UNIVERSITY DEPARTMENTS

ANNA UNIVERSITY:: CHENNAI 600 025

REGULATIONS - 2015

I TO IV SEMESTERS CURRICULUM AND SYLLABUS

M. TECH. RUBBER TECHNOLOGY

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

I. To equip graduates with good scientific and engineering knowledge so as to help comprehend, analyze, design, and create new products based on rubber and rubber like materials, for various engineering applications

II. To prepare graduates to excel in inter-disciplinary research required for the Rubber Industry and/or Research Organizations, with an ethical and social outlook

III. To provide graduates with an academic environment, conducive for research and development in their life-long learning in various aspects of their profession

PROGRAMME OUTCOMES (POs):

On successful completion of the programme, the Post Graduates will

1. Acquire adequate knowledge of scientific and technological aspects of rubber and allied products

2. Have the ability to identify, formulate and solve engineering problems related to rubber product design and manufacture

3. Be capable of designing new components and processes as per needs and specifications for rubber and allied industries

4. Demonstrate the ability to design, experiment, analyze and interpret data for product validation

5. Understand, simulate and work on products and integrate multidisciplinary tasks pertaining to rubber technology

6. Demonstrate skills to use modern engineering tools, software and equipment to analyze and solve problems

7. Be able to provide technical and/or academic leadership for various organizations through life-long learning

8. Develop confidence and tools necessary for technology forecasting including social and environmental aspects.

Programme Educational Objectives	Programme Outcomes							
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
I	✓	✓	✓	✓	✓	✓		
II	✓	✓		✓		✓	✓	✓
III		✓					✓	✓

			PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
YEAR 1	SEM 1	**THEORY**								
		Advanced Numerical Methods	✓							
		Engineering Design			✓	✓				
		Rubber Materials Technology	✓	✓						
		Principles of Polymer Systems	✓						✓	✓
		Rubber Processing Technology	✓							
		Elective-I								
		PRACTICAL								
		Computer Aided Product and Mould Design Lab		✓	✓	✓		✓		
	SEM 2	**THEORY**								
		Polymer Characterisation Techniques	✓					✓	✓	
		Rubber Compounding	✓	✓	✓				✓	
		Rubber Products Design	✓	✓	✓	✓			✓	✓
		Tyre Science and Technology	✓	✓					✓	
		Elective-II								
		Elective-III								
		PRACTICAL								
		Rubber Processing and Testing Lab	✓							
YEAR 2	SEM 3	**THOERY**								
		Elective IV								
		Elective-V								
		Elective-VI								
		PRACTICAL								
		Project Work Phase I						✓	✓	✓
	SEM 4	**PRACTICAL**								
		Project Work Phase II						✓	✓	✓

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REGULATIONS - 2015

CHOICE BASED CREDIT SYSTEM

I TO IV SEMESTERS CURRICULUM AND SYLLABUS

M. TECH. RUBBER TECHNOLOGY

SEMESTER – I

SL. NO.	COURSE CODE	COURSE TITLE	Category	Contact Period	L	T	P	C
THEORY								
1.	MA7155	Advanced Numerical Methods	FC	4	4	0	0	4
2.	RT7101	Engineering Design	FC	3	3	0	0	3
3.	RT7102	Principles of Polymer Systems	PC	3	3	0	0	3
4.	RT7103	Rubber Materials Technology	PC	3	3	0	0	3
5.	RT7104	Rubber Processing Technology	PC	3	3	0	0	3
6.		Elective I	PE	3	3	0	0	3
LABORATORY								
7.	RT7111	Computer Aided Product and Mould Design Lab	PC	4	0	0	4	2
			TOTAL	**23**	**19**	**0**	**4**	**21**

SEMESTER – II

SL. NO.	COURSE CODE	COURSE TITLE	Category	Contact Period	L	T	P	C
THEORY								
1.	RT7201	Polymer Characterization Techniques	PC	3	3	0	0	3
2.	RT7202	Rubber Compounding	PC	3	3	0	0	3
3.	RT7203	Rubber Products Design	PC	3	3	0	0	3
4.	RT7204	Tyre Science and Technology	PC	3	3	0	0	3
5.		Elective II	PE	3	3	0	0	3
6.		Elective III	PE	3	3	0	0	3
LABORATORY								
7.	RT7211	Rubber Processing and Testing Lab	PC	4	0	0	4	2
			TOTAL	**22**	**18**	**0**	**4**	**20**

