GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Rubber Technology
Subject Code : BE03026011
Subject Name : Rubber Technology

w. e. f. Academic Year:	2024-25
Semester:	3
Category of the Course:	PCC

Prerequisite:	None
Rationale:	This course on Rubber Technology is designed to equip students with the fundamental and advanced knowledge required for understanding and working with rubber and polymeric materials. The course covers essential knowledge areas such as polymer chemistry, material morphology, environmental sustainability, and product innovation. By understanding the chemical composition, chain orientation, morphology, and degradation mechanisms of rubber, students are prepared to tackle real-world challenges in industries that rely on these versatile materials. The curriculum was designed to meet the educational needs of this emerging engineering discipline.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Explain the importance of structure and synthesis of polymers.
02	Identify and describe the importance of monomeric ingredients in rubbers & Calculate the molecular mass and molecular weight of different rubbers
03	Assess the specific features of polymer sorbents.
04	Correlate and differentiate the mechanisms of various types of rubber degradation.

Teaching and Examination Scheme:

Teaching - Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL*	TH		ESE (E)	PA (M)	PA/ (I)	PBL (I)	ESE (V)	
45	0	30	45	120	04	70	30	20	30	50	200

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End-Semester Examination, PA = Progressive Assessment

*** Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.**

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	Natural Polymers: Natural polymers like Rubber, Lignin, humus, coal, kerogen, asphaltene, shellac, amber, Tall oil-derived polymers, Polysaccharides like Cellulose, Regenerated cellulose, derivatives of cellulose, starch, derivatives of starch, other Polysaccharides, Proteins like Amino acids, polypeptides and Proteins, Protein structure, synthesis of polypeptides and proteins, wool, silk, collagen, and regenerated protein, Nucleic acids, its structure and Nucleic acids synthesis	07	20
2.	Chemical Composition of Rubbers: Chemical Composition of the Rubber & Polymer Molecule, Monomeric Ingredients in the Final Polymer Composition.	06	10
3.	Chain Orientation of Rubbers & Polymers: Concept of chain orientation, Orientation in amorphous and crystalline Polymers, Uniaxial and biaxial orientation, practical significance, orientation process, properties of oriented polymers	06	15
4.	Morphology and order in crystalline Rubbers & Polymers: Introduction, Configuration involving an asymmetric carbon atom, Structural requirements for crystallinity, The amorphous state, Crystallinity, Polymer Morphology (Glass Transition temperature) (Tg), Thermal transition in polymers, Physical Properties and Morphology of polymers, Other factors affecting crystallisability, Effect of Crystallinity on the properties of polymers, Property-Molecular Weight Relationships, Molecular Weight Distribution, Interchain and intrachain forces, Crystalline-Amorphous Structures, Transitions.	06	15
5.	Monomers for the production of Rubbers: Butadiene (1,3-butadiene),production of Butadiene from n-Butenes, production of Butadiene from n-Butane, production of Butadiene by steam Cracking of Naphtha Petroleum Fraction, production of Butadiene from Ethyl Alcohol, Reppe Process, production of Butadiene from acetaldehyde, production of Styrene by Dehydrogenation of Ethylbenzene, production of Styrene by Oxidation of Ethylbenzene, Acrylonitrile ,production of Acrylonitrile by reaction between Acetylene and Hydrogen Cyanide, production of Acrylonitrile by reaction between ethylene Oxide and Hydrogen Cyanide, production of Acrylonitrile by reaction between Propylene and Ammonia in the presence of Oxygen, production of	08	20

	Acrylonitrile by reaction between Propylene and Nitric Oxide, Isoprene(2-methyl-1-,3-Butadiene), production of Isoprene by the Propylene Dimer Process, production of Isoprene by Dehydrogenation of Isopentane and /or 2- Methyl Butenes, production of Isoprene by the Isobutene Formaldehyde process, production of Isoprene by the acetone-acetylene Process, Chloroprene(2-Chloro-1,3-Butadiene), production of Chloroprene from Acetylene, production of Chloroprene from Butadiene, Ethylene, Propylene, Isobutene(Isobutylene) Acrylic Monomers, Vinyl Chloride, Vinyl Acetate.		
6.	Polymer sorbents & Porous structure of Polymers: Sorption & Adsorption, Porosity & Methods of its Estimation: Calculation of specific surface area of sorbent, calculation of total pore volume of sorbent, Methods of Forming porous Structure of polymers, porous structure of polymers, classification of polymer sorbents, Mechanism of Sorption of Low-Molecular substances by polymers.	06	10
7.	Polymer Degradation: Introduction, Types of degradation, thermal degradation, mechanical degradation, degradation by ultra sonic waves, photo-degradation, degradation by high-energy radiation, oxidative degradation, hydrolytic degradation. Ozone oxidation degradation, Oxidative degradation of saturated polymers, oxidation of phenol formaldehyde, Antioxidants Etc.	06	10
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	10	20	10	10	10

