DEPARTMENT OF RUBBER AND PLASTICS TECHNOLOGY

ANNA UNIVERSITY:: MIT CAMPUS

M.TECH. RUBBER TECHNOLOGY

REGULATIONS 2023

VISION:

The Department of Rubber and Plastics Technology shall constantly strive to be renowned for its academic and research excellence with professionalism and social responsibilities

MISSION:

The Mission of the Department of Rubber and Plastics Technology is to:

- Equip its graduates to meet the expectations of Rubber, Plastics and allied industries and professional organizations
- Expand its knowledge base in collaboration with Rubber, Plastics and allied industries and research organizations
- Emphasize on product design aspects so as to enable graduates to be innovators in the field of Rubber, Plastics and allied areas of Technology
- Enable students to become entrepreneurs
- Carry out inter-disciplinary research and development activities integrating Rubber and Plastics Technology with other Engineering disciplines

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

1. Equip graduates with appropriate scientific and engineering knowledge to analyze, design and create products based on rubber and rubber like materials.
2. Train graduates for inter-disciplinary research involving Rubber Technology with other Engineering areas
3. To provide graduates with an academic environment, conducive for research anddevelopment in their life-long learning in various aspects of their chosen profession

PROGRAMME OUTCOMES (POs):

On successful completion of the programme, the Post Graduates will be able to

1.	Independently carry out research/investigation and development work to solve practical problems
2.	Write and present a substantial technical report/document
3.	Demonstrate a degree of mastery in design, experiment, analysis and research in rubber technology
4.	Use modern engineering tools, software and equipments for analysis, simulation and integrate multidisciplinary tasks pertaining to Rubber Technology
5.	Provide technical and/or academic leadership for various organizations through life-long learning
6.	Gain insights for sustainable development in Rubber and allied Industries

MAPPING OF PROGRAMME EDUCATIONAL OBJECTIVE WITH PROGRAMMEOUTCOMES

PROGRAMME EDUCATIONAL OBJECVIVES	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
I	3	2	3	2	3	2
II	2	2	3	3	2	1
III	3	2	3	1	3	2

1. PROGRAM ARTICULATION MATRIX

Year	Sem	Subjects	PO1	PO2	PO3	PO4	PO5	PO6
Year I	SEM 1	Applied Probability and Statistics	3	3	3	3	2	2
		Concepts of Polymer Systems	2.8	2.2	1.6	1.2	1	1
		Natural and Synthetic Rubbers	2.6	1	3	1	2	2
		Rubber Processing Technology	3	3	3	1.8	3	3
		Research Methodology and IPR						
		CAD and Modelling Laboratory	3	1	3	3	2	1
Year I	SEM 2	Additives and Rubber Compounding	3	1.6	3	1	1	2
		Engineering with Rubber	3	3	3	2	2	3
		Advanced Polymer Characterization Techniques	3	1.8	2	2	1	1
		Theory of Viscoelasticity	2.2	1.6	2	1	2	1
		Rubber Technology Laboratory	3	2	3	2	2	1
		Product Design and Simulations Laboratory	3	3	3	3	2	2
Year II	SEM 3	Interfacesin Polymer Systems	2	1	2	-	1	1
		Tyre Science and Technology	3	2.6	2.6	2	2	3
		Project Work I	3	3	3	2	2	3
		Project Work II	3	3	3	2	2	3

ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
REGULATIONS - 2023
CHOICE BASED CREDIT SYSTEM
M.TECH. RUBBER TECHNOLOGY
CURRICULUM AND SYLLABI FOR I TO IV SEMESTER

SEMESTER I

S. NO.	COURSE CODE	COURSETITLE	CATE GORY	PERIODS PERWEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA3158	Applied Probability and Statistics	FC	4	0	0	4	4
2.	RT3101	Concepts of Polymer Systems	PCC	3	0	0	3	3
3.	RT3102	Natural and Synthetic Rubbers	PCC	3	0	0	3	3
4.	RT3103	Rubber Processing Technology	PCC	3	0	4	7	5
5.		Professional Elective I	PEC	3	0	0	3	3
6.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
PRACTICALS								
7.	RT3111	CAD and Modelling Laboratory	PCC	0	0	4	4	2
			TOTAL	**18**	**1**	**8**	**27**	**23**

SEMESTER II

S. NO.	COURSE CODE	COURSETITLE	CATE GORY	PERIODS PERWEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	RT3201	Additives and Rubber Compounding	PCC	3	0	0	3	3
2.	RT3202	Engineering with Rubber	PCC	3	0	0	3	3
3.	RT3203	Advanced Polymer Characterization Techniques	PCC	2	1	0	3	3
4.	RT3204	Theory of Viscoelasticity	PCC	3	0	0	3	3
5.		Professional Elective II	PEC	3	0	0	3	3
6.		Professional Elective III	PEC	3	0	0	3	3
PRACTICALS								
7.	RT3211	Rubber Technology Laboratory	PCC	0	0	4	4	2
8.	RT3212	Product Design and Simulations Laboratory	PCC	0	0	4	4	2
			TOTAL	**17**	**1**	**8**	**26**	**22**

SEMESTER III

S. NO.	COURSE CODE	COURSETITLE	CATE GORY	PERIODS PERWEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	RT3301	Interfaces in Polymer Systems	PCC	3	0	0	3	3
2.	RT3302	Tyre Science and Technology	PCC	3	0	0	3	3
3.		Professional Elective IV	PEC	3	0	0	3	3
PRACTICALS								
4.	RT3311	Project Work I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**15**

SEMESTER IV

S. NO.	COURSE CODE	COURSETITLE	CATE GORY	PERIODS PERWEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	RT3411	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS: (23 + 22 + 15 + 12) = 72

PROFESSIONAL ELECTIVES

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1	RT3001	Polymer Colloids and Latex Technology	PEC	3	0	0	3	3
2	RT3002	Thermoplastic Elastomers	PEC	3	0	0	3	3
3	RT3003	Polymer Waste Management	PEC	3	0	0	3	3
4	RT3004	Sustainable Technologies for Rubber Industry	PEC	3	0	0	3	3
5	RT3018	Vehicles Dynamics	PEC	3	0	0	3	3
6	RT3005	Elastomer Testing	PEC	3	0	0	3	3
7	RT3006	Rubber Composites	PEC	3	0	0	3	3
8	RT3007	Adhesion Science and Technology	PEC	3	0	0	3	3
9	RT3008	Finite Element Analysis in Rubber Technology	PEC	3	0	0	3	3
10	RT3009	Mould Design and Manufacture	PEC	3	0	0	3	3
11	RT3010	Polymer Composites	PEC	3	0	0	3	3
12	RT3011	Computer Aided Product Design	PEC	3	0	0	3	3
13	RT3012	Polymer Product Design	PEC	3	0	0	3	3
14	RT3013	Specialty Polymers	PEC	3	0	0	3	3

15	RT3014	Polymer Blends and Alloys	PEC	3	0	0	3	3
16	RT3015	Plastics Engineering	PEC	3	0	0	3	3
17	RT3016	Biopolymers and Biocomposites	PEC	3	0	0	3	3
18	RT3017	Rubber Industry Practices	PEC	3	0	0	3	3

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	RM3151	Research Methodology andIPR	RMC	3	3	0	0	3

LIST OF PROFESSIONAL CORE COURSES (PCC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	RT3101	Concepts of Polymer Systems	3	0	0	3	1
2.	RT3102	Natural & Synthetic Rubbers	3	0	0	3	1
3.	RT3103	Rubber Processing Technology	3	0	0	3	1
4.	RT3111	CAD & Modelling Laboratory	0	0	4	2	1
5.	RT3201	Additives and Rubber Compounding	3	0	0	3	2
6.	RT3202	Engineering with Rubber	3	0	0	3	2
7.	RT3203	Advanced Polymer Characterization Techniques	3	0	0	3	2
8.	RT3204	Theory of Viscoelasticity	3	0	0	3	2
9.	RT3211	Rubber Technology Lab	0	0	4	2	2
10.	RT3212	Product Design & Simulations Lab	0	0	4	2	2
11.	RT3301	Interfaces in Polymer Systems	3	0	0	3	3
12.	RT3302	Tyre Science and Technology	3	0	0	3	3
				TOTAL CREDITS		**35**	

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. No.	OURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICALS								
1.	RT3311	Project Work I	EEC	12	0	0	12	6
2.	RT3411	Project Work II	EEC	24	0	0	24	12

SUMMARY

	Name of the Programme: M.TECH. RUBBER TECHNOLOGY					
	SUBJECT AREA	**CREDITS PER SEMESTER**				**CREDITS TOTAL**
		I	**II**	**III**	**IV**	
1.	FC	4				4
2.	PCC	13	16	6		35
3.	PEC	3	6	3		12
4.	RMC	3				3
5.	EEC			6	12	18
6.	**TOTAL CREDIT**	**23**	**22**	**15**	**12**	**72**

MA3158 APPLIED PROBABILITY AND STATISTICS L T P C

4 0 0 4

OBJECTIVE:

- To enable the students to understand basics of random variables with emphasis on the standard discrete and continuous distributions.
- Understand the concepts of sampling distributions and the test statistics.
- Understand statistical methods and concepts by which real life problems are analyzed.
- Analyze various datas using statistical techniques.
- Design experiments and use these concepts for research.

UNIT I PROBABILITY THEORY 12

Random variables – probability density and distribution functions-moment generating and characteristic functions – Binomial, Poisson, Normal distributions and their applications.

UNIT II SAMPLING THEORY 12

Sampling distributions – Standard error – t, F, Chi square distributions – applications.

UNIT III ESTIMATION THEORY 12

Interval estimation for population mean, standard deviation, difference in means, preparation ratio of standard deviations and variances.

UNIT IV TESTING OF HYPOTHESIS AND ANOVA 12

Hypothesis testing – Small samples – Tests concerning proportion, means, standard deviations – Tests based on chi square – and Redistribution test -Design of experiments.

UNIT V ANOVA 12

Design of experiments – One, Two factor Models

TOTAL: 60 PERIODS

OUTCOMES:

At the end of the course, the student will be

CO1 Able to analyze the performance in terms of probabilities and distributions achieved by the determined solution.

CO2 Aware of various test statistics for the samples.

CO3 Able to develop an ability to apply statistical tests in experiments as well as to analyze and interpret data.

CO4 Able to use the statistical tools for their project and future research.

CO5 Able to use the concepts in design of experiments in real life problems.

REFERENCES:

1. Gupta and Kapoor, "Fundamentals of Applied Statistics", Sultan Chand and sons, 4th Edition, New Delhi, 2019.
2. Hooda, "Statistics for Business and Economics", Macmillan, 3rd Edition, India, 2003.
3. John.E.Freunds, "Mathematical statistics with applications", Pearson Education, 8th Edition, New Delhi, 2013.
4. Levin and Rubin, "Statistics for Management", Pearson Education India, 7th Edition, New Delhi, 2013.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Avg	3	3	3	3	2	2

RT3101 CONCEPTS OF POLYMER SYSTEMS L T P C
3 0 0 3

OBJECTIVES

- To impart fundamental knowledge on chemistry of polymers and to understand the structure –property relationship and applications of polymersin various fields.

UNIT I INTRODUCTION 9

Hydrocarbons – reactive species based on carbon – free radicals – cations – anions – catenation – polymerization Classification of Polymers – Natural and synthetic Polymers - Biopolymers – Thermoplastics – Thermosets – Fibers – Fundamentals- Examples

UNIT II POLYMER FORMATION 9

Monomers – Functionality – Polymerization - Various steps in addition Polymerization - Homo and Copolymerization – Examples – Condensation Polymerization – Examples – reactions - Molecular weight of Polymers and their significance - Industrial Polymerization Techniques

UNIT III STATES OF AGGREGATION IN POLYMERS 9

Amorphous polymers – Glass transition Temperature – Factors - Semi-crystalline state in polymers – Crystallinity - Crystalline melting point - crystal nucleation and growth - Spherulites formation – factors affecting crystallinity - Liquid Crystalline polymers – Polymer Blends and Alloys

UNIT IV STRUCTURE PROPERTY RELATIONSHIPS IN POLYMERS 9

Chemical structure - amorphous and crystalline states – Crystallization dynamics - Influence of microstructure on performance properties - Effect of Chemical structure on Mechanical, Chemical, Electrical and Optical Properties of Polymers

UNIT V MECHANICAL PROPERTIES OF POLYMERS 9

Stress - Strain Behavior of polymers – Tensile, Flexural, Fatigue, Compressive Hardness and Impact properties, viscoelastic behavior of polymers, creep and stress relaxation, dynamic mechanical analysis of polymers.