SEMESTER – III

SL. NO.	COURSE CODE	COURSE TITLE	Category	Contact Period	L	T	P	C
THEORY								
1.		Elective IV	PE	3	3	0	0	3
2.		Elective V	PE	3	3	0	0	3
3.		Elective VI	PE	3	3	0	0	3
LABORATORY								
4.	RT7311	Project Work Phase I	EEC	12	0	0	12	6
			TOTAL	**21**	**9**	**0**	**12**	**15**

SEMESTER – IV

SL. NO.	COURSE CODE	COURSE TITLE	Category	Contact Period	L	T	P	C
LABORATORY								
1.	RT7411	Project Work Phase II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL CREDITS : 68

Foundation Courses(FC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Advanced Numerical Methods	FC	3	3	2	0	4
2.		Engineering Design	FC	3	3	0	0	3

Professional Core (PC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Rubber Materials Technology	PC	3	3	0	0	3
2.		Principles of Polymer Systems	PC	3	3	0	0	3
3.		Rubber Processing Technology	PC	3	3	0	0	3
4.		Computer Aided Product and Mould Design Lab	PC	4	0	0	4	2
5.		Polymer Characterisation Techniques	PC	3	3	0	0	3
6.		Rubber Compounding	PC	3	3	0	0	3
7.		Rubber Products Design	PC	3	3	0	0	3
8.		Tyre Science and Technology	PC	3	3	0	0	3
9.		Rubber Processing and Testing Lab	PC	4	0	0	4	2

Professional Electives (PE)

S.No	COURSE CODE	COURSE TITLE	CATE GORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	RT7001	Adhesives and Adhesion Technology	PE	3	3	0	0	3
2.	RT7002	Biopolymers and Biocomposites	PE	3	3	0	0	3
3.	RT7003	Computer Aided Product Design	PE	3	3	0	0	3
4.	RT7004	Finite Element Analysis for Polymer	PE	3	3	0	0	3
5.	RT7005	Heat and Mass Transfer for Polymer	PE	3	3	0	0	3
6.	RT7006	Latex Technology	PE	3	3	0	0	3
7.	RT7007	Mould Design and Manufacturing	PE	3	3	0	0	3
8.	RT7008	Plastics Engineering	PE	3	3	0	0	3
9.	RT7009	Polymer Blends and Alloys	PE	3	3	0	0	3
10.	RT7010	Polymer Composites and Structures	PE	3	3	0	0	3
11.	RT7011	Polymer Nanocomposites	PE	3	3	0	0	3
12.	RT7012	Polymer Reaction Engineering	PE	3	3	0	0	3
13.	RT7013	Polymer Testing	PE	3	3	0	0	3
14.	RT7014	Polymers and Environment	PE	3	3	0	0	3
15.	RT7015	Polymers for Electrical and Electronic Applications	PE	3	3	0	0	3
16.	RT7016	Research Methodology	PE	3	3	0	0	3
17.	RT7017	Specialty Polymers	PE	3	3	0	0	3
18.	RT7018	Stress Analysis of Polymers	PE	3	3	0	0	3
19.	RT7019	Theory of Viscoelasticity	PE	3	3	0	0	3
20.	AL7017	Theory of Vibrations	PE	3	3	0	0	3
21.	AM7251	Vehicle Dynamics	PE	3	3	0	0	3
22.	MN7151	Materials Technology	PE	3	3	0	0	3
23.	MS7151	Manufacturing Management	PE	3	3	0	0	3

Employability Enhancement Courses (EEC)

S.No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Project Phase - I	EEC	8	0	0	12	6
2.		Project Phase - II	EEC	24	0	0	24	12

MA7155 ADVANCED NUMERICAL METHODS L T P C
4 0 0 4

OBJECTIVE

- To impart knowledge on numerical methods that will come in handy to solve numerically the problems that arise in engineering and technology. This will also serve as a precursor for future research.

OUTCOME

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

- It helps the students to get familiarized with the numerical methods which are necessary to solve numerically the problems that arise in engineering.

UNIT I ALGEBRAIC EQUATIONS 12

Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm for tridiagonal system – Jacobi, Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Method, Eigenvalue problems: power method, inverse power method, Faddeev – Leverrier Method.

UNIT II ORDINARY DIFFERENTIAL EQUATIONS 12

Runge Kutta Methods for system of IVPs, numerical stability, Adams-Bashforth Multistep method, solution of stiff ODEs, shooting method, BVP: Finite difference method, orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method.