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Polymer Chemistry An Introduction by Malcom P. Stevens
2. Text Book of Polymer Science, Third Edition by Fred W. Billmeyer, JR
3. Introductory Polymer Science By S. K. Bashin & Rekha Mann
4. Synthetic Rubbers, their Chemistry and Technology, by D. C. Blackley
5. Polymer Latices Science and Technology, Second Edition: Volume- 3 Applications of Latices, by D. C. Blackley

6. Polymer Structure, Properties and Applications by Rudolph D. Deamin.
7. Physical Chemistry of Polymers by A. Tager

(b) Open source software and website:

1. www.vosflips.com/recycling/natural-rubber-cultivation-process/
2. www.sciencedirect.com/science/article/pii/S0032386100008533
3. www.researchgate.net/.../0141-3910_Polymer_Degradation_and_Stabilit.
4. www.rubberchemtechnol.org/doi/pdf/10.5254/1.3538460
5. www.bioe.psu.edu/labs/yang.../Richard%202010%20Soft%20Matter.

Suggested Course Practical List: If any

Practical based on above topics.

List of Laboratory/Learning Resources Required:

Suggested Project List:

1. Study various natural polymers (e.g., Hevea brasiliensis, guayule, dandelion) and their potential for rubber production.
2. Compare the mechanical properties and environmental impact of rubbers derived from different natural polymers
3. Analyse the chemical composition of different rubbers (e.g., natural rubber, styrene-butadiene rubber) and their behaviour during vulcanization.
4. Investigate how changes in chemical composition affect the rubber's elasticity, strength, and heat resistance.
5. Study the influence of chain orientation and molecular alignment in rubber and polymer materials.
6. Investigate how the stretching, orientation, and crystallinity impact the mechanical properties like tensile strength, elongation, and modulus.
7. Investigate the synthesis and properties of various monomers (e.g., butadiene, isoprene, chloroprene) used in the production of rubbers.
8. Study how different monomers influence the final properties of the rubber, such as flexibility, durability, and resistance to heat or chemicals.
9. Develop polymer-based sorbents with a porous structure for applications like water purification, oil spill cleanup, or air filtration.
10. Characterize the porosity, surface area, and absorption efficiency of these polymer sorbents.
11. Investigate different degradation mechanisms (thermal, oxidative, UV, or chemical) that affect the durability and performance of rubbers.
12. Propose methods for enhancing rubber stability, such as through antioxidants, UV stabilizers, or protective coatings.

- **List of suggested activities for Problem Based Learning:**

Sl. No.	Name of the activity	No. of hours	Evaluation Criteria
1.	Online Course	Minimum duration of the course should be 20 h.	Based on assignment submitted and certificate produced.
2.	Virtual Industry Trip	Duration of hours-5h Report preparation- 5h Total -10 h	Based on report submitted. Report should contain manufacturing process, flow chart.
3.	Self-Learning Through Assignment Creation related to subject	Completion of five independent tasks, each designed for a 3-hour engagement. Total = 15h	Based on assignment submitted.
4.	Case Study Analysis related to subject	Duration of data collection -6 h Report preparation – 4h Total- 10 h	Based on Problem identification, depth of analysis, technical insight, application relevance
5.	Technical Article/Video Reviews related to subject	Duration of Review -6h Report preparation -4h Total-10h	Relevance of content, clarity of summary, insights drawn, conceptual understanding
6.	Peer Teaching Video	2 video preparation -10 h	Create a 5–10-minute video explaining a rubber technology concept for peers, incorporating visuals.
7.	DIY Experiments	5 hours including report preparation	Based on report submitted. Report should contain experiments performed which have Creativity, relevance to rubber properties, observation documentation, safety awareness.
8.	Glossary Compilation	Duration -5h	Based on report submitted. Report should contain Accuracy, completeness, formatting, and use of illustrations/examples
9.	Videos focusing on industrial safety topics relevant to the subject	Duration of video = 5h Report preparation = 5h Total = 10h	Based report submitted. Report should contain all safety aspects explaining its importance.

10.	Visual presentation of technical content through posters, charts, or PowerPoint slides	Duration = 10 h	Based on quality of poster/chart preparation, creativity, accuracy and effectiveness of presentation skills.

- All records pertaining to the evaluation and assessment of self-learning activities must be properly maintained and preserved at the institute level. These records should be made available to the university upon request.
- Institutes are encouraged to utilize digital platforms, such as Microsoft Teams, for effective record-keeping and to ensure transparency in the evaluation and assessment of self-learning activities.