TOTAL:45 PERIODS

OUTCOMES

By the end of this course, students will be able to

CO1 Relate different types and choices of polymer materials

CO2 Identify appropriate manufacturing technologies for making polymers

CO3 Relate states of aggregation with polymer structure

CO4 Relate Structure of Polymers with Performance properties

CO5Analyze various mechanical properties of polymers

REFERENCES

1. J.J.Aklonis and WJMac Knight,1983, Introduction to Polymer Viscoelasticity,2nd ed.,Wiley, New York
2. Ferdinand Rodriguez,ClaudeCohen,ChristopherK.ObesandLyndenA.Archer,2003“Principles of Polymer Systems” ,Taylor and Francis publications
3. John Brydson, 1999, Plastics Materials, Butterworth -Heinemann,7th Edition
4. I.M.Ward,1983, Mechanical Properties of Solid Polymers, Wiley, NewYork
5. Manas Chanda and SalilK Roy, 2009, Industrial Polymers, Speciality Polymers and Their Applications, CRC Press,Taylor and Francis Group

Course Articulation Matrix:

Course Outcomes	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	1	1	-	1
CO2	2	2	1	1	1	1
CO3	3	3	2	2	1	1
CO4	3	3	2	1	1	1
CO5	3	1	2	1	1	1
Over all CO	**2.8**	**2.2**	**1.6**	**1.2**	**1**	**1**

RT3102 NATURAL AND SYNTHETIC RUBBERS L T P C
3 0 0 3

OBJECTIVES

- Enable the students to learn about the preparation, properties and application of different rubbers.

UNIT I INTRODUCTION TO RUBBER MATERIALS 9

Structure-property relationships in rubbers-structure and rubber elasticity-effect of structure on Tg – influence of chemical structure on thermal and mechanical properties and chemical resistance

UNIT II GENERAL PURPOSE RUBBERS 9

Natural rubber latex – tapping – conversion to dry rubber - grading and specifications of NR – chemically modified NR – SBR – preparation – types and properties – BR – polymerization – IR – vulcanization of general purpose rubbers - poly alkenamers, poly norbornenes – reclaimed rubbers – other recycling methods for rubbers

UNIT III SPECIAL PURPOSE RUBBERS 9

Need – IIR, EPRs, NBR, CR, HNBR, ACM, EMA, EVA, CSM, CM, epichlorohydrin rubbers – polysulphide rubbers

UNIT IV HIGH PERFORMANCE RUBBERS 9

fluorine containing rubbers and silicones – their preparation, properties, curing and uses

UNIT V POLYURETHANES AND THERMOPLASTIC RUBBERS 9

SBS, PP-EPDM blends, PU, poly amide and poly ester based TPEs, blend type TPEs - plasticized PVC , castable and millable rubbers based on PU – processing advantages of PUs in foams, RIM products

TOTAL:45 PERIODS

OUTCOMES

By the end of this course, students will be able to

CO1 Relate structure and properties of various rubbers
CO2 Select an appropriate rubber for commodity application.
CO3 Analyze and select suitable rubbers for specialty and high performance applications
CO4 Demonstrate about TPUs and TPEs
CO5 Design a formulation for a specific requirement.

REFERENCES

1. Franta,I; Elastomers and Rubber Compounding materials, Elsevier, 1989.
2. Morton, M.; Rubber Technology, Chapman Hall, 1995.
3. Dick.J.S., Rubber Technology Compounding and testing for performance, Hanser Publisher, 2001.
4. REACH Manual - Rubber Industry - ETRMA-European Tyre www.etrma.org, 2008-02-07

reach-rubber-industry-manual.

Course Outcomes	Programme Outcomes(POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	1	3	1	-	2
CO2	3	1	3	1	-	2
CO3	3	1	3	1	-	2
CO4	3	1	3	1	-	2
CO5	2	1	3	1	2	2
Overall CO	**2.6**	**1**	**3**	**1**	**2**	**2**

RT3103 RUBBER PROCESSING TECHNOLOGY **L T P C**
3 0 4 5

OBJECTIVES

- To introduce the different rubber processing techniques to produce rubber products with required properties and to enhance the skills of the students to design and prepare different rubber compounds, and to visualize / know the flow behaviour of various rubber compounds during mixing and forming stages.

UNIT I RHEOLOGY OF POLYMER SYSTEMS 9

Flow behavior-viscosity, Newtonian and non-Newtonian behavior, capillary and rotational viscometers, flow curve, mathematical approximation of flow behavior, curing behavior, rheometry

UNIT II COMPOUNDING AND MIXING PROCESS 9

Rubber mixing mechanism - mixing machinery - two roll mill - internal mixer–machine design& operation - Simulation of flow - mixing in internal mixers & two roll mill, mixing cycles and procedures, operating variables and mix quality.

UNIT III FORMING OPERATIONS 9

Rubber extrusion - single screw extruders -types, extruder screws designs-simulation and flow mechanism through dies, process optimization, extrudate defects; Calendaring of rubber, roll configurations, process simulation & flow analysis and troubleshooting; Latex Processing.

UNIT IV MOLDING AND VULCANIZATION 9

Compression, transfer and injection molding of rubbers, moulds, process optimization, simulation and flow analysis of molding process; vulcanization processes - batch processes. Continuous vulcanization – machinery & process - Reaction injection molding of PU; silicone injection molding.

UNIT V MANUFACTURE OF RUBBER PRODUCTS 9

Materials, machinery, mould, dies and process optimization for the manufacture of rubber products-Tyre, tube, hose, belts, cables, sports goods, footwear, molded and rubber to metal bonded products.

TOTAL : 45 PERIODS

OUTCOMES

By the end of this course, students will be able to

CO1: Decide the processing parameters for a specific rubber product within realistic constraints.
CO2: Solve the product defect due to rheological behavior and processing variables.
CO3: Modify the design of the processing equipment to achieve an efficient processing.
CO4: Enhance the skills of the students to design and prepare different rubber compounds.

CO5: Identify the different rubber molding techniques and analyze its problems with troubleshooting techniques.

REFERENCES

1. B.R.Gupta, Applied Rheology in Polymer Processing, Asian Books, 2005.
2. James L.White, “Rubber Processing” Hanser Publishers,1995.
3. Anil K.Bhowmick et al,” Rubber Products Manufacturing Technology”, Marcel Dekker, 1994.
4. John S Dick, Rubber Technology, Hanser 2001.
5. Kleemann and Weber, Elastomer Processing, Hanser 1998
6. James E mark etal., Science and technology of rubber, Elsevier, 2005.
7. Richard F.Grossman, The Mixing of Rubber, Chapman & Hall, 1997.

LIST OF EXPERIMENTS

1. IDENTIFICATION OF RAW RUBBERS
2. RUBBER MIXING (6Exp)
- Mastication of natural rubber and mixing of rubber (gum and filledcompounds) using two-roll mixing mill, Kneader and Banbury mixture.
- Mixing of synthetic rubbers (SBR, PBR, EPDM, NBR, CR) with variousfillers (CB, Silica, Talc and others) using Two roll mixing mill, Kneader and Banbury mixture.
3. RUBBER EXTRUSION (1Exp)
- Processing of Rubber compounds with various profileon a rubber extruder, trouble shootingin extrusion
4. MOLDING OF RUBBER COMPOUNDS (3Exp)
- Molding of rubber compounds by compression and transfer moulding.
5. LATEXCOMPOUNDING (2Exp)
- Preparation of dispersion in a ball mill
- Preparation of compounded latex.

TOTAL: 60 PERIODS

Course Outcomes	**Programme Outcomes(POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	1	3	3
CO2	3	3	3	1	3	3
CO3	3	3	3	1	3	3
CO4	3	3	3	3	3	3
CO5	3	3	3	3	3	3
Overall CO	**3**	**3**	**3**	**1.8**	**3**	**3**

RM3151 RESEARCH METHODOLOGY AND IPR L T P C
2 1 0 3

OBJECTIVES:

To impart knowledge on

- Formulation of research problems, design of experiment, collection of data, interpretation and presentation of result
- Intellectual property rights, patenting and licensing

UNIT I RESEARCH PROBLEM FORMULATION 9

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, the student can

CO1: Describe different types of research; identify, review and define the research problem

CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data

CO3: Explain the process of data analysis; interpret and present the result in suitable form

CO4: Explain about Intellectual property rights, types and procedures

CO5: Execute patent filing and licensing

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
3. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.
5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

RT3111 CAD AND MODELLING LABORATORY L T P C
0 0 4 2

OBJECTIVES

- To give an exposure in using Software tools for new product development, mould designing.

LIST OF EXPERIMENTS

i. DESIGN AND DRAWING OF MOULDS

1. Hand Mould

2. Semi–Injection Mould
3. Multi Cavity–Multiday Light Mould
4. Side Core
5. Collapsible core
6. Compression Mould
7. Transfer Mould
8. Blow mould

ii. DESIGN AND DRAWING OF DIES

1. Hot and Cold Extrusions
2. Extrusion of Tubes and profiles

TOTAL: 60 PERIODS

OUTCOMES

By the end of this course, students will be able to

CO1 Apply Computer Aided design in product and Mould Design
CO2 Know the different techniques of graphical representation for simple parts and assemblies
CO3 Convert 3D solid models into 2D drawing and prepare different views, sections and dimensioning of part models

Course Outcomes	**Programme Outcomes(POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	3	3	2	1
CO2	3	1	3	3	2	1
CO3	3	1	3	3	2	1
Overall CO	3	1	3	3	2	1

RT3201 ADDITIVES AND RUBBER COMPOUNDING L T P C
3 0 0 3

OBJECTIVES

- To enable the students to develop rubber compounds for various rubber products

UNIT I RUBBER ADDITIVES 9

Need for compounding - Vulcanizing agents – sulphur, peroxides, phenolic resins, metal oxides, amines, urethane cure, etc - accelerators – activators- PVI, retarders, coagents etc. Fillers – carbon black-their preparation, reinforcement mechanism, characteristics, non- black fillers, anti oxidants and anti ozonants, colorants, processing aids – reclaimed rubbers

UNIT II DESIGN FOR PROCESS, PERFORMANCE AND ECONOMICS 9

Line call out - Compound cost calculations- Compounding approach to cost control (black, nonblack, polymer substitution), productivity- process and vulcanization – experimental designin compound development – DoE

UNIT III DESIGNING COMPOUNDS FOR VARIOUS RUBBERS 9

Order of addition – conventional - other mixing procedures - examples and case studies. Mixing procedures for specific compounds –NR, EPDM based, SBR / IR based, CR/ SBR based, low hardness CR/ SBR, CR in electrical applications, NBR, NBR/ PVC, CSM, ACM, ECO, and FKM. Phase mixing techniques of tyre tread compounds.

UNIT IV QUALITY CONTROL AND THE MIXING PROCESS 9

Raw material check - elastomers- fillers and other additives-bin storage problems - SPC charting, rheograph data- its meaning and application, DOE, Taguchi method

UNIT V COMPOUND DEVELOPMENT FOR A FEW NON TYRE PRODUCTS 9

Coolant hoses, fuel hoses, v belts, v ribbed belts, conveyor belts, compound design for load bearing and vibration control - engine mounts, diaphragms, and bearings.

TOTAL: 45 PERIODS

OUTCOMES

By the end of this course, students will be able to

CO1 Select the additives for various compound formulations

CO2 Explain the line callout and analyze the compound design.

CO3 Design cost effectiveformulationforaspecificproductrequirement.

CO4 Maintain and improvethequalityoftheproductconsistently

CO5Design and develop suitable compounds for non tyre products

REFERENCES

1. Brendan Rodgers, Rubber Compounding- Chemistry and Applications (ed) Marcel DekkerInc, 2004.
2. Hepburn.C, Rubber Compounding Ingredients- Need, theory and innovation Part I & Part II, RAPRA Review Reports Vol. 9 (1), 1997.
3. John S Dick, Rubber Technology- Compounding and Testing for Performance (ed) Hanser Publishers, 2001.
4. Richard F Grossman, The Mixing of Rubber (ed) Chapman & Hall, 1997.
5. Smith, Len, Butterworth, Language of Rubber, - Heinemann Ltd, 1993.

