GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering
Level: Under Graduate
Branch: Rubber Technology
Subject Code : BE05026101
Subject Name : Thermoplastic Elastomers and Polymer Blends

w. e. f. Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Elective Course - 1

Prerequisite:	None
Rationale:	This course provides knowledge of Thermoplastic Elastomers (TPEs) including their synthesis, morphology, structure–property relationships, compounding, processing, and applications. It covers major TPE systems such as SBC, copolyesters, TPO, TPU, thermoplastic rubber blends, and crosslinked polyethylene. The course also introduces recyclable and recycled TPE materials along with recent technological developments, enabling students to understand modern elastomer processing, material selection, and sustainable polymer engineering practices.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	Marks % weightage
01	Explain the importance and industrial applications of thermoplastic elastomers in the rubber field.	20
02	Evaluate the rheological behavior and processing characteristics of thermoplastic elastomers.	25
03	Identify and analyze the properties of unvulcanized rubber–plastic blends.	20
04	Classify and apply analytical methods used for characterization of thermoplastic elastomer blends.	20
05	Differentiate between polyester amide and polyether ester amide thermoplastic elastomers based on structure, properties, and applications.	15

Teaching and Examination Scheme:

Teaching/Learning Scheme in hrs/semester					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Practical			
L	T	P	PBL*	TH	TH/30	ESE (E)	PA (M)	PA (I)	PBL (I)	ESE (V)	
45	0	30	15	90	3	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.	Introduction: Introduction of Thermoplastic elastomers (TPEs), Classification, Synthesis, Morphology of Thermoplastic Elastomers, Properties & Effect of Structure, Thermodynamics of Phase Separation, Rheology & Processing of Thermoplastic Elastomers, compounding Additives**,** Technological Application	05	10
2.	Thermoplastic Styrene Block Copolymers (SBC): Introduction, Polystyrene-Polydiene Block Copolymers, Structure and Composition, SBCs Synthesized by Carbocationic Polymerization, Synthesis and Manufacturing, Availability of Polymer, Properties, Compounding, Mixing & Processing, Applications.	06	15
3.	Thermoplastic Polyester Elastomers (Copolyesters) : Introduction and Segmented Block Copolymer Concept, Basic Structure, Synthesis and Chemistry, Manufacturing Processes, Comparison of Polyester-Based and Polyether-Based Copolyesters, Commercial Elastomer Grades such as Hytrel and Arnitel, Engineering and Mechanical Properties, Processing Methods (Injection Molding, Extrusion, etc..), Applications	06	15
4.	Thermoplastic Polyolefin based elastomers: Introduction, Formulation and Structure of TPO, Properties, Processing and fabrications, Application, Polyolefin-Based Elastomer Blends including Butyl Rubber with Polyethylene & Polypropylene, Ethylene/Propylene Copolymers & Terpolymers with Polyethylene & Polypropylene, Other Blends like Ethylene-Acrylate Copolymers (EEA) with Polyethylene, Ethylene Vinyl Acetate(EVA) and Vistaflex thermoplastics elastomers Manufacturing, Properties, Processing, Compounding, Applications.	06	15
5	Thermoplastic Polyurethane Elastomers (TPU): Introduction to Polyurethanes and Comparison between Thermoset PU and TPU, Classification (Polyester-Based and Polyether-Based TPU), Preparation and Urethane Chemistry, Reaction Components (Diisocyanates, Macrogylacols, Chain Extenders) and Their Structural Effects, Polymerization Processes, Characteristics of TPU , Molecular Weight Effects and Chemical Crosslinking Effects, Environmental Stability and Stabilization Methods, Compounding Additives, Processing Methods and Industrial Applications	06	15
6.	Thermoplastic Rubber Blends (TPE Blends and TPVs): Introduction to Elastomer–Thermoplastic Blends as Thermoplastic Elastomers, Difference between TPO and TPV, Preparation Methods (Melt Blending,	06	10

	Reactive Blending), Phase Morphology and Compatibilization, Properties of Unvulcanized Rubber–Plastic Blends, Dynamic Vulcanization Process and Concept of TPV, Properties of Thermoplastic Vulcanizates, PVC-Based Thermoplastic Elastomer Blends, Structure–Property Relationships and Industrial Applications.		
7.	Crosslinked Polyethylene (XLPE): Introduction, Basic Structure, Compounding & Mixing of Polyethylene, Processing, Properties of Crosslinked Polyethylene, Applications of Crosslinked Polyethylene, Distinction between Thermoplastic and Chemically Crosslinked Systems. Additional Types of Thermoplastic Elastomers : Thermoplastic 1,2-Polybutadiene, Trans-1-4-Polyisoprene, Polysiloxane based Thermoplastic Elastomers, Poly (Dimethylsiloxane) with Polyethylene – structure, properties, processing and applications.	05	10
8.	Thermoplastic Elastomers Based on Recycled Rubber and Plastics: Introduction, EPDM or TPE Scrap, Butadiene-acrylonitrile Rubber (NBR), Recycled Rubber, Waste Latex, Waste Plastics, Recycling Methods for Thermoplastic Elastomers (TPEs). Recycling Methods for Thermoplastic Elastomers (TPEs) Recent Developments and Trends, **IS 13360 Series** – Methods of Testing Plastics (TPE, TPU, XLPE, Copolyesters) and **IS 3400 Series** – Methods of Test for Rubber (TPV / rubber blends) for testing of Rubber and Plastics blends.	05	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**
12	12	16	10	10	10

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy) Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

References/Suggested Learning Resources:

(a) Books:

Reference Books:

1. Handbook of Elastomers: New Development & Technology, Edited by Anil K. Bhowmick, Howard L. Stephens
2. Thermoplastic Elastomers: A Comprehensive Review, Edited by N. R. Legge, G.Holden, H. E. Sehroeder
3. Rubber Materials & Their Compounds, by J. A. Brydson

4. Handbook of Thermoplastic Elastomer, Edited by Benjamin M. Walker
5. Science & Technology of Rubber, Edited by James E. Mark, Burak Erman, Frenrick R. Eirich
6. Handbook of Rubber Technology, Volume-3: Recycling & Pollution Control in Rubber Industries, Edited by J. M. Martin, W. K. Smith

(b) List of Open Source Software/learning website:

- **http://onlinelibrary.wiley.com/**
- **http://www.sciencedirect.com/**
- **https://www.crcpress.com/**

Overall SDG Mapping:

The Thermoplastic Elastomers course primarily supports **SDG 9** through advanced material innovation and processing technologies. It contributes to **SDG 12** by promoting recyclable elastomers and utilization of recycled rubber and plastics, and supports **SDG 13** and **SDG 7** through energy-efficient processing and sustainable material development for modern engineering applications.

Activities suggested under problem based learning:

Sr 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.	Assignments	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	Relevance of content, clarity of summary, insights drawn, conceptual understanding

		Total-10h	
6.	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.
7.	Course Seminar	Duration -10h	Based on technical Content & Understanding, Analysis, literature review, Quality of report and presentation.
8.	Mini/ Micro Project	Duration -10h	Based on Technical Analysis, literature review, methodology, innovation/ sustainability aspect, Quality of report and presentation.
9.	Complex Problem solving	Duration -5h	Evaluation is based on problem complexity & clarity, analytical approach, design/experimental methodology, use of modern tools, sustainability considerations, innovation, result validation, and feasibility of solution.
10.	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.
11.	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.

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