GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3162608
Semester – VI
Subject Name: Reverse Engineering and Analysis of Rubber Products

Type of course: Professional Elective Course Core –II

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	Introduction to Reverse Engineering Concepts Related To Rubber: General Concepts and Examples, Solvent Extraction, Ash Content Determination, Chemical Digestion, Formula Reconstruction—Specific Example, Sample Preparation, Brief Description and Use of Analytical Techniques, Formula Reconstruction, Comparison of Reconstructed Formulation with Actual Recipe, Numerical Problem on Reverse Engineering	5
2	Principle Chemical Methods used in Rubber Reverse Engineering: Chemical Methods, Introduction, Chemical Analysis, Comminution of the polymer sample, Separation of additives, Qualitative and quantitative investigation of the additives, Identification and quantitative analysis of isolated polymer samples.	6
3	**Analytical Methods used in Rubber Reverse Engineering:** (3.1) Chromatography: Gas Chromatography (GC), High Performance Liquid Chromatography (HPLC), Gel Permeation Chromatography (GPC) (3.2) Spectroscopy: Introduction, Infrared Spectroscopy, Determination of Acrylonitrile Content (ACN) of Acrylonitrile Butadiene Rubber (NBR), Quantitative Determination of the Microstructure of the Butadiene Units in Solution-Polymerized SBR (S-SBR), Determination of Residual unsaturation in Hydorginated Acrylonitrile Butadiene Rubber (NBR), Determination of Ethylene Content in Ethylene Propylene Co-polymers (EPM) and in Ethylene Propylene Diene Monomer (EPDM), Determination of Microstructure of Polybutadiene (BR) Rubber, Fourier Transform Infrared Spectroscopy(FTIR), Carbon Type Analysis (C_A, C_P, and C_N) of the Rubber Process Oil by Fourier Transform Infrared (FTIR), Miscellaneous	4 9

	Quantitative Applications of FTIR Nuclear Magnetic Resonance Spectroscopy(NMR), Ultraviolet(UV), Theory, And Application of Rubber, Blends, Composites, Additives, Atomic Absorption Spectroscopy (AAS), Various Applications of Atomic Absorption Spectrometric Instruments in Rubber Industries. **(3.2)** Microscopy and Image Analysis: Introduction, :Applications & Principle of Optical Microscope, Scanning Electron Microscope, Transmission Electron Microscope, Identification of Carbon Black Type, Carbon Black Identification by Transmission Electron Microscopy (TEM), Elastomer Blend Morphology by TEM, Microtomy, Staining, and TEM Analysis, TEM Image Analysis—Examples, X-ray Diffraction Techniques (WAXS, SAXS)	**9**
4	**Thermal Analysis of Rubber:** Introduction, Some Important Technical Terms Related to Thermal Analysis, Principle of Differential Scanning Calorimetry (DSC) Operation, Application of DSC, Differential Thermal Analysis (DTA), Thermomechanical Analysis (TMA) and Thermodilatometry (TD), Thermodilatometry of Rubbers, Rubber composites & blends, Thermo sets & Fibers Dynamic Mechanical Analysis (DMA), Principle of Thermogravimetric(TG) ,Evolved Gas Detection (EGD) and Evolved Gas Analysis (EGA),	**9**
5	**Thermal Analysis of Additives in Polymers:** Introduction, Protective agents, Plasticizers, Accelerators, Vulcanizing Agents, Other Additives etc, Polymer Flammability, Thermal Analysis & Flammability Evaluation, Conclusions.	**6**
6	**Experimental Methods:** Polymer synthesis, isolation & purification of polymers, polymer fractionation and determination of glass transition temp. etc .	**6**

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	15	15	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:

- Thermal Characterization of Polumeric Materials by Edvin A. Turi
- Science & Technology of Rubber, by James E. Mark, Burak Erman, Frederich R.Eirich
- Principles of Polymer Systems, by Ferdinad Rodrigeuz
- Polymer Characterization by Schroden
- Understanding Polymer Morphology by Woodhard
- Thermal Degradation of Polymer Materials by Pielichowski
- Polymer Characterization Laboratory Techniques and Analysis by Nicholas P. Cheremisinoff
- Reverse Engineering of Rubber Products: Concepts, Tools, Techniques, by Saikat Dasgupta, Mukhopadhyaya, Krishna C. Branwal, Anil Bhowmick

After learning this course students will be able to:

Sr. No.	CO statement	Marks % weightage
CO-1	Summarize the basic concepts and methods related to rubber reverse engineering.	10
CO-2	Indentify the different types of rubbers and rubber related materials on the basis of their properties.	20
CO-3	Explain the principle, construction and working of various analytical techniques.	15
CO-4	Analyze the properties of rubber and rubber related materials on the basis of it's thermal behavior.	15
CO-5	Distinguish the reconstructed formulation and actual formulation of any rubber product.	10

List of Experiments:

Tutorials/Presentation/Practical/Industrial visit based on above topics.

Major Equipment:

Extraction Assembly, Thermogravimetric Analysis Apparatus, Differential Scanning Calorimetry, Differential Thermal Analyzer UV-Visible Spectrophotometer etc..,

List of Open Source Software/learning website:

- http://www.biomedcentral.com/
- http://www.sciencedirect.com/
- http://onlinelibrary.wiley.com