Course Articulation Matrix:

Course Outcomes	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	3	-	1	2
CO2	3	1	3	1	1	2
CO3	3	1	3	2	-	2
CO4	3	2	-	2	-	2
CO5	3	2	3	-	1	2
Over all CO	**3**	**1.6**	**3**	**1**	**1**	**2**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium)and Substantial (High) respectively

RT3202 ENGINEERING WITH RUBBER L T P C
3 0 0 3

OBJECTIVES

- To impart the knowledge on design factors involved in a rubber products
- To impart the design principles of rubber product under different loading conditions
- To impart the importance of rubber in space filling applications.
- To impart the knowledge of rubber in noise and vibration control.

UNIT I SIMPLE GEOMETRIES 9

Importance of materials, product design- distribution of rubber product geometry- under load and load free conditions. Spring Rates - Creep – Stress relaxation – Rubber Products in compression – Design of simple Geometries – Rubber Blocks –Rubber bonded assemblies Design to specific spring rates

UNIT II RUBBER UNDER COMPLEX LOADING 9

Rubber products in simple shear – axial shear – rotary shear - rubber sleeves – rubber in torsion-shear spring rates – compression and shear in combination – Compound design considerations, UVstability, Chemical stability, Oil resistance.

UNIT III RUBBER PRODUCTS UNDER DYNAMIC CONDITIONS 9

Rubber in dynamic applications – Hysteresis – Heat generation - vibration control Damping and isolation – Engine mounts – Bridge bearings – earthquake resistant bearings – Analysis and calculations – Compound Design aspects. Importance of hysteresis on strength, fatigue life

UNIT IV NON TYRE PRODUCTS 9

Rubbers in fluid sealing – role of hydrodynamic film, rubberiness under variable strain amplitude and stress - Types of Seals - Gaskets - Flexible couplings -Hose Design and construction -Profiles-Material selection and compound design-Design considerations - ConveyerBelts V-belts- Rubber rollers and Rubber linings

UNIT V MOULD AND DIE DESIGN 9

Design of Moulds & Dies for Rubber products – Compression Moulds - Transfer Moulds-Injection Moulds - Designing rubber products for specialty applications - Design for High Consistent Rubbers.

TOTAL:45 PERIODS

OUTCOMES:

By the end of this course, students will be able to

CO1 Analyze various simple geometry in rubber products
CO2 Demonstrate the ability to design with rubbers
CO3 Analyze rubber geometry in various loading conditions
CO4 Demonstrate the ability to design with non tyre rubber products
CO4 Design and Analyze various mould and die system available for rubber products

REFERENCES

1. AlanN Gent, Engineering with Rubber, Carl HanserVerlag,Munich2001.
2. KhairiNagdi, Rubber as an Engineering material,HanserPublishers,1993.
3. Freakley P.R.,and Payne A.R.,Theory and Practice of Engineering with Rubber, Applied SciencePublishers,London,1970
4. Lindley P.B.,Engineering Design with Natural Rubber,Natural Rubber Producers Research Association,London,1974.

Course Articulation Matrix:

Course Outcomes	**Statement**	**Programme Outcomes (POs)**					
		PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	Analyze various simple geometry in rubber products	3	3	3	2	2	3
CO2	Demonstrate the ability to design with rubbers.	3	3	3	2	2	3
CO3	Analyze rubber geometry in various loading conditions.	3	3	3	2	2	3
CO4	Demonstrate the ability to design with non tyre rubber products	3	3	3	2	2	3
CO5	Design and Analyze various mould and die system available for rubber products	3	3	3	2	2	3
Over all CO		**3**	**3**	**3**	**2**	**2**	**3**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium)and Substantial (High) respectively

RT3203 ADVANCED POLYMER CHARACTERIZATION TECHNIQUES **L T P C 2 1 0 3**

OBJECTIVES

- To impart knowledge on various characterizations methods and techniques

UNIT I REVIEW ONCHARACTERIZATION METHODS 9

Rubber and Plastics analysis – Chemical methods – Latex analysis – Compound analysis– Extraction – RE – Compound ingredient analysis- sample preparation methods

UNIT II THERMALANALYSIS 9

Thermal behaviour – measurement technique - instrumentation– DTA- DSC – TGA – DMA-TMA – DETA – Thermal Conductivities- (interpretation and analysis)

UNIT III MOLECULAR WEIGHTSTUDIES 9

Characterization of molecular weight distribution – number average – weight average Molecular weight – Fractionation – Light scattering – Low angle Laser Light Scattering – GPC Techniques, Viscometery.

UNIT IV SPECTROSCOPY 9

Electronic spectra –Vibrational Spectra UV–VIS – IR – Raman - NMR Spectra – GC Mass– ESCA –Instrumentation and Polymer interpretation.

UNIT V MORPHOLOGY 9

AFM – SEM – X-ray Diffraction – SAXS – Crystal Structure – Birefringence – Optical – ORD – Interpretation and analysis of data

TOTAL:45PERIODS

OUTCOMES

By the end of this course, students will be able to

CO1 Select suitable chemical methods to identify rubber and its products

CO2 Use sophisticated techniques for thermal characterization of polymers

CO3 Interpret the given data for molecular weight analysis

CO4 Analyze and interpret the polymers by spectroscopic methods

CO5 Interpret and analyze the data of morphological characterization

REFERENCES

1. Campbell D &White J.R,Polymer Characterization,Chapman&Hall,London (1989).
2. Hoffman, Rubber Technology Handbook,HanserPublisher,Munich(1996).
3. Hunt & James, Polymer Characterization, Chapman & Hall, London(1993).
4. Roger Brown, Physical Testing of Rubber, Interscience, New York(1996).

Course Articulation Matrix:

Course Outcomes	**Programme Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	2	2	1	1
CO2	3	2	2	2	1	1
CO3	3	2	2	2	1	1
CO4	3	2	2	2	1	1
CO5	3	1	2	2	1	1
Over all CO	**3**	**1.8**	**2**	**2**	**1**	**1**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium)and Substantial (High) respectively.

RT3204 THEORY OF VISCOELASTICITY **L T P C**
3 0 0 3

OBJECTIVES

- To impart the fundamentals of viscoelastic behaviour of a polymer

UNIT I INTRODUCTION TO RUBBER ELASTICITY 9

Nature of rubber elasticity – Molecular mechanisms – phenomenological aspects Illustrations – Rubber Elasticity: Basic Concepts and Behavior, Elasticity of a Single Molecule, Elasticity of a three - Dimensional Network of Polymer Molecules - Some Unsolved Problems in Rubber Elasticity

UNIT II TIME-TEMPERATURE EFFECTS ON VISCOELASTICITY 9

Temperature and viscoelasticity – Different zones – behaviour of linear and cross linkedpolymers – Time temperature superposition – Viscoelastic correspondence principle – Theory and Applications - Rubber elasticity - Comparison with Experiment

UNIT III VISCOELASTICITY AND LONG TERM DEFORMATION 9

Viscoelasticity in bulk deformation – Maxwell and Voight models – Standard linear model – Four parameter model - Boltzmann superposition principle - Applications to practical problems - Continuum Theory of Rubber Elasticity, Second-Order Stresses

UNIT IV VISCOELASTICITY AND MICROSTRUCTURE 9

Viscoelasticity in amorphous and semi crystalline states – Polymer solutions and gels - Rheological properties of polymer melts - Flow analysis and measurements - elastic Behavior under Small Deformations

UNITV MEASUREMENT OF VISCOELASTICITY 9

Experimental viscoelasticity – Complex modulus – Dynamic modulus – Loss modulus – dielectric relaxation spectra - Molecular relaxation studies

TOTAL:45 PERIODS

OUTCOMES:

By the end of this course, students will be able to

CO1 Adapt suitable methods to study about the rheological behaviour and properties while processing the compound

CO2 Correlate and fix the external parameter to achieve desirable flow behaviour

CO3 Use the advantages and limitations of viscoelasticity

CO4 Relate the structure of rubber and their orientation with their physical behaviour.

CO5 Evaluate the viscoelastic properties of elastomers

REFERENCES:

1. AklonisJ.J. and MacKnight, Introduction to Polymer Viscoelasticity, John Wiley & Sons,1983.
2. Frederick R. Eirich, Science and Technology of Rubber, 1st Edition, Academic Pres, 1978.
3. John D.Ferry, Viscoelastic Properties of Polymers, John Wiley & Sons,1980
4. Richard M Christensen, Theory of Viscoelasticity, Dover Publications, 2003

Course Outcomes	**Programme Outcomes(POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	2	1	2	1
CO2	3	2	2	1	2	1
CO3	1	1	2	1	2	1
CO4	1	1	2	1	2	1
CO5	3	2	2	1	2	1
Overall CO	**2.2**	**1.6**	**2**	**1**	**2**	1

RT3211 RUBBER TECHNOLOGY LABORATORY L T P C
0 0 4 2

OBJECTIVS

- To enable the students to evaluate the basic testing methods to predict the properties of the latex, Raw rubber and vulcanizates.

LIST OF EXPERIMENTS

LATEX TESTING EXPERIMENTS

1. Determination of Total Solids Content, Dry Rubber Content., KOH number of natural rubber Latex
2. Estimation of total alkalinity of the latex

RUBBER COMPOUND TESTING

1. Determination of Mooney Viscosity of Raw and Compounded rubber
2. Determination of Scorch and Cure parameters of Compounded rubber using MDR
3. Determination of Scorch and Cure parameters of Compounded rubber using RPA

RUBBER VULCANIZATE TESTING

1. Determination of Hardness
2. Determination ofResilience
3. Determination of Tensile properties
4. Determination of Tear strength
5. Determination of Spring properties
6. Determination of Fatigue (crack initiation and propagation)
7. Determination of Abrasion resistance
8. Determination of Compression Set Resistance
9. Determination of Hot air aging Resistance
10. Determination of Swelling Resistance
11. Fatigue to Failure
12. Heat Build-up study

TOTAL: 60 PERIODS

OUTCOMES

By the end of this course, students will be able to

CO1 :Evaluate the rheological properties of the prepared rubber vulcanizates

CO2 Estimate the basic mechanical properties of the prepared rubber vulcanizates

CO3 :Assess the performance properties

Course Articulation Matrix:

Course Outcomes	**Programme Outcomes (POs)**					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	3	2	2	1
CO2	3	2	3	2	2	1
CO3	3	2	3	2	2	1
Overall CO	3	2	3	2	2	1

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium)and Substantial (High) respectively

RT3212 PRODUCT DESIGN AND SIMULATIONS LABORATORY L T P C
0 0 4 2

OBJECTIVES

- To expose students to Engineering design concepts for components design

LIST OF EXPERIMENTS

I. Calculation of bending moment and induced stress for the following

1. Simply supported beam (various cross sections) subjected Central point load.

2. Cantilever beam (various sections) subjected to point load at various points.
3. Fixed beam (various sections) subjected to point load at various points.

II. Calculation of optimum cross section dimensions and optimum material for the following.

4. Lathe Shaft subjected to various loading
5. Clamping rod design in injection moulding
6. Calculation of Spur and helical gear dimensions in any polymer processing machinery.

III. Determination of factor of safety for the various cases like

7. Any two loading conditions and for any two materials in any polymer processing machinery.

IV. Determination of stress concentration factor for the various shapes like with/without holes/stepped bar for various loading conditions.

