characterization of Polymer Composites using DSC and TGA
10	Morphological Characterization using SEM (Scanning Electron Microscopy)

Semester – VII: Departmental Elective – IV

Subject Code: BPE071	Polymers for Energy Storage Applications	L T P : 3 0 0	Credits: 3
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Outcomes: They should be able to:		Blooms Taxonomy
CO-1	Draw the molecular structure of common conducting polymer monomers/polymers	K3
CO-2	Know basic synthetic methods	K1
CO-3	Understand the concept of doping and dedoping	K2
CO-4	Be familiar with common applications of conducting polymers and the science behind them	K2
CO-5	Be familiar with the history of the field, some leading scientists and classical references, and some current research activities in the field	K2

OBJECTIVE:

- To enable the students to understand the basic concepts on conducting polymers, conduction mechanism, various methods of synthesis and characterization of conducting polymers and their applications.

UNIT I ELECTROCHEMISTRY OF CONDUCTING POLYMERS

Electrochemistry of electronically conducting polymers-source of electronic conduction in polymers – solitons, polarons and bipolarons – semiconductors and conducting polymers.

UNIT II GENERAL SYNTHESIS OF CONDUCTING POLYMERS

Synthesis of conducting polymers – chemical, electrochemical and enzymatic methods – doping – general considerations – measurement of conductivity – van der Pauw technique – factors affecting conductivity.

UNIT III CHARACTERIZATION OF CONDUCTING POLYMERS

Characterization of conducting polymers – electro analytical techniques – cyclic voltammetry, chronoamperometry and chronocoulometry, spectral methods - use of UV-vis, Raman, XRD and NMR.

UNIT IV SYNTHESIS, PROCESSABILITY AND APPLICATIONS

Synthesis, processability and applications of acetylene, aniline, pyrrole, thiophene and para – phenylene based conducting polymers.

UNIT V APPLICATIONS OF CONDUCTING POLYMERS

Conducting polymers in microelectronics – corrosion and ESD protection, EMI shielding and lithography. LED-rechargeable batteries – artificial muscles - electrochromic devices– sensor devices–conductive composites.

REFERENCES

1. Skotheim.T.A., Elsenbaumer.R.L. and Reynolds J.R., “Hand book of Conducting Polymers”, 2nd Edn, Marcel Dekker Inc., New York, 1998.
2. Margolis J.M., “Conducting Polymers and Plastics”, Chapman and Hall, London, 1989.
3. Seymour R.B., “Conductive Polymers”, Plenum Press, New York, 1981.
4. Tadmore Z., “Principles of Polymer Processing,” Wiley – Interscience, New York, 1979.
5. Wessling B., “Electronic Properties of Conjugated Polymers,” Vol.3, Springer, Berlin, 1989.
6. Kiess H.G., “Conjugated Conducting Polymers,” Springer, Berlin, 1992.
7. Soane.D.S. and Martynenko.Z., “Polymers in Microelectronics”, Elsevier,Amsterdam, 1989.

Semester – VII: Departmental Elective – IV

Subject Code: BPE072	Biomedical Plastics	L T P : 3 0 0	Credits: 3
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Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Acquire knowledge of nature and application of biomedical plastics	K2
CO-2	Understand various aspects of natural biomedical polymers	K2
CO-3	Acquire knowledge about various applications of polymers in biomedical devices	K2
CO-4	Understand the various aspect of application of polymers in soft lenses	K2
CO-5	Understand the various aspect of biopolymers in dental field	K2

UNIT I**Introduction to biomedical applications of polymers.**

Contemporary biomedical materials, Their advantages over other materials in use.

Biomaterials

Biomaterials, Biocompatibility, Stabilization, Inflammation and Wound Healing, Blood Clotting System, Kinn System, Biological response to Implants, Implant Design and Applications.

UNIT II**Biomedical Polymers**

Natural biomedical polymers (natural rubber, representative biopolymers) Biodegradation and biodegradable polymers like polylactides, polyglycolides and their copolymers; polydioxanones etc., Criteria for the Selection of Biomedical Polymers, Physicochemical Aspects of the Blood Compatibility of Polymeric Surface. Biomedical Polymers from biological sources: Poly hydroxy Alkanoic Acids, Microbial polysaccharides, Silk, Collagen, Microbial Cellulose, Hyaluronic Acid, Synthetic Polymers such as PTMA, Silicon Rubber, Polyethylene, Natural Rubber, Hydrogels.

UNIT III**Biomedical Applications of Polymers**

Permanent implants For Function- Orthopaedics, Cardio Vascular, Respiratory Patches and Tubes, Digestive System, Genitourinary System, Nervous System, Orbital (Corneal And Lens Prosthesis) – Permanent Implant For Cosmeses, Other Applications of Engineered Material In Clinical Practices, Silicone Implants, Polymer Membranes, drug delivery systems, Polymer Skin, Polymeric Blood substitute. Properties and applications of various polymers used for biomedical polymers Synthetic biomedical polymers [Polyolefins; PVC, Polyacrylates, Polystyrenes and its copolymers, Polyesters, Polyamides (Nylons), Fluorocarbon polymers, Polyacetals, Polycarbonates, Polysulphones, Epoxy resins]

UNIT IV**Polymeric Lenses**

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.

UNIT V

Dental Polymers

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

Reference Books:

1. H.F. Mark (Ed), Encyclopedia of polymer science and engineering, John Wiley and Sons New York, 1989.
2. Galin and M. Ruben Ed., Soft compact Lenses clinical and applied Technology. John Wiley and Sons, Inc. New York, 1978.
3. HR Allcock, FW Lampe and JE Mark. Contemporary polymer chemistry (3rd edition). Pearson Education, Inc (Pearson/Prentice Hall)
4. Manas Chanda, Salil K. Roy (Ed) Plastic Technology Hand Book Marcel Dekker, Inc. New York, 1993.

Semester – VII: Departmental Elective – IV

Subject Code: BPE073	Conducting Polymers	L T P : 3 0 0	Credits: 3
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Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understanding of the basics of conducting polymers and their conduction mechanism	K2
CO-2	understand various types of conducting polymers and their properties	K2
CO-3	Aquire knowledge about various mechanisms and techniques used in synthesis of conducting polymers	K2
CO-4	Understand various characterization techniques for conducting polymers	K2
CO-5	Acquire knowledge of various applications of conducting polymers	K2

UNIT I**Introduction**

Need of conducting polymers, Classification of conducting polymer, Concept of doping, n-Type, p-Type, Electrochemistry of electronically conducting polymers-source of electronic conduction in polymers, polaron, bipolaron, conduction mechanism.

UNIT II**Properties of conducting polymers**

Structure-property relationship, Types of conducting polymers, e.g. Polyaniline (PANI), Polypyrrole (PPy), Polythiophene (PTh), Discovery of polyacetylene

UNIT III

Synthesis of conducting polymer-Chemical synthesis, electrochemical synthesis, template synthesis, precursor synthesis, soluble polymers (Colloid and dispersion), advantage and disadvantage of various synthesis methods. General Methodology; Synthesis and processability of selected conducting polymers like – Polyacetylene, Polyaniline, Polypyrrole, Polythiophene and Poly-para – phenylene

UNIT IV**Analytical Techniques for Characterization of Conducting polymers**

IR ,UV, Impedance spectroscopy, Fourier Transform Infra-red spectroscopy, X-ray photoelectron spectroscopy, Scanning Electron microscopy (SEM), Transmission electron microscopy(TEM), Electrochemical quartz crystal micro balance(EQCM), Four Probe conductivity measurement, Galvanostat/Potentiostat

UNIT V**Applications**

Rechargeable batteries, o-LED, Gas sensors, Bio sensors, Photovoltaic energy device, Microelectronics, PCB fabrication, Electro catalyst. Application proposed antistatic coating, electrochemical mechanical device, super capacitor, Telecommunication system, Electromagnetic screening material, Analytical sensor. Recent trend in conducting polymer, functionalized conducting polymer (Second generation polymer), Super conductor (Inorganic, organic hybrid structure), Conducting polymer based on nano composite.