UNIT III FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATION 12

Parabolic equations: explicit and implicit finite difference methods, weighted average approximation - Dirichlet and Neumann conditions – Two dimensional parabolic equations – ADI method; First order hyperbolic equations – method of characteristics, different explicit and implicit methods; numerical stability analysis, method of lines – Wave equation: Explicit scheme- Stability of above schemes.

UNIT IV FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS 12

Laplace and Poisson's equations in a rectangular region: Five point finite difference schemes, Leibmann's iterative methods, Dirichlet and Neumann conditions – Laplace equation in polar coordinates: finite difference schemes – approximation of derivatives near a curved boundary while using a square mesh.

UNIT V FINITE ELEMENT METHOD 12

Partial differential equations – Finite element method - orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method.

TOTAL : 60 PERIODS

TEXT BOOKS

1. Saumyen Guha and Rajesh Srivastava, "Numerical methods for Engineering and Science", Oxford Higher Education, New Delhi, 2010.
2. Gupta S.K., "Numerical Methods for Engineers", New Age Publishers, 1995.

REFERENCE

1. Burden, R.L., and Faires, J.D., "Numerical Analysis.

RT7101 **ENGINEERING DESIGN** **L T P C**
3 0 0 3

OBJECTIVE

- To introduce the concepts of design in common machine elements for engineering applications.

UNIT I ENGINEERING DESIGN CONCEPTS 9

Stress-Strain relations - Mohr's circle- Shear force - Bending moment diagram - Deflection of beams. Factor of safety-Preferred numbers -Various stresses in Design-Design steps

UNIT II FRICTION 9

Nature of surfaces and contact – Friction mechanisms and limiting angle of friction – Friction on screw and nut – Pivot and collar friction – Belt friction – Plate and disc clutches – Brakes – Application of journal bearings and rolling element bearings – Hydrostatic and aerostatic bearings.

UNIT III DESIGN OF MACHINE ELEMENTS 9

Design of shafts – Couplings - Journal Bearings - springs – power screws

UNIT IV DESIGN OF TRANSMISSION ELEMENTS 9

Belt and chain drives – Design of gear drives – Spur gear – Worm and worm wheel.

UNIT V MECHANICAL VIBRATION 9

Single degree of freedom systems – Forced, damped vibrations – System response - time constant – Log dc – Vibration isolation – Torsional vibrations – Two rotor systems.

TOTAL : 45 PERIODS

REFERENCES

1. Shigley, J.E., - Mechanical engineering Design, -McGraw Hill Co., 1988.
2. Hall, - Machine Design, - Schaum's outline Series, McGraw Hill, 1983.
3. Sundararajamurthy and Shanmugham, - Machine Design – Khanna Publishers, Delhi, 1988.
4. P.L.Ballaney, - Theory of machines – Khanna Publishers, Delhi, 1992.

RT7102 **PRINCIPLES OF POLYMER SYSTEMS** **L T P C**
3 0 0 3

OBJECTIVES

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

OUTCOMES

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

- Analyze the mechanism of polymerization in the synthesis of various polymers.
- Apply the structure – property relationship in arriving at a decided property.

UNIT I INTRODUCTION 9

Chemical bonding involving carbon – hybridization – allotropes of carbon – 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 – Simple reactions – Molecular weight of Polymers and their significance - Industrial Polymerization Techniques

UNIT III STATES OF AGGREGATION IN POLYMERS 9

Amorphous polymers – Glassy and Rubbery states –Glass transition Temperature – Factors affecting Glass Transition - Crystallinity and semi- crystalline state in polymers – Crystalline melting point- crystal nucleation and growth - Spherulite 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

REFERENCES

1. Ferdinand Rodriguez, Claude Cohen, Christopher K. Obes and Lynden A. Archer, 2003 “Principles of Polymer Systems” , Taylor and Francis publications
2. Manas Chanda and Salil K Roy, 2009, Industrial Polymers, Speciality Polymers and Their Applications, CRC Press, Taylor and Francis Group
3. John Brydson, 1999, Plastics Materials, Butterworth – Heinemann, 7th edition I.M.Ward,1983, Mechanical Properties of Solid Polymers, Wiley,New York
4. J.J.Aklonis and WJ MacKnight,1983, Introduction to Polymer Viscoelasticity, 2nd ed., Wiley, New York

RT7103 RUBBER MATERIALS TECHNOLOGY L T P C
3 0 0 3

OBJECTIVES

- To know about the preparation, properties and application of different rubbers.
- To realize the need for vulcanization.
- To learn about the role various ingredients used in a rubber compounding.