V. To simulate the above said conditions in rubber using suitable simulation software

TOTAL: 60 PERIODS

OUTCOMES

By the end of this course, students will be able to

1. Evaluate the calculation of bending moment and total induced stress in various products
2. Analyze the concepts of product design based on various loading and design criterions
3. Demonstrate the importance of stress concentration factor in various product geometries
4. Investigate various rubber materials selection in engineering design
5 Simulate various loading conditions by using suitable simulation software

Course Outcomes	Programme Outcomes(POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2
Overall CO	**3**	**3**	**3**	**3**	**2**	**2**

RT3301 INTERFACES IN POLYMER SYSTEMS L T P C
3 0 0 3

OBJECTIVES

- To provide insight into interfaces in block copolymers, composites ofpolymers with fibres and metals

UNIT I POLYMER - POLYMER INTERFACES 9

Thermodynamics of polymer mixtures - interfaces between weakly immiscible polymers - kinetics of formation of polymer -polymer interfaces – morphology of immiscible polymer blends

UNIT II ADSORPTION AND SURFACE SEGREGATION FROM POLYMER SOLUTIONS AND MIXTURES 9

Surface segregations in polymer mixtures – adsorption from polymer solutions – wetting and surface driven phase separation from polymer mixtures and solutions

UNIT III BLOCK COPOLYMERS, POLYMERIC BRUSHES 9

Block copolymers at polymer-polymer interfaces – polymeric brushes in solutions and melts – other interfacially active species in polymer - polymer interfaces - adhesion in polymeric interfaces in molecular levels in blends – strength of the interfaces involving glassy and rubbery polymers

UNIT IV POLYMER- METAL AND POLYMER-FILLER INTERFACES 9

Interfaces in polymers with metals like Ni and Cu – microstructures in such composites – strength of these interfaces – coupling agents and their roles in polymer-filler interfaces-use of acid-base approach to enhance metal-polymer adhesive joint strength-rubber to metal bonding

UNIT V POLYMER-FIBRE INTERFACES 9

Mechanisms of bonding between rubber and nylon, polyester and rayon fibres – epoxy-fibre interfaces – bonding PE fibre to polymers – bonding aramid fibres to polymers

TOTAL:45 PERIODS

OUTCOMES

By the end of this course, students will be able to

CO1 Demonstrate the surface phenomena and interfaces in polymer blends and solutions
CO2 Explain adsorption phenomenon at interfaces
CO3 Relate the nature of interfaces forming in block copolymers and blends
CO4 Get an insight into optimization of performance properties of polymer blends and composites
CO5 Analyze the polymer-fiber interface

REFERENCES

1. Jones R.A.L. and Richards R.W., Polymers in surfaces and interfaces Cambridge University Press, 1999
2. StammM.,Polymer surfaces and Interfaces, Springer, 2008
3. Starostina I.A., Stoyanov O.V., Deberdeev R.Y., Polymer surfaces and interfaces, Apple Academic Press, 2014

Course Articulation Matrix:

Course Outcomes	Programme Outcomes (POs)					
	PO1	PO 2	PO3	PO4	PO5	PO6
CO1	2	1	2	-	1	1
CO2	2	1	2	-	1	1
CO3	2	1	2	-	1	1
CO4	2	1	2	-	1	1
CO5	2	1	2	-	1	1
Over all CO	**2**	**1**	**2**	**-**	**1**	**1**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

RT3302 TYRE SCIENCE AND TECHNOLOGY L T P C
3 0 0 3

OBJECTIVS

- To provide insight to the test design, tyre properties, tire retreading and related end of lifecycle.

UNIT I TYRE COMPONENTS AND STRUCTURE 9

Tyres – Definitions – Function – Construction – Basic tyre design-Tyre Components and their functions, Tyre Materials, Tyre Nomenclature and Structural Dimensions, Classification of tyres based on applications and its requirements. Tubeless Tyre-Function, Construction, Materials and advantages. Tyre Retreading – Process and advantages and limitations.

UNIT II TYRE REINFORCEMENTS 9

Tyre cords – Physical Properties of tyre-cords- Rayon, Nylon, Polyester, Fibre glass, Aramid, Steel Wire-Cord Processing – Heat Treatment, Adhesive treatment, Bonding systems, Rubberto Cord

Mechanism, Tyre Cord Construction, Evaluation of adhesive systems.

UNIT III TYRE COMPONENTS DESIGN 9

Tread Design: Basic Tread Patterns for Long Life, Road Adhesion, Noise Reduction, Cracking, Appearance, Special Patterns, Selection of Materials – Carcass Design - Side Wall Design - Mould Design - Tread Depth, Tread Curvature, Tread Width, Groove Shape, Pattern and Venting, Sidewall Curvature.

UNIT IV TYRE AND TUBE MANUFACTURE 9

Green Tyre, Ply width and Building Drum width, Tyre Building –Tread and Sidewalls-Reinforcements and Tolerances, Vulcanization techniques-Curing bags, Tyre Presses and Finishing operations – Solid tyres - Tube Manufacturing

UNIT V TYRE PERFORMANCE AND TESTING 9

Tyre Mechanics – Forces acting on Tyres – Steering properties - slip angle, Aligning Torque, Static steering Torque. Road Contact Pressure, Traction, Power loss, Heat Build-up, Fatigue and separation - Rolling Resistance, tyre noise, Tread Wear, Tyre Testing – Destructive and Non-destructive Testing of Tyres, Tyre Labelling

TOTAL:45 PERIODS

OUTCOMES

By the end of this course, students will be able to

CO1 Analyze the complex design of a high performance pneumatictyre
CO2 Choose various carcass materials and methods in tyre reinforcement
CO3 Design new tread patterns and evaluate its role in grip, life and safety
CO4 Explain the Tyre and tubes manufacturing techniques
CO5 Evaluate the performance of tyre

REFERENCES

1. Automobile Tyres, LJKSetright, ChapmanandHall,1972.
2. Tyre Technology, Tom French, Adam Hilger,1989.
3. Mechanics of PneumaticTyres,(ed) Samuel K Clark,US Dept of Transportation.
4. Textile Reinforcement of Elastomers(ed)WCWake&DBWootton, AppliedScience Publishers Ltd,1982.
5. Pneumatic Tyre Design, EC Woods, W Heffer & SonsLtd,1952.
6. TyreTechnology, FJ Kovac, The Goodyear Tyre & Rubber Company,1973.

Course Articulation Matrix:

Course Outcomes	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	2	3
CO2	3	2	3	2	2	3
CO3	3	2	3	2	2	3
CO4	3	3	2	2	2	3
CO5	3	3	2	2	2	3
Over all CO	**3**	**2.6**	**2.6**	**2**	**2**	**3**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium)and Substantial (High) respectively

RT3311 **PROJECT WORK I** **L T P C**
0 0 12 6

OBJECTIVES:
The course aims to enable the students to identify the research problem relevant to their field of interest, search databases to define the problem, design experiment, conduct preliminary study and report the findings.

COURSE CONTENT
Individual students will identify a research problem relevant to his/her field of study with the approval of project review committee. The student will collect, and analyze the literature and design the experiment. The student will carry out preliminary study, collect data, interpret the result, prepare the project report and present before the committee.

TOTAL: 180 PERIODS

OUTCOMES:
At the end of the course the students will be able to
CO1: Identify the research problem
CO2: Collect, analyze the relevant literature and finalize the research problem
CO3: Design the experiment, conduct preliminary experiment, analyse the data and conclude
CO4: Prepare project report and present

Course Outcomes	Programme Outcomes(POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	-	-	-	1	2
CO2	3	-	-	-	1	2
CO3	3	-	3	3	1	2
Co4	-	3	-	-	1	-
Overall CO	**3**	**3**	**3**	**2**	**2**	**3**

RT3411 **PROJECT WORK II** **L T P C**
0 0 24 12

I. Continuation of Project Work I (at Institution/Industry)

OBJECTIVES:
The course aims to enable the students to conduct experiment as per the plan submitted in Project work I to find solution for the research problem identified.

COURSE CONTENT
The student shall continue Project work I as per the formulated methodology and findings of preliminary study. The student shall conduct experiment, collect data, interpret the result and provide solution for the identified research problem. The student shall prepare the project report and present before the committee.

TOTAL: 360 PERIODS

OUTCOMES:
At the end of the course the students will be able to
CO1: Conduct the experiment and collect data
CO2: Analyze the data, interpret the results and conclude
CO3: Prepare project report and present

Course articulation Matrix

Course Outcomes	Programme Outcomes(POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	-	3	-	1	2
CO2	3	2	3	3	1	2
CO3	-	3	-	-	1	-
Overall CO	**3**	**2.5**	**3**	**3**	**1**	**2**

II. Not the continuation of Project Work I (at Industry)

OBJECTIVES:
The course aims to enable the students to identify the research problem at the company, search databases to define the problem, design experiment, and conduct experiment to find the solution.

COURSE CONTENT
Individual students will identify a research problem relevant to his/her field of study at the company and get approval of project review committee. The student will collect, and analyze the literature and design the experiment. The student will carry out the experiment, collect data, interpret the result, prepare the project report and present before the committee.

TOTAL: 360 PERIODS

OUTCOMES:
At the end of the course the students will be able to
CO1: Identify the research problem
CO2: Collect, analyze the relevant literature and finalize the research problem
CO3: Design and conduct the experiment, analyse the data and conclude
CO4: Prepare project report and present

Course articulation Matrix

Course Outcomes	Programme Outcomes(POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	2	3
CO2	3	3	3	2	2	3
CO3	3	3	3	2	2	3
CO4	-	3	-	-	1	-
Overall CO	**2.66**	**3**	**3**	**3**	**1**	**2**

RT3018	**VEHICLE DYNAMICS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:
- To provide fundamental knowledge of the vibration, tyre dynamics, suspension and stability of road vehicles

UNIT I CONCEPT OF VIBRATION 9
Modelling and Simulation, Globaland Vehicle Coordinate System. Fundamentals of ibration - Definitions, Types, Free, Forced, Undampedand Damped Vibration. Vibration analysis – Formulation of Governing equation. Response Analysis of SingleDOF,TwoDOF, MultiDOF. Magnification factor, Transmissibility ratio, Baseexcitation. Vibration absorber, Vibration measuring instruments, Torsional vibration, Criticalspeed.

UNIT II TYRES 9

Tyre axissystem, Construction and manufacturing of tires, tyreforces and moments, tyremarking, tyre structure, hydroplaning, wheel andrim. Rolling resistance, factors affecting rolling resistance. Tire slip – Longitudinal slip and slip angle concept, Relation between tractive effort and longitudinal slip, Friction circle. Longitudinal and Lateral force at various slipangles,Tractiveandcornering property of tire. Camber and cambertrust. Performance of tire on wetsurface. Ride property of tyres. Various test carried on a tyre. Tyre models

UNIT III VERTICAL DYNAMICS 9

Human response to vibration, Sources of Vibration. Suspension requirements–types. State Space Representation. MR & ER Dampers. Design and analysis of Passive, Semiactive and Active suspension using Quarter car, Bicycle Model, Halfcar and full car vibrating model. Influence of suspensions tiffness, suspension damping,and tirestiffness. Controllaw. Suspension optimization techniques. Air suspension system and their properties.

UNIT IV LONGITUDINAL DYNAMICS AND CONTROL 9

Aerodynamic forces and moments. Forces acting on a vehicle – Resistance forces, Traction force supplied by power plant. Equation of motion Load distribution for three-wheeler and four-wheeler. Calculation of maximum acceleration, tractive effort and reaction forces for different drive vehicles. Power limited acceleration and traction limited acceleration. Estimation of CGlocation. Longitudinal load transfer during acceleration and braking. Stability of vehicles resting on slope. Drive line dynamics Braking and Driving torque. Prediction of Vehicle performance. ABS, stability control, Traction control.

UNIT V LATERAL DYNAMICS 9

Steering Geometry –Steady state handling characteristics. Steady state response to steering input– Yaw velocity gain, Lateral acceleration gain, curvature response gain. Testing of handling characteristics. Transient response characteristics. Directional stability. Stability of vehicle on banked road, during turn. Effect of suspension on cornering. Roll dynamics - Roll centre, Roll axis, effect of roll on vehicle dynamics. Yaw control. Stability control.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the courses the students can

CO1 Develop physical and mathematical models of a mechanical vibrating system
CO2 Indicate the forces and moment acting on tyres
CO3 Identify the suspension parameters that governs ride comfort
CO4 Evaluate the vehicle performance in longitudinal direction
CO5 Evaluate the lateral dynamics and control in an automobile

TEXTBOOKS:

1. Singiresu S. Rao, "Mechanical Vibrations – SI Edition," Sixth Edition, Pearson, 2018
2. J. Y. Wong, "Theory of Ground Vehicles", Fifth Edition, Wiley-Interscience, 2022
3. Rajesh Rajamani,"Vehicle Dynamicsand Control," Second edition,Springer,2012
4. Reza N. Jazar, "Vehicle Dynamics: Theory and Application", Third edition, Springer, 2017

REFERENCES:

1. Thomas D. Gillespie, "Fundamentals of Vehicle Dynamics", Revised Edition, Society of Automotive Engineers Inc, 2021
2. DeanKarnopp,"VehicleDynamics,Stability,andControl",SecondEdition,CRCPress, 2013
3. Michael Blundell &Damian Harty, "The Multibody Systems Approach to Vehicle Dynamics", 2nd Edition, Butterworth - Heinemann,2014
4. HansB Pacejka,"Tyre and Vehicle Dynamics," Second edition,Butterworth - Heinemann,2006

Course Articulation Matrix:

Course Outcomes	Programme Outcomes(Pos)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	2	1	-	1
CO2	1	1	2	1	1	1
CO3	2	1	2	1	1	1
CO4	2	1	2	1	-	1
CO5	2	1	2	1	-	1
Overall CO	**1.6**	**1**	**2**	**1**	**1**	**1**

1,2and3arecorrelation levels with weightings as Slight (Low), Moderate (Medium)and Substantial(High)respectively

RT3001 POLYMER COLLOIDS AND LATEX TECHNOLOGY **L T P C 3 0 0 3**

OBJECTIVES

- To enable to students to learn about the manufacture, properties and applications of synthetic latex

UNIT I LATEX– NATUREAND CHARACTERISTICS 9

General nature and characteristics of latex, classification of latex, comparison of polymer lattices and polymer solutions, colloidal stability and destabilization of lattices, flow properties oflatex.

UNIT II COMPOUNDINGOFLATEX 9

Natural rubber latex tapping - chemical composition– preservation - concentration –stabilization - quality control test - Compounding of latex - selection of compounding ingredients & formulation design - maturation - prevulcanized and chemically modified latex

UNIT III PROCESSING OF LATEX 9

Dipping process, types of dipping, dipping plant design, formers, process control; Foaming, extrusion, spraying and casting - process control; leaching, sterilization, chlorination, de-protenization - Manufacture and formulation of latex products - condom, gloves, balloons, catheters; Foam rubber, thread, tubing, toys

UNIT IV SYNTHETIC LATICES 9

Synthetic latex, manufacture, properties and application - SBR, NBR, CR, Vinyl ester polymers, acrylic polymer, ethylene - vinyl chloride copolymer, polybutadiene and synthetic isoprene: Specialty lattices - PVDC, PAN, polyvinylpryidine, butyl, fluro polymer, and CSM latex.

UNITV APPLICATIONSOFLATEX 9

Medical, Building and construction, Textiles and Non-woven fabrics, surface coatings, paper, inks, leather, adhesives and sealants

TOTAL:45 PERIODS

OUTCOMES:

By the end of this course, students will be able to

CO1: Design latex formulations and products
CO2: Explain the principles behind latex processing and product manufacture
CO3: Realize constraints concerning sustainability in latex technology
CO4 Choose suitable synthetic lattices for required applications
CO5 Illustrate various applications of latex

REFERENCES

1. Blackely D.C,”PolymerLattices”,Vol1, 2 & 3

2. Warson Hand Finch C.A, Applications of synthetic Resin latices,Vol.1,2,3, John Wiley& Sons Ltd. 2001

Course Articulation Matrix:

Course Outcomes	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	3	1	1	3
CO2	3	1	3	1	1	3
CO3	2	1	2	1	1	3
CO4	2	1	2	1	1	3
CO5	2	1	2	1	1	3
Over all CO	**2.4**	**1**	**2.4**	**1**	**1**	**3**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium)and Substantial (High) respectively

RT3002 THERMOPLASTIC ELASTOMERS L T P C
3 0 0 3

OBJECTIVES:

- To impart knowledge on the need and approaches to development of TPEs, morphology properties and uses

UNIT I STYRENIC AND OLEFINIC THERMOPLASTIC ELASTOMERS 9

Preparation, properties, morphology and uses of ABA block type TPEs Blending of PE and PP with EPDM, NBR, dynamic vulcanization and its importance

UNIT II PU, POLYESTER AND POLYAMIDE TYPES TPES 9

Preparation of PUs – soft and hard segments – morphology and transitions in TPUs - properties and uses of PUs – polyether-ester TPEs-preparation - crystallization behaviour in the hard phase of polyester TPEs- morphology, properties and uses of polyester TPEs – polyamide PEs-morphology-properties and uses

UNIT III IONOMERS AND RUBBER-PLASTIC BLENDS 9

NBR/PP blends, nylon/NBR blends-NBR/PVC blends–compatibilization of these blends- ionomers-their preparation, properties and uses

UNIT IV NEWER POLYMERISATION METHODS FOR TPEs 9

TPEs by cationic polymerization, free radical polymerization - TPEs from macromolecules as precursors, TPEs by IPNs

UNIT V PRODUCT DESIGN ASPECTS OF TPES 9

Comparison of conventional and TPEs in processing methods and tooling – comparison of design aspects of products from conventional rubbers and TPEs-comparison of design aspects of processing between TPEs and plastics- mould design for TPE product manufacture

TOTAL :45 PERIODS

OUTCOMES:

By the end of this course, students will be able to

CO1 Compare the differences between conventional and thermoplastic elastomers
CO2 Selecttherawpolymer(TPE)forthegiven application
CO3 Analyze the blends and their properties
CO4 Explain various recent polymerization methods for TPEs
CO5 Validate the design aspects of product manufacture with TPEs

REFERENCE

1. Holden G, Kricheldorf H R, Quirk R P, Thermoplastic Elastomers, 3rd Edition, Hanser,2004

Course Articulation Matrix:

Course Outcomes	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	--	2	1	--
CO2	3	1	-	2	-	--
CO3	3	2	1	2	1	1
CO4	3	2	1	2	1	1
CO5	3	2	1	2	1	1
CO1	3	1	--	2	1	--
Overall CO	**3**	**1.6**	**1**	**2**	**1**	**1**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium)and Substantial (High) respectively

RT3003 POLYMER WASTE MANAGEMENT

L T P C
3 0 0 3

OBJECTIVS:

- To impart knowledge on the recycling methods and techniques of polymer waste

UNIT I SOURCE SEGREGATION AND SORTING 9

Introduction - sources of polymer waste – waste segregation techniques – Plastics waste management - 4R's approach - recycling classification - code of practice - primary - secondary - tertiary - quaternary recycling with examples – machineries used for recycling

UNIT II DEGRADATION MECHANISMS 7

Polymer degradation– types of degradation – thermal – oxidative – photo – mechanical – biodegradation - factors – evaluation of bio degradation

UNIT III PLASTICS RECYCLING 11

Recycling of thermoplastics - Polyolefins - PVC, PET, Polystyrene, Nylon, Polyurethanes, polyacetals - mechanical process and chemical process - Recycling of thermosets and polymer composites - applications of recycled materials

UNIT IV RUBBER RECYCLING 9

Recycling of used tyres and other rubber products conventional methods –mechanochemical processing – ultrasonic devulcanization – thermomechanical – recycling crosslinked networks via high pressure, high temperature sintering- conversion of tyres to carbon black and oil

UNIT V CLOSED LOOP RECYCLING 9

Feed Stock Recycling - pyrolysis – Hydrogenation – gasification - incineration - energy recovery- Medical plastics waste management–waste management of plastics packaging

TOTAL: 45 PERIODS

OUTCOMES:

By the end of this course, students will

CO1Select suitable segregation methods for various polymeric waste
CO2 Explain the degradation mechanism
CO3Design and implement appropriate recycling technologies for the management of Polymer wastes
CO4 Choose suitable techniques for recycling waste rubbers
CO5 Have professional and ethical responsibility to solve environmental issues related to polymers.

REFERENCES:

1. Attilio.L.Bisio, MarinoXanthos,“ How to manage plastics waste : Technology and market Opportunities” Hanser Publishers, 1994.
2. Francesco LaMantia.,“ Handbook of Plastics Recycling” Chem Tec Publishing,2002.
3. JohnScheirs.,- “Polymer Recycling” John Wiley andSons,1998.
4. Nabil Mustafa–“Plastics Waste Management” John Wiley and Sons,1998
5. MunaBitter, Johannes Brandup, Georg Menges “Recycling and Recovery of plastics”1996
6. Sadhan K.De, Avraam.I.Isayev, Klementina Khait,”RubberRecycling”,CRC Press,Taylorand Francis Group, 2005

Course Articulation Matrix:

Course Outcomes	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	2	1	1	3
CO2	3	3	2	1	1	3
CO3	3	3	2	1	1	3
CO4	3	3	2	1	1	3
CO5	3	3	2	1	1	3
Overall CO	**3**	**3**	**2**	**1**	**1**	**3**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium)and Substantial (High) respectively

RT3004 SUSTAINABLE TECHNOLOGIES FOR RUBBER INDUSTRY **L T P C**
3 0 0 3

OBJECTIVES –
To impart knowledge on new technologies for sustainable rubber processing and recycling

UNIT I NATURAL RUBBER AND ITS ADVANTAGES 9
Sustainable conversion of Latex into NR - Energy efficiency - Efficient use of Water-Natural rubber sources based on biomass - Guayule - Dandelion - Sustainable modifications on latex and natural rubber - Alternative forms of Natural Rubber - Modified natural rubber as replacement for synthetic rubbers

UNIT II BLOCK COPOLYMERS FOR ELASTOMER APPLICATIONS 9
Advanced Thermoplastic elastomers - New copolymer architectures to replace conventional elastomers - Advanced Catalyst systems for sustainable copolymer systems - Block copolymers for dynamic applications including Tyres

UNIT III GREEN RUBBER CHEMICALS AND ADDITIVES 9
Monomers form Biomass - Butadiene from renewable resources - Catalysts systems for conversion of biomass into monomers - Process aids from renewable resources - Substitute for carbon blacks - Fillers from renewable resources - Silica - Nanocellulose and other nanofillers for elastomer reinforcement - Replacement of hazardous rubber chemicals

UNIT IV ENERGY EFFICIENCY IN RUBBER PROCESSING 9
Energy efficient raw Materials - Designing of rubber compounds for energy efficiency - Tyres with low rolling resistance - Energy efficiency in Rubber mixing and other processing operations-Energy efficiency in heating and cooling operations and reduction of Green housegas emissions in rubber industries

UNIT V SUSTAINABLE RUBBER RECYCLING 9
Life cycle analysis of rubber products- Long life tyres - Source reduction - Producers responsibility

- Closed loop rubber recycling - Rubber recycling and circular economy - Sustainable recycling technologies - Tyre recycling - Applications of recycled rubber

TOTAL: 45 PERIODS

REFERENCES

1. Shinzo Kohjiya and Yuko Ikeda, Chemistry, Manufacture and Applications of Natural Rubber,
   Woodhead, (2014)
2. Omar Faruk, Jimi Tjong and MohiniSain, Light weight and sustainable Materials for Automative Applications, CRC press, 2017
3. Takaomi Kobayashi, Applied Environmental Materials for Sustainability, IGI Global, 2016
4. Martin Forrest, De Gruyter Recycling and Re-use of Waste Rubber, , 2019
5. SadhanK.De, Isayev A, I., and KlementinaKhait,Rubber Recycling, CRC Press, 2005.

OUTCOMES: By the end of this course, students will be able to

CO1 Explore the possible alternatives for and modified forms of Natural Rubber

CO2 Substitute TPEs in place of conventional rubbers and plastics

CO3 Identify sustainable additives for rubber compounding

CO4 Recognize the importance of energy efficiency in Rubber industries

CO5 Develop new applications based on recycled rubber

Course Articulation Matrix:

Course Outcomes	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	2	3	2	3
CO2	3	3	3	2	2	3
CO3	3	2	2	2	2	2
CO4	3	2	3	2	2	2
CO5	3	2	3	2	2	2
Over all CO	**3**	**2**	**3**	**2**	**2**	**2**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

RP3005 ELASTOMER TESTING L T P C
3 0 0 3

COURSE OBJECTIVES:

- To impart knowledge on the various testing instruments and procedures required by the standards and to comprehend the various rubber compound and product tests.

UNIT – I TESTS ON RAW RUBBERS AND COMPOUNDS 9

Plastimeters – Plasticity Retention Index (PRI) – extrusion rheometers – Torque rheometers – Mooney - Scorch and cure rate – ODR & MDR – Dynamic responses of unvulcanized rubber compounds (RPA) - Tack- Green strength – Bound rubber content.

