

GUJARAT TECHNOLOGICAL UNIVERSITY

Rubber Technology
SUBJECT NAME: Basic Rubber Science
SUBJECT CODE: 2132601
B.E. 3RD SEMESTER

Type of course: Core-I(B. E. Rubber Technology)Prerequisite:

Rationale:

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks						Total Marks
L	T	P		Theory Marks			Practical Marks			
				ESE (E)	PA (M)		PA (V)		PA (I)	
			PA		ALA	ESE	OEP			
3	0	3	6	70	20	10	20	10	20	150

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit; ESE- End Semester Examination; PA- Progressive Assessment; OEP-Open Ended problem; AL-Active learning;

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	Rubber Science: Introduction of science of large molecule, Classification of polymers, Forms of polymers, Tactility, Functionality, types of polymers, Polymerization, Degree of Polymerization, Types of polymerization, polymerization Techniques, Thermosetting & Thermoplastics polymers, Properties & uses, Crystallinity, Strengthening of polymers. Rubber Vulcanizates, Structure of Rubber Vulcanizates, Structure/Property Relations in Rubbers, Conditions for Rubber like Elasticity in Polymers, Molecular Motion in Rubbers, Characteristic Properties of Rubbers, Various states in Rubber Goods Manufacture, Classification of Rubbers, Chain Structure & Chemical Reactivity of Rubbers, Molecular Masses & Sizes, Determination of Reactive Molecular Mass, End group analysis, Osmotic pressure, Light Scattering, Ultracentrifuge methods, Viscosity method, General rules for Polymer Solubility, Thermodynamics of Polymer solution, Polymer solutions, Effect of Cross linking on Solubility, Solubility Parameter, Crystallinity & Orientation. The Crystalline Structure of Rubber, Strain Crystallizate Rubbers, Glass-Rubber Transition Behavior, Rubber Properties which change at Tg. Factors which influence Glass Transition in Amorphous Polymers.	10	15
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, Surface Tension Measurement, Friction, Static, Sliding & Rolling Friction, Sliding Friction of Rubber, Rolling of Rigid bodies down Rubber tracks.	6	10

3	Energy & The Electromagnetic Spectrum : Electromagnetic Radiation & its Properties, Absorption & Scattering of Light, Critical Angle & Total Internal Reflection, Refraction through a Parallel-sided Block, Refraction through a Triangular Prism, The Refractive Index of a liquid, Polarization, Refractive Index of Polymers, Magnification (Optical & Electron Microscope) Pigments.	6	5
4	Vibrations & Waves : Velocity & Absorption of Elastic Waves, Resonant Frequency & Transmissibility in Steady-state Forced Vibration, Transmissibility of Oscillations, Effect of Compounding on Transmissibility, Mechanism of Damping, Ultrasonic Applications in Rubber.	3	5
5	Heat Transfer: Principles involved in establishing Temperature Scale, Internations Temperature Scale, Measurement Principles, Electrical Resistance Thermosets, Thermoelectric Thermometers, Temperature Indicator Patches, Infrared Thermometers, Expansion of Solids & Gases, Polutropic Change, Gauge Pressure, Effects of Temperature change on Gas Pressure at Constant Volume, Vapor Pressure, Heat Transfer by Conduction, Determination of Thermal Diffusivity, Effect of Materials & Processing Variables on Thermal Properties, Thermal Conductors in series & Parallel, Concept of Film Heat Transfer Coefficient & Overall Coefficient of Heat Transfer, Conducting through Cylinders, Steam ,Energy Sources: Calorific Values, Convection Boundary Conditions, Heat Transfer by Radiation, Prediction of State of Cure, Time-Temperature-Fractional Conversion Charts, Combined Heat Transfer & Fluid Flow, Heat Flow through High Viscosity Polymer & Rubber melts during Processing.	6	10
6	Mass Transfer Fundamentals: Definitions of Concentrations & Velocities, Fluxes & their relationships, Fick's First Law of Diffusion, Microscopic Material Balance, Similarity with Heat Transfer, Simple Applications, Mass Transfer Coefficients, Definitions, Analogy between Heat & Mass Transfer.	4	10
7	Viscous Flow : Introduction, Viscosity, Polymer Shapes in Solution, Effect of Concentration & Molecular Weight, Effect of Temperature & Pressure, and Normal Stress Differences in Shear, Models for Non-Newtonian Flow, Viscometry, Rheometry, and Turbulent Flow etc.	4	5
8	Viscoelasticity of Rubber : Time-Temperature Equivalence, Molecular Model of Viscoelasticity, Creep, Stress Relaxations.	3	5
9	Colloid Science : Colloidal Dispersions, Stability of Colloidal Dispersions, Potential Energy Curves, General Properties of Colloidal Dispersions, Brownian Motion, Osmosis, Dialysis, Effect on Freezing & Boiling Point, Electrical Properties, Electrophoresis of Polymer Latices, Scattering of Radiation, Sedimentation & Creaming, Preparation of Colloidal Dispersions, Association Colloids, Gels, Emulsions.	8	10
10	Rubber Elasticity: Basic Concepts & Behaviour, Introduction, Elasticity of a single molecule, Elasticity of a Three-Dimensional Network of Polymer Molecules, Comparison with Experiment, Cintinum Theory of Rubber Elasticity, Second-order Stresses, Elastic Behaviour under Small Deformations, Some unsolved problems in Rubber Elasticity.	4	10

Reference Books:

- 1) Science & Technology of Rubber, by James E. Mark, Burak Erman, Frederich R. Eirich
- 2) Principles of Polymer Systems, by Ferdinad Rodrigeuz
- 3) Rubber Engineering, IRI

Course Outcome:

After learning the course the students should be able to:

- Understand the Science of Motion of Molecule.
- Know about the classification of Rubbers.
- Compare Characteristic properties of Rubbers.
- Analyze molecular masses & Sizes.
- Apply knowledge and understanding the general rules of Polymer Solubility.
- Know about the effect of Temperature, Pressure and concentration on Viscosity.
- Compare the models for Non-Newtonian flow.
- Understand the basic Concepts & Behaviour of elasticity.
- Predict the elastic nature base on physical properties like modulus, strain, density of rubber etc.
- Measure the density, viscosity, surface tension, static and dynamic friction of rubber.

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/

Active learning Assignments (AL) : Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The Power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU