GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3132604
Semester III
Rubber Physics & its thermodynamics

Type of course: Engineering science

Prerequisite:

Rationale:

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Rubber Science:** Introduction of science of large molecule, Classification of polymers, Forms of polymers, Tactility, Functionality, types of polymers, Degree of Polymerization, Types of polymerization Techniques, Strengthening of polymers. Structure/Property Relations in Rubbers, Conditions for Rubber like Elasticity in Polymers, Molecular Motion in Rubbers, Characteristic Properties of Rubbers, Classification of Rubbers, Chain Structure & Chemical Reactivity of Rubbers, Molecular Masses & Sizes, Determination of Reactive Molecular Mass, End group analysis, Viscosity method, General rules for Polymer Solubility, Basic Concepts & Behaviors of Elasticity, Elasticity of a single molecule, Elasticity of a Three-Dimensional Network of Polymer Molecules.	**10**
2	**Rubber Physics :** Density, Archimedes Principle, Laws of Flotation, Elastic Behavior of Bodies, Young's Modulus, Shear Modulus, Bulk Modulus, The four Elastic Constants, Elastic Strain Energy, Difference between Rubbery & Elastic Deformations, The Theory of Rubber Elasticity, Elastic collisions, Viscous Flow of Liquids, Measurement of Viscosity, Surface Tension, SurfaceTension Measurement, Friction, Static, Sliding & Rolling Friction, Sliding Friction of Rubber, Rolling of Rigid bodies down Rubber tracks.	**06**
3	**Energy & The Electromagnetic Spectrum :** Electromagnetic Radiation & its Properties, Absorption & Scattering of Light, Critical Angle & Total Internal Reflection, The Refractive Index of Polymers, Magnification Pigments.	**06**
4	**Basic Concepts of Thermodynamics:** Terminology of thermodynamics, Zero law of thermodynamics , first law of thermodynamics, Second law of thermodynamics , Concept of enthalpy, reversible isotherm, heat capacity, Concept of entropy, entropy change in reversible & irreversible process, entropy of phase transition, free energy & its change of an ideal gas in isothermal change, Gibbs-Helmholtz equation.	**10**
5	**Fundamental Principles of Thermodynamics:** Balance Equations, Basic thermodynamics for Rubber Elasticity & Strain induced Crystallization. Basics of Devolatilization, Devolatilization of Particulate polymer, Devolatilization of Polymer Melts.	**03**

6	**Heat of Polymerization and Ceiling Temperature:** Heat of Polymerization (ΔH_P), Factors affecting ΔH_P. Variations in Heat of Polymerization. Estimation of Heat of Polymerization. Concept of Ceiling Temperature, Spontaneity, Conditions for Polymerization Reaction.	**04**
7	**Thermodynamics of Polymer Solutions:** Basic concepts of solutions, Flory-Huggins theory**:** Entropy of mixing on formation of an Thermal solution, change in Gibbs Free Energy on Dissolution of Polymers, Phase equilibrium in polymer solutions.	**04**
8	**Thermodynamics of Binary Polymer-Polymer Systems :-** Enthalpy of Mixing of Two Polymers, Free Energy of Mixing of Polymers, Entropy of Mixing of Two Polymers, Phase Diagrams of Polymer-Polymer Systems.	**04**
9	**Thermodynamic Properties:** Relationship between molecular weight and two fundamental thermodynamic properties (1) Thermal conductivity (2) Coefficient of Thermal Expansion., Thermodynamic forces favoring maximum potential Crystallinity.	**04**
10	**Thermodynamics Investigation of Polymer-Polymer Systems.** Three- component Systems.	**03**

Suggested Specification table with Marks (Theory): (For BE only)

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

Reference Books:-

- Science & Technology of Rubber, by James E. Mark, Burak Erman, Frederich R. Eiric
- Principles of Polymer Systems, by Ferdinad Rodrigeuz
- Rubber Engineering, IRI
- Physical Chemistry of Polymers, by A. TAGER, MIR Publishers-Moscow
- Engineering Chemistry by Jain & Jain
- Polymer Processing Principles and Design, by Donald G. Baird, Dimitris I. Collias
- Polymer Structure, Properties and Applications by Rudolph d. Denim
- Thermodynamics of Polymerization', Hideo Sawada.

Course Outcome:

After learning this course students will be able to:

Sr. No.	CO statement	Marks % weightage
CO-1	Understand the Science of Motion of Molecule and able to Interpret the Configuration & conformation of molecules & Macromolecules	20

CO-2	Learn the different laws of thermodynamics and able to Prepare the design models for elastomers based on fundamental of thermodynamic properties	15
CO-3	Compare Characteristic properties of Rubbers	15
CO-4	Analyze molecular masses & Sizes	15
CO-5	Apply knowledge and understanding the general rules of Polymer Solubility	20
CO-6	Measure the density, viscosity, surface tension, static and dynamic friction of rubber	15

List of Experiments:

Tutorials/Presentation/Practicals based on above topics.

Major Equipments:

Ph meter, Specific gravity balance, U-tube manometer, Weighing balance, Hot Plate etc.

List of Open Source Software/learning website:

- www.sciencedirect.com/science/book/9780124647862
- onlinelibrary.wiley.com/doi/10.1002/polb.21010/pdf
- www.sciencedirect.com/science/article/pii/0032395069902718
- www.iupac.org/publications/pac/26/3/0423/pdf/
- www.journals.elsevier.com/...journal...heat...mass-transfer/recent-articles/
- wolf.chemie.uni-mainz.de/.../thermodynamics_of_polymer_solutions.pdf
- fluid.wme.pwr.wroc.pl/.../combustion.../LIQUID_FUEL_COMBUSTION.
- www.chem.ufl.edu/~itl/4411L_f96/rubber/rubber_sav.html
- www.boundless.com › ... › The Laws of Thermodynamics