OUTCOMES

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

- Select an appropriate rubber for a given application.
- Design a formulation for a specific requirement.

UNIT I INTRODUCTION TO RUBBER MATERIALS 10

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 10

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 10

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

UNIT IV HIGH PERFORMANCE RUBBERS 7

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

UNIT V POLYURETHANES AND THERMOPLASTIC RUBBERS 8

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

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

RT7104 RUBBER PROCESSING TECHNOLOGY **L T P C**
3 0 0 3

OBJECTIVES

- To study the rheological characteristics of a polymer.
- To introduce the different rubber processing techniques.

OUTCOMES

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

- Decide the processing parameters for a specific rubber product within realistic constraints.
- Solve the product defect due to rheological behavior and processing variables.
- Modify the design of the processing equipment to achieve an efficient processing.

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

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.

RT7111 COMPUTER AIDED PRODUCT AND MOULD DESIGN LAB L T P C
0 0 4 2

OBJECTIVE

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

OUTCOMES

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

- To impart knowledge on CAD and CAE.
- To able to understand mould design and drawing.
- To be able to apply CAD in real life Applications
- To perform simulation and analysis using software tools.
- To impart knowledge of non linear material Analysis.

Introduction to mould, Dies & production drawing - classification of drawing - BIS conventions. Reviews of the concepts of limits, tolerance, fits, surface roughness, and symbols terminology used in Production drawing.

LIST OF EXPERIMENTS

I. DESIGN AND DRAWING OF MOULDS

1. Hand Mould, Semi – Injection Mould
2. Multi Cavity – Multiday Light Mould
3. Side Core ,Collapsible core - Mechanism
4. Compression Mould, Transfer Mould, Blow mould.

II. DESIGN AND DRAWING OF DIES

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

III. ANALYSIS OF INJECTION MOULDING OF SIMPLE PRODUCTS USING MOULD ANAYSIS SOFTWARES

Product mould design considerations – Mould filling and cooling analysis – Control of product tolerances – Increasing product strength and stiffness – Designing for assemblies- Design for assembly and service.

IV. ANALYSIS OF SIMPLE PRODUCTS USING SOFTWARES

a. O-rings
b. Seals
c. Dampers/springs
d. Rubber boot
e. Engine mount

TOTAL : 60 PERIODS

RT7201 POLYMER CHARACTERIZATION TECHNIQUES

L T P C
3 0 0 3

OBJECTIVES

- To impart the knowledge of various characterizations methods.
- To understand the importance of characterization techniques.

OUTCOMES

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

- Select suitable characterization techniques to characterize the given compound.
- Interpret and analyze the given data of any compound.

UNIT I REVIEW ON CHARACTERIZATION METHODS 9

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

UNIT II THERMAL ANALYSIS 9

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

UNIT III MOLECULAR WEIGHT STUDIES 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 : 45 PERIODS

REFERENCES

1. Hoffman, Rubber Technology Handbook, Hanser Publisher, Munich (1996).
2. RogerBrown, Physical Testing of Rubber, Interscience, New York (1996).
3. D Campbell & JR White, Polymer Characterization, Chapman & Hall, London (1989).
4. Hunt & James, Polymer Characterization, Chapman & Hal, London (1993).

RT7202 RUBBER COMPOUNDING L T P C
3 0 0 3

OBJECTIVES

- To introduce the rubber compounding ingredients, their importance and technical classification of rubber mixes.
- To estimate the compound cost.
- To study the quality related concepts.
- To understand the compound design requirement of various rubber products.

OUTCOME

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

- Understand the line call out and analyse the compound design.
- Design a cost effective formulation for a specific product requirement.
- Maintain and improve the quality of the product consistently

UNIT I RUBBER ADDITIVES 12

Need for compounding - Vulcanising 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 8

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

UNIT III DESIGNING COMPOUNDS FOR VARIOUS RUBBERS 12

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 5

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 8

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

REFERENCES

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

RT7203 **RUBBER PRODUCTS DESIGN** **L T P C**
3 0 0 3

OBJECTIVES

- To impart the knowledge on design factor involved in a rubber product manufacture.
- To understand the behavior of rubber product under different loading conditions.