UNIT – II TESTS ON VULCANIZATES – I 9

Stress-strain relationships – Poisson’s Ratio – Data for finite element analysis – Hardness – Tensile stress/strain – Relaxed modulus – Compressive stress/strain – Shear stress/strain – Tear tests – Cutting resistance – adhesion tests – Dispersion test – Ageing tests- Rebound resilience – Compression set

UNIT – III TESTS ON VULCANIZATES – II 9

Principles of dynamic tests – DMA - Heat build-up test – Flex cracking and cut growth resistance test – Friction and wear test – wear mechanism – low temperature properties – Effect of fluids, gases and ozone – Electrical properties – Permeability test.

UNIT – IV TESTS ON RUBBER PRODUCTS 9

Rubber products – chemical analysis – Breaking strength of conveyor belt – Sealability of rubber gaskets and seals – Bursting strength of hoses – Rubber threads – Adhesion strength of coated fabrics – Interfacial strength of rubber-to-metal bonded products.

UNIT – V REVERSE ENGINEERING OF RUBBER PRODUCTS 9

Concept of reverse engineering – Different instrumentation techniques - Applications of DSC, TGA, GCMS, and FTIR in reverse engineering – Case studies- Formula reconstruction – Specific examples.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO 1: Assess the processing properties using rheometer

CO 2: Estimate the short-term stress-strain behavior of rubber vulcanizates

CO 3: Familiarize the importance of synthetic latex and its analyze and interpret the dynamic properties of vulcanizates

CO 4: evaluate the product performance and life prediction of rubber components

CO 5: apply reverse engineering principles and create new formulations

REFERENCES:

1. R P Brown, “Physical Testing of Rubber”, 4th edition, Springer, 2006 (e-Copy 2012).
2. John S Dick, “Basic testing of rubber: selecting methods for rubber test program”, ASTM International, ASTM Stock number MNL 39, 2003.
3. John S Dick, “Rubber Technology : Compounding and Testing for performance”, 2nd Edition, Carl Hanser Verlag, Munich 2009.
4. Saikat Dasgupta, " Reverse Engineering of Rubber Products, Concepts, Tools, And Techniques", Taylor & Francis Group, 2014
5. ASTM Standards Volumes 8 and 9, 2022

Course Articulation Matrix:

Course Outcomes	Programme Outcomes(POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	3	2	1	1
CO2	3	2	3	2	1	1
CO3	3	2	3	2	1	1
CO4	3	2	3	2	1	1
CO5	3	2	3	2	1	1
Overall CO	3	2	3	2	1	1

1,2and3arecorrelation levels with weightings as Slight (Low),Moderate(Medium)and Substantial(High)respectively

RT3006 RUBBER COMPOSITES L T P C
3 0 0 3

COURSE OBJECTIVES:

- To impart knowledge on preparation, properties and applications of filled and reinforced rubber composites

UNIT I FILLERS IN RUBBER COMPOSITES 9

Fillers - Hydrodynamic Effect, Interfacial Interaction, Occlusion, Filler Agglomeration - Parameters Influencing Filler Dispersion, Effect of Fillers on the Properties of Uncured Compounds, Vulcanizates, Dynamic Properties

UNIT II NON-LINEAR VISCOELASTICITY 9

Origin - Filled Rubbers: Theory and Practice - One Dimensional, Two Dimensional, Three Dimensional Filler, Rubber-Rubber Blend Composites and Nanocomposites: Effect of Spherical, Layered and Tubular Fillers. Effect of Hybrid Fillers, Effect of Double Networking – Modeling

UNIT III THEORY AND MECHANISMS 9

Reinforcing Fillers **in Natural Rubber**, Theory and Mechanisms of Reinforcement - Model of Weak and Strong Linkage, Load-Sharing Mechanism, Slippage at Interface; Electrical and Mechanical Behaviour of Filled Elastomers under Strain - Mechanism of Reinforcement in Modulus - Mechanism of Reinforcement in Tensile Strength

UNIT IV PREPARATION AND PROPERTIES 9

Based on Conventional Fillers; Based on Natural Fillers – Fibre, Starch, Natural Mineral Fillers; Based on Metal or Metallic Compound Fillers ; Based on Hybrid Fillers - Strength and Durability of NR, Chemically Modified NR ,Carbon Black, Silica, Clay, Long and Short Glass Fiber Reinforced Natural Rubber Composites

UNIT V TEXTILE MATERIALS FOR RUBBER REINFORCEMENT 9

Basic classification of fibres; properties of textile reinforcing materials - determining the properties; Fibre production; Cotton, Viscose rayon, Polyamide silk, Polyester silk, Glass fibres, Steel fibres, Asbestos - Basic properties of fibres - Production of cord threads and fabrics, cord threads – twisting - Production of fabrics; Adhesive and heat treatment - Adhesive systems - Heat treatment of cords and cord fabrics- Reinforcing systems of individual rubber products – Tyres, Conveyor belts, Driving belts, Hoses, Other rubber products - Tyre cords – Physical Properties of tyre-cords- Rayon, Nylon, Polyester, Fibre glass, Aramid, Steel Wire-Cord Processing – Heat Treatment, Adhesive treatment, Bonding systems, Rubber to Cord Mechanism, Tyre Cord Construction, Evaluation of adhesive systems.

TOTAL : 45 PERIODS

REFERENCES

1. Meng-Jiao Wang and Michael Morris "Rubber Reinforcement with Particulate Fillers", Hanser, (2021). https://doi.org/10.3139/9781569907207.fm.
2. D Ponnamma, Sabu Thomas “Non-Linear Viscoelasticity of Rubber Composites and Nanocomposites”, Springer Cham, (2014). https://doi.org/10.1007/978-3-319-08702-3
3. Joy, Jithin & Chan, Chin Han & Maria, Hanna & Thomas, S. (2003). Natural Rubber-Based Composites and Nanocomposites: State of the Art, New Challenges and Opportunities. 10.1039/9781849737654-00001.
4. FJ Kovac, “Tyre Technology”, The Goodyear Tyre & Rubber Company,(1973).
5. I Franta, “Elastomers and Rubber Compounding Materials”, Elsevier, (2012)

OUTCOME

By the end of this course, students will be able to

CO1: Design a rubber composites formulation for a specific requirement

CO2: Demonstrate the concepts of polymer blends and alloys

CO3: Identify a suitable blend to meet desired needs within realistic constraints

CO4 Choose appropriate fibers for non tyre applications

CO5 Select suitable reinforcement for tyres

Course Articulation Matrix:

Course Outcomes	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	1	1	2
CO2	2	1	3	1	1	2
CO3	2	1	3	1	1	2
CO4	2	1	3	1	1	2

CO5	2	1	3	1	1	2
Overall	2	1	3	1	1	2

RT3007 ADHESION SCIENCE AND TECHNOLOGY L T P C
3 0 0 3

OBJECTIVS:

- To impart knowledge on the fundamentals on adhesives and adhesion process, properties and applications

UNIT I FUNDAMENTALS OF ADHESION 10

Adhesives–importance– theories of adhesion - types of substrates – mechanisms of setting, adhesive strength – thermodynamics of adhesives – concepts of surface energy, contact angle etc - types of joints – joint selection – testing of adhesive joints.

UNIT II SURFACE PREPARATION 9

Nature of various substrates – characterization of surfaces of substrates - importance of surface preparation – surface preparation methods for various substrates – role of primers.

UNIT III NONREACTIVE ADHESIVES 12

Natural adhesives like animal glue, casein, starch–rubber based adhesives–NR,SBR,NBR, CR,IIR adhesives – Latex based &solution based–principles behind formulations and applications of Pressure sensitive &hotmelt adhesives based on SBS, EVA–polyvinyl acetate &polyvinyl alcohol based adhesives.

UNIT IV REACTIVE ADHESIVES 7

Phenolics, epoxies, acrylics, anaerobics, cyanoacrylates – polyimides - bismaleimideand other high temperature adhesives-properties and applications

UNIT V ADHESION IN RUBBER PRODUCT MANUFACTURE 7

Rubber to metal bonding – rubber to fabric bonding – bonding systems available for manufacture of rubber to metal and rubber to fabric bonded products.

TOTAL :45 PERIODS

OUTCOMES:

By the end of this course, students will be able to

CO1 Explain the Basics of adhesion and its mechanism
CO2 Find the suitable Surface preparation methods for different substrate
CO3 Choose suitable non reactive adhesives for various applications
CO4 Select appropriate adhesives and adhesion process for specific applications
CO5 Design new adhesive formulations for emerging applications

REFERENCES

1. Lucas F.M.da Silva, A.Ochsner, R.D.Adams, Handbook of Adhesion technology, Springer, 2011
2. Skiest I (ed), Handbook of Adhesives–VanNostrand Reinhold,1990.

Course Articulation Matrix:

Course Outcomes	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	-	2	2
CO2	3	1	3	-	2	2
CO3	3	1	3	-	2	2
CO4	3	1	3	-	2	2
CO5	3	1	3	-	2	2

Over all CO	3	1	3	-	2	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium)and Substantial (High) respectively

RT3008 FINITE ELEMENT ANALYSIS IN RUBBER TECHNOLOGY **L T P C**
3 0 0 3

OBJECTIVES

- To impart knowledge on Numerical Methods and Mathematical Modeling in solving Engineering Problems using Finite Element techniques

UNIT I INTRODUCTION 8

Review of various approximate methods – Rayleigh - RitZ, Galerkinand Finite DifferenceMethods – Stiffness and flexibility matrices for simple cases – Basic concepts of finite element method – Formulation of governing equations and convergence criteria.

UNIT II DISCRETE ELEMENTS 12

Use of bar and beam elements in structural analysis – Bar of varying section –Temperature effects.

UNIT III CONTINUUM ELEMENTS 15

Different forms of 2-D elements and their applications for plane stress, plane strain and axsymmetric problems - CST Element - LST Element – Consistent and lumped formulation – Use of local co-ordinates - Numerical integration Application to heat transfer problems

UNIT IV ISOPARAMETRIC ELEMENTS 7

Definition and use of different forms of 2-D and 3-D elements – Formulation of element stiffness matrix –Load vector

UNIT V NONLINEAR SOLUTION SCHEMES 3

Different methods of solution of simultaneous equations governing static, dynamics and stability problems. Elastomers - Elastic material model correlation - Terminology - Types of FEA models-Model building - Nonlinear material behavior - Boundary conditions - Applications - Software packages

TOTAL : 45 PERIODS

OUTCOMES

By the end of this course, students will be able to
CO1:Formulate governing equations in FEM
CO2: Analyse structural elements
CO3: Relate numerical integration with heat transfer problems.
CO4: Investigate 2D and 3 D elements
CO5: Use the modern engineering tools and analyze the problems

REFERENCES:

1. Alan N Gent, Engineering with Rubber, 2nd Edition, Carl Hanser Verlag, Munich2001.
2. Segerlind, L.J."Applied Finite Element analysis", Second Edition, John Wiley and SonsInc., New Yors,1984.
3. Tirupathi R.Chandrupatla and Ashok D Belegundu, Introduction to Finite Elementsin Engineering, PrinticeHall,2002
4. Bathe K.J.,and Wilson E.L.,"NumericalMethods infinite Elements Analysis",PrenticeHall ofIndiaLtd.,1983.
5. Robert D.Cook, David S.Malkus, Michael E.Plesha and Robert J,Witt "Concepts& applications of finite Element Analysis",4th Edition,John Wiley & Sons, 2002
6. Krishnamurthy C.S.,"Finite Elements Analysis",Tata McGraw–Hill, 1987

Course Articulation Matrix:

COURSE OUTCOMES	PROGRAMME OUTCOMES (POS)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	-	2
CO2	3	3	3	2	-	2
CO3	3	3	3	2	-	2
CO4	3	3	3	2	-	2
CO5	3	3	3	2	-	2
Overall CO	**3**	**3**	**3**	**2**	**-**	**2**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium)and Substantial (High) respectively

RT3009 MOULD DESIGN AND MANUFACTURE L T P C
3 0 0 3

OBJECTIVES

- To impart the knowledge on design of mould and die for polymer products.