Text book :-

1. Electrochemical science and technology of polymers -1 & 2 ed., R.G Linford, Elsevier applied sciences, London 1987 and 1989.

Reference Books:

1. Hand book of Conducting Polymers: Terje A. Skotheim (Vol.1), Dekker (668.42)
2. Hand book of Polymer Synthesis (Part B): Hans Kricheldorf, Dekker (668.9).
3. Sensors: Principles and Applications: Peter Hauptmann, Prentice Hall
4. Polymer Science and Technology: Premamoy Ghosh, Tata McGraw Hill (668.42).
5. Hand book of organic conductive molecules and polymers, Hari singh Nalwa (ed.), 4-Volume set, John wiley and sons, England 1997.

Semester – VII: Departmental Elective – IV

Subject Code: BPE074	Polymer Structure and Property Relationship	L T P : 3 0 0	Credits: 3
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Course Outcomes: The students will be able to		Blooms Taxonomy
CO-1	Understand the basics of structure and properties of polymers.	K2
CO-2	Acquire knowledge about effect of polymer structure on various properties of polymers.	K2
CO-3	Acquire knowledge of different thermal transitions in polymers	K2
CO-4	Understand various electrical and optical properties of polymers	K2
CO-5	Understand various chemical properties of polymers	K2

UNIT I**Structure of polymers**

Linear, branched, cross-linked and network polymers – Homochain and hetero atomic chain polymers- Copolymers-Linear and cyclic arrangement – Prediction of polymer properties, group contribution techniques, topological techniques- Volumetric properties-molar volume, Density, Vander Waals volume
- Coefficient of linear thermal expansion and volumetric thermal expansion – Pressure volume temperature (PVT) relationship.

UNIT II**Stress-strain properties of polymers**

Effect of polymer structure on modulus of elasticity, tensile strength, flexural strength, impact strength, yield strength, fracture toughness –Crazing in glassy polymers - Ductile brittle transition. Effect of additives on mechanical properties of polymers - Creep, stress relaxation and fatigue.

UNIT III**Thermodynamic and transition properties**

Transition temperature in polymers, glass transition (T_g), melt transition (T_m), relationship between T_g and T_m – other transitions like β -transitions, upper and lower glass transition temperatures-Prediction of T_g and T_m of polymers by group contributions.

Calorimetric properties – Heat capacity, specific heat, latent heat of crystallization and fusion, enthalpy and entropy – Calculation of heat capacities of polymers.

UNIT IV**Electrical and optical properties**

Effect of polymer structure on Dielectric constant, power factor, dissipation factor and loss factor effect of frequency of voltage and temperature on dielectric properties - Prediction of molar polarization and effective dipole moment. Effect of additives on electrical properties of polymers. Optical properties- Effect of polymer structure on optical properties-clarity, transparency, haze, transmittance, reflectance and gloss – Prediction of refractive indices of polymers by group contributions.

UNIT V**Chemical Properties**

Cohesive energy, cohesive energy density, solubility parameter, determination of solubility parameter of polymers – Prediction of solubility parameter- Effect of polymer structure on solubility in solvents and oils - Influence of structure in prediction of flame retardancy, water repellency – Chemical resistance of polymers - Polymer toxicity.

Reference :-

1. D.W. Van Krevelen and P.J. Hoftyzen, "Properties of Polymer , 3rd Edition Elsevier Scientific, Publishing Company Amsterdam - Oxford - Newyork . 1990.
2. J.E. Mark Ed.AIP, Physical Properties of Polymers Handbook, Williston, Vt, 1996.