OUTCOME

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

- Demonstrate the ability to design and conduct experiments, as well as to analyze and interpret data for different rubber products

UNIT I SIMPLE GEOMETRIES 9

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, UV stability, 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

UNIT IV RUBBERS IN SEALING APPLICATIONS 9

Rubbers in fluid sealing – Types of Seals – Gaskets – Flexible couplings – Hose Design and construction – Profiles - Material selection and compound design- Design considerations - Conveyer Belts – V-belts

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

TOTAL : 45 PERIODS

REFERENCES

1. Alan N Gent, Engineering with Rubber, Carl Hanser Verlag, Munich 2001.
2. Khairi Nagdi, Rubber as an Engineering material, Hanser Publishers, 1993.
3. P.R.Freakley and A.R.Payne, Theory and Practice of Engineering with Rubber, Applied Science Publishers, London, 1970
4. P.B.Lindley, Engineering Design with Natural Rubber, Natural Rubber Producers Research Association, London, 1974.

RT7204 TYRE SCIENCE AND TECHNOLOGY L T P C
3 0 0 3

OBJECTIVES

- To impart interest and sense of appreciation of all about pneumatic tyre,
- To educate the students in respect of tyre performance as a function of size, carcass design, reinforcement and rubber materials.
- To reiterate the role of various forces and moments as variables to tyre performance and life.
- To capture the features of tread design and materials as related to grip, life and safety,
- To provide insight to the test design, tyre properties, tire retreading and related end of life cycle.

OUTCOMES

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

- To appreciate the role of rubber materials and particularly general purpose rubbers shaping into a high performance pneumatic tyre,
- To understand various carcass materials and methods in tyre reinforcement,
- To visualize various tread design and its role in grip, life and safety,
- To relate to automobiles like 2 wheeler, 4 wheeler (LT, HDT, PC) and OTR in terms of the design variations relating to tyre performance,
- To understand the fundamental design differences among these end use dependent tyre sizes, tubed and tubeless tyres.

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 CORD 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, Rubber to Cord Mechanism, Tyre Cord Construction, Evaluation of adhesive systems.

UNIT III TYRE COMPONENT DESIGN BASICS 9

Tread Design: Basic Tread Patterns for Long Life, Road Adhesion, Noise Reduction, Cracking, Appearance, Special Patterns, Selection of Materials – Carcass Design: Selection of Fabrics, Cord Angle Ply Construction, Fabric Stretch, Compression, Bias Angle, Crown Angle, Crown Stretch, Casing strength and Bead Strength. Side Wall Design: Requirements, Selection of Materials, Flexing, Mould Design: Selection of Mould Materials, Rim Dimensions, Bead Seat, Sectional Height and Width Tread Depth, Tread Curvature, Tread Width, Groove Shape, Pattern and Venting, Sidewall Curvature.

UNIT IV TYRE AND TUBE MANUFACTURING 9

Rubber Processing Techniques for Tyre manufacturing, Green Tyre, Ply width and Building Drum width, Tyre Building specifications – Carcass – Gum, Inserts and Squeegees, Breakers, Cushion, Beads, Bead Covers, Flippers, Chafers, Tread and Sidewalls-Reinforcements and Tolerances, Vulcanization techniques-Curing bags, Tyre Presses and Finishing operations – Tube Manufacturing-Selection of Materials, Manufacturing Process, Defects.

UNIT V TYRE PERFORMANCE AND TESTING 9

Tyre Mechanics – Forces acting on Tyres – Lateral, Vertical and longitudinal forces, Steering properties-slip angle, Aligning Torque, Static steering Torque. Road Contact Pressure, Traction, Power loss, Friction, Rolling Resistance, Noise and Vibration, Tread Wear, Fatigue and separation, Heat Build up, Bruise, Cutting, Cracking and Tearing.

Tyre Testing – Destructive and Non-destructive Testing of Tyres, Plunger Tests (Breaking energy), Pulley wheel test Field Tract Testing – Braking, Acceleration, mileage, Regulations, Tyre Labelling.

TOTAL : 45 PERIODS

REFERENCES

1. Automobile Tyres, L J K Setright, Chapman and Hall, 1972.
2. Tyre Technology, Tom French, Adam Hilger, 1989.
3. Mechanics of Pneumatic Tyres, (ed) Samuel K Clark, US Dept of Transportation.
4. Textile Reinforcement of Elastomers (ed) W C Wake & D B Wootton, Applied Science Publishers Ltd, 1982.
5. Pneumatic Tyre Design, E C Woods, W Heffer & sons Ltd, 1952.
6. Tyre Technology, F J Kovac, The Goodyear Tyre & Rubber Company, 1973.

RT7211 RUBBER PROCESSING AND TESTING LAB **L T P C**
0 0 4 2

OBJECTIVES

- To enhance the skills of the students to design and prepare different rubber compound.
- To study the curing characteristics of the compound.
- To evaluate the basic mechanical properties of the prepared rubber compound.