UNIT I CONCEPTS IN MOULD ENGINEERING AND MOULD DRAWING 8

Basic Mould Function – Mould requirements – physical strength – wear resistance – maintenance and interchangeability – Mould drawing – tolerance –mould allowances– responsibility for shrinkage – surface finish.

UNIT II COMPRESSION,TRANSFERAND BLOW MOULD DESIGN 10

Types of compression moulds - clamping pressure - pressure pads - depth of loading chamber - heating systems - types of heaters - calculation of heat requirement and heater capacity - Types of transfer moulds - clamping pressure -transfer pot design -Types of blow moulds - blowratio – blow pin and neck ring design - clamping force

UNIT III DESIGNOF INJECTION MOULDS 12

Standard Mould Systems - Various types of Moulds - Principle of Mould Design - Determination of Mould size – clamping force – calculation of strength of cavity and guidepillars – Design of runner, gates, mould cooling system, ejection system - case studies

UNIT IV EXTRUSIONDIEDESIGN 7

Extrusion die design - process characteristics of polymer melt - die geometry - Mechanical design of extrusion dies - Extrusion dies for elastomers - case studies.

UNIT V RECENT TRENDS IN MOULD MANUFACTURING 8

Mould making techniques - Mould polishing - Rapid prototyping and tooling – EDM - CNC - EDM – ECM – USM - Pantograph engraving - hydro copying - Surface coatings – Computer aided mould design and use of CAD in Mould construction and analysis

TOTAL: 45 PERIODS

OUTCOMES

By the end of this course, students will be able to

CO1 Analyze the concept of Mould Engineering and mould drawing in product making
CO2 Illustrate the compression, transfer and blow mould design concepts
CO3 Examine the Injection mould design in polymer product making
CO4 Analyze the Extrusion mould design in polymer product making
CO5 Compare the various recent mould manufacturing techniques

REFERENCES

1. Dubois and Pribbles, Plastics mold engineering hand book,5th Edition, Chapman and Hall, New York-1995.
2. Herbert Rees, Mould Engineering, 2nd edition Hanser Publishers.
3. Laszlo Sors and Imre Balazs, Design of Plastics Moulds and Dies, Elsevier, Amsterdam-Oxford- Tokyo- NY,1989.
4. Menges / Machaeli / Mohren,How to make Injection Moulds,3rd edition, Hanser Publishers
5. Stoeckhert / Mennig, Mould Making Hand Book, 2nd edition Hanser Publishers
6. Walter Michaeli, Extrusion dies for plastics and rubbers,3rd edition,Hanser Publishers

Course Articulation Matrix:

Course Outcomes	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	2	2	3
CO2	3	3	3	2	2	3
CO3	3	3	3	2	2	3
CO4	3	3	3	2	2	3
CO5	3	3	3	2	2	3
Over all CO	**3**	**3**	**3**	**2**	**2**	**3**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

RT3010 POLYMER COMPOSITES L T P C
3 0 0 3

OBJECTIVES

- To impart knowledge on design, analysis and manufacture of polymer composites and structures

UNIT I COMPOSITE MATERIALS 9

Polymer composite materials, classification and theory of composite materials; Polymer matrices-thermoplastics and thermosetting plastics; Fiber reinforcement of elastomers - short and long fiber composites – Other additives

UNIT II MECHANICS OF COMPOSITES 9

Fiber orientation; Hooke's law for orthotropic and anisotropic materials; micromechanics and macro mechanics of lamina; Lamina stress-strain relations referred and principal material directions and arbitrary axes

UNIT III ANALYSIS OF LAMINATED COMPOSITES 9

Governing equations for anisotropic and orthotropic plates - Angle - ply and cross ply laminates; Static, dynamic and stability analysis for simpler cases of composite plates; inter laminar stresses, failure and fracture analysis.

UNIT IV DESIGNING OF COMPOSITES 9

Design of FRP products - pipe, boat, wind mill blade, storage tanks, automotive drive shafts, leaf spring etc; Joining and repairing of FRP; Quality control test and non-destructive testing of FRP

UNIT V MANUFACTURING PROCESS 9

Hand layup, spray up, resin transfer molding, vacuum bag and pressure bag molding; centrifugal - casting, pultrusion, filament winding; compression, transfer and injection molding; Sandwich construction and Foam reservoir molding.

TOTAL:45 PERIODS

OUTCOMES: By the end of this course, the students will be able to
CO1 Use appropriate materials in suitable forms for making polymer composites
CO2 Explain the basic mechanics of composites
CO3 Test and analyse composite materials
CO4 Design various FRP products
CO5 Familiarize with various manufacturing processes

REFERENCES

1. AutarKaw," Mechanics of composite materials",CRC Press, 1997.
2. Calcote L.R."Analysis of laminated structures",VanNostrand ReinholdCo.,1989.
3. DominickV. Rosato, Designing with reinforced composites,Hanserpublishers,1997.
4. Jones R.M.,"Mechanics of composite materials",McGraw-Hill,KogakushaLtd.Tokyo,1975.
5. Peter Morgan,"Carbon fiber and their composites",Taylor and Francis,2005.
6. StuartM.Lee,"CompsoitesTechnology",Vol1&2,TechnomicPub.,1989.
7. Weatherhead R.G,"FRPTechnology", Applied science publishers Ltd,1980.

Course Articulation Matrix:

Course Outcomes	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	1	1	2
CO2	3	3	3	1	1	2
CO3	3	3	3	1	1	2
CO4	3	3	3	1	1	2
CO5	3	3	3	1	1	2
Over all CO	3	3	3	1	1	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium)and Substantial (High) respectively

RT3011 COMPUTER AIDED PRODUCT DESIGN **L T P C**
3 0 0 3

COURSE OBJECTIVES:

- To enable the students to learn and apply the fundamental concepts of computer graphics and its tools in engineering design.

UNIT I FUNDAMENTALS OF COMPUTER GRAPHICS 9

Product cycle- Design process - Computer Aided Design – Computer graphics – co-ordinate systems- 2D and 3D transformations- homogeneous coordinates - graphic primitives (point, line, circle drawing algorithms) - Clipping- viewing transformation.

UNIT II GEOMETRIC MODELING 9

Representation of curves - Hermite cubic spline curve, Bezier curve, B-spline curves, Surface Modeling – Surface Entities, Representation of Surface, Bezier Surface, B-Spline Surface and Coons Surface. Solid Modeling - Solid Entities, Solid Representation, Boundary Representation (B-Rep), Sweeps Representation, Constructive Solid Geometry (CSG).

UNIT III PART ASSEMBLY 9

Mass properties - Assembly modeling – Inference of position and orientation – Geometric Dimensioning and Tolerancing – Functional importance of various types of fits, Geometrical dimensioning and Tolerancing, Tolerance stacking – types and remedies.

UNIT IV CAD STANDARDS 9

Standards for computer graphics- Graphical Kernel System (GKS) - Open Graphics Library (OpenGL) - Data exchange standards - IGES, STEP, ACIS and DXF - communication standards.

UNIT V ADVANCES IN PRODUCT DESIGN 9

Tooling aspects in product design- Rapid prototyping and tooling- Design for variable loading- polymer composite tooling

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 Apply the fundamental concepts of computer graphics and its tools in a generic framework.
CO2 Create and manipulate geometric models using curves, surfaces and solids.
CO3 Create and add geometric tolerances in assembly modeling.
CO4 Apply standard CAD practices in engineering design.
CO5 Apply advanced design concepts in tooling and prototyping

Course Articulation Matrix:

Course Outcomes	Programme Outcomes (POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	3	3	2	1
CO2	2	1	3	3	2	1
CO3	2	1	3	3	2	1
CO4	2	1	3	3	2	1
CO5	2	1	3	3	2	1
Overall CO	2	1	3	3	2	1

1,2and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High)respectively

RT3012 POLYMER PRODUCT DESIGN L T P C
3 0 0 3

OBJECTIVES

- To impart knowledge on various concepts in product Design
- To know about recent advances in computer based design
- To impart knowledge on various product modeling concepts

UNIT I PRODUCT DESIGN CONCEPTS 9

Product development process tools – Scope in product developments – Understanding customer needs – establishing product function – Benchmarking and establishing Engineering specifications – Product architecture – generating concepts – modeling of product metrics – Introduction to Intellectual property rights – patents – Trademarks and Service marks –Copyrights – patent laws – open source movement

UNIT II PRODUCT DESIGN TOOLS AND STANDARDS 8

TRIZ – Quality function Deployment – Design FMEA – Design for Reliability – Design for Assembly and disassembly – Product Data exchange – standards – STEP, IGES, GKS - Applications of AI in product development process

UNIT III COMPUTER AIDED PRODUCT DESIGN 9

Engineering Systematic Design – Various phases – CAD tools – Sequential Engineering – Concurrent engineering – Principles of interactive computer graphics – 2D,3D transformations –

projections – Geometric modeling – concepts Surface and solid modeling – mathematical representation of solids – design data base – Feature based modelers – Product models

UNIT IV PLASTICS PRODUCT DESIGN 10

Product Design, Development and Manufacture – Check list forms - Mechanical properties – creep curves of Plastics. Product design consideration - Stress-strain curves - Structural Analysis - Beams, Pressure vessels and tubes - Ribbed Plate Design – Plastics Springs–SnapFit Designs – Design of Plastics gears and bearings - Design of plastic pipes.

UNIT V ADVANCES IN PRODUCT DESIGN 9

Tooling aspects in product design- Rapid prototyping and tooling- Design for variable loading- polymer composite tooling-

TOTAL: 45 PERIODS

OUTCOMES

By the end of this course, students will be able to

CO1 Understand the various product design concepts and tools
CO2 Design, formulate, interpret and analyze data using CAD tools and software
CO3 Use modern engineering tools and solve the product design problems
CO4 Distinguish polymer product design from conventional design
CO5 Apply tooling concepts in product design

REFERENCES

1. Crawford R.J.,Plastics Engineering, 3rd Edition, Elsevierpublications.
2. David F., Rogers,J. and Alan Adams.“Mathematical Elements for Computer Graphics”,McGraw Hill, 1990.
3. James G.Bralla.,“Handbookof Product Design for Manufacturing”, McGraw Hill,1986.
4. Karl.T.Ulrich, Stephen D.Eppinger‘ Product Design and Development', McGraw Hill,1994.
5. Kevin Otto,Kristin Wood,‘Product Design”,Pearson education,2000.

Course Articulation Matrix:

Course Outcomes	Programme Outcomes (POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	3	3	2	1	-
CO2	2	3	3	2	1	-
CO3	2	3	3	2	1	-
CO4	1	2	3	1	1	3
CO5	3	1	2	3	2	-
Over all CO	**2**	**2.4**	**2.8**	**2**	**1.2**	**3**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

RT3013 SPECIALTY POLYMERS L T P C
3 0 0 3

OBJECTIVES

- To introduce the properties and applications of engineering thermoplastics, thermosets and other strategic polymer materials.

UNIT I TECHNOLOGY OF NON- NEWTONIAN FLUIDS 9

Characteristics – properties – specific cases – Plastisols, Organosols, PVC pastes, slurries etc - processing – properties – applications

UNIT II POLYELECTROLYTES AND COATING MATERIALS 9

Polyelectrolytes – Polymer electrolyte membranes- ionomers –polymer microgels – polymer colloids -emulsion paints – adhesives - types – properties – industrial applications – coatings – surface preparation – types – properties – applications

UNIT III ENGINEERING THERMOPLASTICS 9

Thermoplastics – UHMWPE, Polyacetals, ABS, PBT, PEI, PPE, PEEK – Thermoplastic polyimides, liquid crystal polymers, polyamide – imide, polyaryle the sulphones, polycarbonates, PPS – polybenzimidazoles

UNIT IV THERMOSETS 9

Unsaturated polyesters – vinylesters – epoxy resins – cyanate esters – isocyanate polymers – BMI's – PMR resins – benzocyclobutene resins – silicones

UNIT V STRATEGIC MATERIALS 9

Conducting polymers – electroluminescent polymers - photoconducting polymers – polymers in optoelectronics - polymers with piezoelectric, pyroelectric & ferroelectric properties – biomedical applications – IPN's.-Polymers in space applications - Propellent binders-Insulation lining etc.