OUTCOMES

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

- Operate and analyze the problems in various rubber processing equipments.
- Optimize the curing parameters to suit the productivity.
- Prepare the specimens as per the standard to assess its mechanical and other relevant properties

LIST OF EXPERIMENTS

1. Rubber Mixing (4 Exp)

   Mastication of natural rubber and mixing of rubber (gum and filled compounds) using two-roll mixing mill and Kneader.

2. Vulcanization studies using ODR (1 Exp)

3. Rubber Extrusion (1 Exp)

   Processing of Rubber compounds on an rubber extruder, die, extrudate defects

4. Moulding of Rubber Compounds (2 Exp)

   1. Study on construction, operation and molding of rubber compound on a hydraulic press.
   2. Study on optimizing the curing parameters

5. Latex Compounding (2 Exp)

   1. Preparation of dispersion in a ball mill

2. Preparation of compounded latex.

6. 1. Mechanical Testing, Abrasion test, Compression set test
2. Swelling Tests-Cross-link density measurements, Viscosity-solution

(6 Exp)

TOTAL : 60 PERIODS

RT7001 ADHESIVES AND ADHESION TECHNOLOGY L T P C
3 0 0 3

OBJECTIVES

- To impart the fundamentals on adhesives and adhesion process.
- To know about the properties and applications of various adhesives and its joining mechanism

OUTCOME

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

- Understand the selection of adhesives and adhesion process and its 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 NON REACTIVE 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 & hot melt adhesives based on SBS, EVA – polyvinyl acetate & polyvinyl alcohol based adhesives.

UNIT IV REACTIVE ADHESIVES 7

Phenolics, epoxies, acrylics, anaerobics, cyanoacrylates – poly imides-bis maleimide and 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

REFERENCES

1. Skiest I (ed), Hand book of Adhesives – Van Nostrand Reinhold, 1990.
2. Shields, Hand Book of Adhesives, Butterworths, 1984.

RT7002 BIOPOLYMERS AND BIOCOMPOSITES L T P C
3 0 0 3

OBJECTIVES

- To impart the fundamentals of biopolymer and biocomposites.
- To know about the manufacture, properties and applications of various biopolymer, biofiber/filler and their composites.

OUTCOME

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

- Understand the concepts of biopolymer blends and biocomposites, properties, biodegradabality and applications

Demonstrate the ability to select a suitable biopolymer and its reinforcement to meet desired needs within realistic constraints

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

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.

RT7003 **COMPUTER AIDED PRODUCT DESIGN** **L T P C**
3 0 0 3

OBJECTIVES

- To have an exposure on various concepts in Computer Aided Design.
- To know about recent advances in computer based design.
- To impart knowledge on various product modeling concepts.

OUTCOME

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

- Understand the various product design concepts and tools.
- Design, formulate, interpret and analyse data using CAD tools and software.
- Use modern engineering tools and solve the problems.

UNIT I INTRODUCTION TO COMPUTER AIDED DESIGN 8

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

UNIT II PRODUCT MODELLING 8

Surface and solid modeling – mathematical representation of solids – design data base – Feature based modelers – Product models – Process chains – Product life cycle management – product data management – components of PDM – Configuration Management.

UNIT III PRODUCT DESIGN CONCEPTS 10

Product development process tools – Scoping product developments – Understanding customer needs – establishing product function – Bench marking 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 IV PRODUCT DESIGN TOOLS AND STANDARDS 10

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

UNIT V POLYMER PRODUCT DESIGN 9

Selection of Plastics **-** Product Design, Development and Manufacture – Checklist forms-Mechanical properties of plastics – creep curves of Plastics. Product design consideration — Stress strain curves. Structural Analysis – Beams, Pressure vessels and tubes- Ribbed Plate Design – Plastics Springs – Snap Fit Designs – Design of Plastics gears and bearings-Design of plastic pipes.

TOTAL: 45 PERIODS

REFERENCES

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

RT7004 FINITE ELEMENT ANALYSIS FOR POLYMER **L T P C**
3 0 0 3

OBJECTIVES

- To impart the knowledge on Numerical Methods in solving the problems using Finite Element techniques.
- To introduce the concepts of Mathematical Modeling of Engineering Problems.
- To understand the behaviour of rubber product under different loading conditions.

OUTCOMES

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

- Demonstrate the ability to FEM to a range of Engineering Problems.
- Use the modern engineering tools and analyze the problems within the domains of rubber and plastics as the members of multidisciplinary teams.

UNIT I INTRODUCTION 8

Review of various approximate methods – Rayleigh-RitZ, Galerkin and Finite Difference Methods – 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 axisymmetric 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-Delements–Formulation of element stiffness matrix – Load vector

UNIT V NON LINEAR 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- Non linear material behavior- Boundary conditions-Applications- Software packages

TOTAL : 45 PERIODS

TEXT BOOKS

1. Segerlind,L.J. “Applied Finite Element analysis”, Second Edition, John Wiley and Sons Inc., New Yors, 1984.
2. Tirupathi R. Chandrupatla and Ashok D Belegundu, Introduction to Finite Elements in Engineering, Printice Hall, 2002.
3. Alan N Gent, Engineering with Rubber, 2nd Edition, Carl Hanser Verlag, Munich 2001.

REFERENCES

1. K.J. Bathe and E.L. Wilson, “Numerical Methods infinite Elements Analysis”, Prentice Hall of India Ltd., 1983.
2. Robert D.Cook, David S.Malkus, Michael E. Plesha and Robert J, Witt “Concepts and Applications of finite Element Analysis”, 4th Edition, John Wiley & Sons, 2002
3. C.S.Krishnamurthy, “Finite Elements Analysis”, Tata McGraw – Hill, 1987.

RT 7005 HEAT AND MASS TRANSFER FOR POLYMER **L T P C**
3 0 0 3

OBJECTIVES

- To impart the fundamental concepts of heat and mass transfer.
- To understand the impact of heat transfer in rubber processing.

OUTCOME

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

- Understand the basics of heat and mass transfer mechanism.
  Demonstrate the ability to apply the principle of heat and mass transfer in rubber processing

UNIT I HEAT TRANSFER 10

Thermal conductivity and mechanism of energy transport – measurement of thermal conductivity – temperature dependence of thermal conductivity in solids and liquids. Fourier's law of heat conduction – one dimensional steady state heat conduction equation for flat plate, hollow cylinder and sphere – heat conduction through a series of resistances – two dimensional steady conduction – unsteady state heat conduction – heat transfer in polymer melts.

UNIT II HEAT TRANSFER COEFFICIENTS 12

Individual and overall – coefficients for forced convection in tubes and around submerged objects, for free convection, film type condensation and boiling liquids – thermal radiation – laws – radiation between surfaces, from gases – temperature measurement – from radiation – Design and analysis of heat transfer equipment

UNIT III MASS TRANSFER 8

Mass transfer – molecular and Eddy diffusion – steady state diffusion under stagnant and laminar flow conditions – diffusivity measurement and prediction

UNIT IV CONCEPT OF MASS TRANSFER COEFFICIENT 10

Overall mass transfer coefficients – additivity equation in terms of individual phase coefficients – j_D factor – HTU and NTU concepts – equilibrium and operating line concepts in mass transfer calculation. Diffusion of gases and vapours in polymer melts.

UNIT V HEAT TRANSFER IN RUBBER PROCESSING 5

Heat transfer in Rubber Injection Moulding process – Heat transfer in other continuous Vulcanization techniques.

TOTAL : 45 PERIODS

REFERENCES

1. J.R.Welty, C.E.Wicks and R.E.Wilson, "Fundamentals of Momentum,Heat and Mass Transfers", John Wiley and Sons, New York, 1976.
2. D.Q. Kern, 'Process Heat Transfer', McGraw Hill Book Co., NY 1970.
3. W.L.McCabe and J.C.Smith, 'Unit Operation in Chemical Engineering", McGraw Hill, Kogakusha, 1976.
4. R.E. Treybal, "Mass transfer operations", McGraw Hill, Kogakusha, 1980.

RT7006 **LATEX TECHNOLOGY** **L T P C**
3 0 0 3

OBJECTIVES

- To understand the characteristics of latex, its classification and source.
- To impart the fundamentals of latex compounding and processing.
- To study about the manufacture, properties and applications of synthetic latex.

OUTCOMES

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

- Differentiate the behaviour of latex from dry rubber in terms of stability, compounding and processing.
- Understand the principle behind latex product manufacture.
- Demonstrate the ability to design a formulation and select a suitable process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.

UNIT I LATEX –NATURE AND 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 of latex.

UNIT II COMPOUNDING OF LATEX 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, deproteinzation. Manufacture and formulation of latex products- condom, gloves, balloons, catheters; Foam rubber, thread, tubing, toys

UNIT IV SYNTHETIC LATEX 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, fluropolymer, and CSM latex.