TOTAL : 45 PERIODS

OUTCOMES

By the end of this course, students will be able to
CO1 Select an appropriate polymer for the required application.
CO2 Design polymer systems for specific end use
CO3 Demonstrate the necessity for material development in engineering applications
CO4 Assess the importance of thermoset materials
CO5 Use polymers in strategic applications

REFERENCES

1. R.W. Dyson "Specialty Polymers", 2 nd edition, Blackie Academic & Professional, 1998.
2. James M.Margolis "Engineering Plastics Handbook" McGraw-Hill, 2006.
3. Sidney H. Goodman "Handbook of Thermoset plastics", Jaico Publishing House, 2005.
4. Engineering Plastics, Vol 2 ASM international, 198

Course Articulation Matrix:

Course Outcomes	Programme Outcomes(POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	3	2	-	1	2
CO2	1	2	2	-	1	3
CO3	-	-	3	-	2	2
CO4	1	2	2	2	1	2
CO5	3	3	1	-	2	1
Overall CO	**1.4**	**2**	**2**	**2**	**1.4**	**2**

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

RT3014 POLYMER BLENDS AND ALLOYS L T P C
3 0 0 3

OBJECTIVES

- To impart knowledge on the fundamentals of polymer blends and alloys, its manufacture, properties and applications.

UNIT I INTRODUCTION 9

Need for Polymer blends– Thermodynamics of polymer solutions – Binary systems – thermodynamics of polymer blends – Criteria for miscibility – Compatible and incompatible polymer blends – Polymer Alloys

UNIT II BLOCK COPOLYMERS AS COMPATIBILIZERS 9

Need for Compatibilizers – Science and Technology of Compatibilization-Morphology development in compatibilized blends – Morphology development during processing – Blends of Thermoplastics such as PE,PP, polyesters, polyamides, polycarbonates, ABS – processing – structure-property relationships – morphology and properties – applications

UNIT III BLOCK COPOLYMERS 9

Preparation methods – types - morphology – structure-property relationships - rheology – mechanical properties - compounding – applications – Block copolymers like PEO – preparation, properties and uses of ionomers – Block copolymers as templates for nanosynthesis.

UNIT IV THERMOPLASTIC ELASTOMERS 9

Styrenic TPE's- Thermoplastic Polyurethanes -Thermoplastic Copolyesters-Ethylene-co-vinyl acetate polymers - Ethylene Propylene rubbers -Preparation, Structure-property relationships and applications.

UNIT V BLENDS OF TPE 9

NBR-PVC blends – NR-poly olefin blends – EPDM -PP blends -NBR-PP blends- NBR-nylon blends – other blends as TPEs – Dynamic vulcanization – compatibilisation of these blends – morphologies – properties and uses – Rubber toughened thermoplastics and thermosets

TOTAL : 45 PERIODS

OUTCOME

By the end of this course, students will be able to
CO1 Explain the concepts of polymer blends and alloys.
CO2 Demonstrate the ability to select a suitable blend to meet desired needs within realistic Constraints
CO3 Construct reactive compatibilization schemes for making new blends
CO4 Distinguish thermoplastic elastomers from thermoplastic vulcanizates
CO5 Create required blend morphology for specific applications

REFERENCES

1. Thermoplastic Elastomers by Leggie (Ed), 1989.
2. M.A.Wheelans, Developments in Rubber Technology, Vol.3
3. D.R.Paul and C.B.Bucknall, Polymer Blends, Vol. I and II, 2000

Course Articulation Matrix:

Course Outcomes	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	-	2	3
CO2	3	2	2	1	2	3
CO3	1	3	2	3	2	2
CO4	1	2	2	1	2	2
CO5	3	3	3	1	2	-

Overall CO	2.2	2.4	2.2	1.2	2	2

1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium)and Substantial(High) respectively

RT3015 **PLASTICS ENGINEERING** **L T P C**
3 0 0 3

OBJECTIVES

- To study the compounding, mixing and processing techniques for Plastics

UNIT I PROPERTIES OF PLASTICS 9

Stress-strain properties of plastics -Compressive strength – Impact strength – Fatigue properties of plastics –Selection of Plastics for short term and long term behaviour – Flow behavior

UNIT II CONTINUOUS PROCESSING OF PLASTICS 9

Extrusion, single screw and twin-screw extruders, screw design - process optimization, mechanism of flow, analysis of flow, related extruder process and its die design; Co-extrusion - multilayer films, reactive extrusion. Calendaring process, machinery, analysis of flow in calendaring, control of thickness of calendared sheet.

UNIT III INJECTION MOULDING OF PLASTICS 9

Basic principles – Classification of processing methods – Effect of polymer properties on processing behavior: Injection Moulding – Definition of terms – Specification – Types of machines used – Part & their functions – Cycle time – Process variables & its effect on Moulding quality – Cavity pressure profile – Factor influencing moulding shrinkage, annealing – Frozen-in – Stresses – Types of clamping systems and their merits & demerits – Start up and shut down procedures – Processing parameters and special precaution to be taken while processing of Engineering plastics such as Nylon, Acetal, PC, etc., - Common moulding
defects, causes and remedies.

UNIT IV BLOW MOULDING, ROTATIONAL MOULDING, COMPRESSION AND TRANSFER MOULDING PROCESS 9

Blow moulding, rotational moulding, compression& transfer moulding, thermoforming- materials, mould, process optimization, flow simulation and troubleshooting; Joining and machining of plastics.

UNIT V COMPOUNDING AND MIXING OF POLYMERS 9

Principles of plastics compounding – additives - pre-compounding operations, machinery, post compounding operations, compounding for specific properties.

TOTAL: 45 PERIODS

OUTCOMES

By the end of this course, students will be able to
CO1 Analyze the properties of plastics
CO2 Decide the processing parameters for a specific plastics product within realistic constraints.
CO3 Solve the product defect due to rheological behavior and processing variables.
CO4 Relate processing variable with product morphology.
CO5 Apply the principles of compounding to prepare plastic products of required properties

REFERENCES

1. Tim A .Oswald, Polymer Processing fundamentals", Hanser1998.
2. R.J.Crawford, "Plastics Engineering" Butterworth, 3rd Edition, 1998

Course Articulation Matrix:

Course Outcomes	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6

CO1	1	3	3	-	2	1
CO2	1	2	3	3	-	-
CO3	3	2	2	3	1	-
CO4	-	1	1	2	-	-
CO5	3	1	1	2	-	-
Overall CO	**1.6**	**1.8**	**2**	**2**	**1.5**	**1**

1, 2and3arecorrelation levels with weightings as Slight (Low),Moderate (Medium)and Substantial (High) respectively

R3016 BIOPOLYMERS AND BIOCOMPOSITES **L T P C**
3 0 0 3

OBJECTIVES

- To enable the students to know about the manufacture, properties and applications of various biopolymer, biofiber/filler and their composites.

UNIT I BIOPOLYMERS 8

Introduction – Classification - Biopolymers from natural origin and mineral origin - isolation – properties.

UNIT II BIODEGRADATION 10

Biodegradation.- Mechanism of biodegradation (polyesters, polycarbonates, polyvinyl alcohol, polyurethanes and polyethers) factors influencing biodegradation. Types of biodegradable polymers – properties and application.

UNIT III CHARACTERIZATION AND TESTING FOR BIODEGRADABILTY 9

Test methods and standards for bio-degradable plastics – Criteria used in evaluation of biodegradable plastics – Description of current test methods – Scanning test for ready biodegradability – Test for inherent biodegradability – Test for simulation studies – Other methods for assessing polymer biodegradability.

UNIT IV BIOCOMPOSITES 9

Definition- classification- natural bio - fibre and nano fillers as reinforcement, biodegradable/ biobased resins as matrices. Properties of biocomposites. Applications in automobile & buildings.

UNIT V APPLICATIONS OF BIOPOLYMER 9

Biopolymer Films – Biodegradable mulching – Advantages and Disadvantages – Chemical sensors – Biosensors - Functionalized Biopolymer Coatings and Films – Applications of biopolymers in horticulture Food Packaging – Functional Properties – safety and Environmental aspects – Shelf life – Films and coatings in Food Applications – Materials for edible films and coatings – Biopolymer coatings for paper and paperboard – Bio-nanocomposite films and coatings.

TOTAL : 45 PERIODS

OUTCOME

By the end of this course, students will be able to
CO1 Illustrate the concepts of biopolymer and biocomposites
CO2 Explain the mechanism of bio degradation in polymers
CO3 Evaluate biodegradability of polymers
CO4 Design polymer products involving sustainable sources
CO5 Create packaging solutions based on biopolymers

REFERENCES

1. Biodegradable polymers for industrial applications, Ray Smith , Woodhead Publishing Ltd, CRC Press, 2005.

2. Handbook of Biodegradable polymers – Abraham J. Domb, Joseph Kost & David M. Wiseman.
3. Bio-Based Polymers and Composites – Richard P.Wool . Xiuzhi Susan Sun.
4. Green Polymer Materials – Amar Singh Singha and Vijay Kumar Thakur.
5. Natural Fibers, Bio Polymers, and Bio Composites – Amar K.Mohanty, Manjusri Misra and Lawrence T. Drzal.

Course Outcomes	Programme Outcomes(POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	2	2	-	1	2	2
CO2	-	3	2	1	1	3
CO3	2	2	2	-	-	3
CO4	-	1	2	-	2	2
CO5	-	1	1	2	2	3
Overall CO	**2**	**1.8**	**1.4**	**2**	**1.75**	**2.6**

1, 2and3arecorrelation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High)respectively

RT3017 RUBBER INDUSTRY PRACTICES L T P C 3 0 0 3

OBJECTIVES

- To enable the students to know about the management practices in various rubber industries.

UNIT I INDUSTRIAL MANAGEMENT 9

Introduction and Importance of maintaining TQM culture from Security to Senior management level Total Productive Maintenance (TPM) - Importance of machine handling and basic disciplines to be followed wrt machines. (like Jishu Hozen (Autonomous maintenance), Preventive / Predictive maintenance, My Machine, Condition monitoring)

UNIT II BUSINESS MANAGEMENT 9

Business Analysis, Project management, Business Finance (Preparation of Balance sheet, Human resource management, EBITDA, Costing, Accounting, Organizational behaviour, Organizational strategy, Entrepreneurship, Business law and ethics, Operational and information management

UNIT III QUALITY ANALYTICS AND LEAN MANUFACTURING 9

QC tools(Pareto chart, fishbone diagram, scatter diagram etc), 6 Sigma, QC story methodology, PFMEA, DMAIC, 8D, APQP, PPAP, SPC, DOE etc) - Practical examples Lean Manufacturing systems - 5S, Kaizen, Kanban, Value stream mapping, SMED, Takt time, Continual improvement process, Waste reduction(Muda, Mura, Muri), OEE, Jidoka, JIT, Poka-Yoke, Awareness on resource utilization, manufacturing excellence

UNIT IV INDUSTRIAL STANDARDS 9

EMS, OHSAS, IATF, ISO-QMS, SAE, ISO-TS etc.(All standards to be detailed with application requirement and its importance in Industries)

UNIT V MODERNIZATION 9

Artificial Intelligence(AI), Internet on Things(IoT), Machine learning, Condition monitoring, SCADA, Smart factory automation, Low-cost automation(LCA), Digitalization

TOTAL: 45 PERIODS

OUTCOME

By the end of this course, students will be able to

CO1 Inculcate and insist quality culture in the organization
CO2 Use modern tools in the entire business operations for efficiency
CO3 Implement various quality management concepts
CO4 Apply regulatory standards in rubber product manufacture
CO5 Combine existing practices with emerging technologies

REFERENCES:

1. P.K. Freakley, "Rubber Processing and Production Organization",Springer,2012.
2. Theodore T. Allen , Introduction to Engineering Statistics and Lean Six Sigma, Springer, 2018
3. Manufacturing Performance Enhancement Through TQM-TPM Paradigms, Lap Lambert Academic Publishing,2014

Course Articulation Matrix:

Course Outcomes	Programme Outcomes(POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	-	2	-	3	3	2
CO2	-	2	2	3	2	1
CO3	3	3	-	2	2	3
CO4	-	-	2	2	3	1
CO5	1	2	-	3	-	1
Overall CO	**2**	**2.25**	**2**	**2.6**	**2.5**	**1.6**

1, 2and3 are correlation levels with weightings as Slight (Low) ,Moderate (Medium) and Substantial (High)respectively