UNIT V APPLICATIONS OF LATEX 9

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

TOTAL : 45 PERIODS

REFERENCES

1. D.C.Blackely,"Polymer Lattices", Vol 1,2 & 3.
2. H.Warson and C.A.Finch, Applications of synthetic Resin latices, Vol.1,2,3, John Wiley & Sons Ltd. 2001

RT 7007 MOULD DESIGN AND MANUFACTURING L T P C
3 0 0 3

OBJECTIVES

- To understand the concept of Mold and Die design and its manufacturing techniques.
- To introduce recent trends in mould manufacturing.

OUTCOMES

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

- Implement the various concept of Mould design.
- Apply CAD in Mould design and Analysis
- Study any mould design and drawing.

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 – draft angles – responsibility for shrinkage – surface finish.

UNIT II COMPRESSION, TRANSFER AND 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 - blow ratio – blow pin and neck ring design - clamping force.

UNIT III DESIGN OF 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 guide pillars – Design of runner, gates, mould cooling system, ejection system – case studies

UNIT IV EXTRUSION DIE DESIGN 7

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

UNIT V RECENT TRENDS IN MOULD MANUFACTURING 8

Mould making techniques – rapid prototyping and tooling – EDM – ECM – USM Microfabrication - Surface coatings – Computer aided mould design and use of CAD in Mould construction and analysis.

TOTAL : 45 PERIODS

REFERENCES

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

RT7008 PLASTICS ENGINEERING L T P C
3 0 0 3

OBJECTIVES

- To study the mechanical behaviour of plastics.
- To introduce the different compounding, mixing and processing techniques for plastics

OUTCOMES

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

- Able to compound and mix plastics and prepare plastics compound as per the required properties
- Decide the processing parameters for a specific plastics product within realistic constraints.
- Solve the product defect due to rheological behavior and processing variables.
- Modify the design of the processing equipment to achieve an efficient processing.

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 behaviour

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

REFERENCES

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

RT7009 **POLYMER BLENDS AND ALLOYS** **L T P C**
3 0 0 3

OBJECTIVES

- To impart the fundamentals of polymer blends and alloys.
- To know about the manufacture, properties and applications of various TPE and their blends.

OUTCOME

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

- Understand the concepts of polymer blends and alloys.

  Demonstrate the ability to select a suitable blend to meet desired needs within realistic constraints

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

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

RT7010 POLYMER COMPOSITES AND STRUCTURES L T P C
3 0 0 3

OBJECTIVES

- To impart the fundamentals of polymer composites and structures
- To know about the manufacture, properties and applications of various FRP.

OUTCOME

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

- Understand the concepts of polymer composites and mechanics of composites.
  Demonstrate the ability to select a suitable polymer and fiber to meet desired needs within realistic constraints and processing techniques.

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 macromechanics 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; interlaminar stresses, failure and fracture analysis.

UNIT IV DESIGNING OF FRP 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 lay up, spray up, resin transfer molding, vacuum bag and pressure bagmolding; centrifugal-casting, pultrusion, filament winding; compression, transfer and injection molding; Sandwich construction and Foam reservoir molding.

TOTAL : 45 PERIODS

REFERENCES

1. R.M. Jones, "Mechanics of composite materials", McGraw-Hill, Kogakusha Ltd.Tokyo, 1975.
2. L.R. Calcote, "Analysis of laminated structures", Van Nostrand Reinhold Co., 1989.
3. Dominick V.Rosato,"Designing with reinforced composites", Hanser publishers, 1997.
4. Autar Kaw," Mechanics of composite materials", CRC Press, 1997.
5. R.G.Weatherhead,"FRP Technology",Applied science publishers Ltd,1980.
6. Peter Morgan,"Carbon fiber and their composites", Taylor and Francis, 2005.
7. Stuart M.Lee,"Compsoites Technology",Vol 1 & 2, Technomic Pub.,1989.

RT7011 **POLYMER NANOCOMPOSITES** **L T P C**
3 0 0 3

OBJECTIVES

- To impart the fundamentals of nanofiller and polymer nanocomposites
- To know about the manufacture, properties and applications of various nanofillers and polymer nanocomposites

OUTCOME

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

- Understand the concepts in selecting nano fillers and its incorporation in polymer matrix

UNIT I POLYMERS IN NANOSYNTHESIS 9

Template - Directed Assembly -Block copolymers and their phase behavior - Directed assembly of polymer blends - Assembly and transfer of nanoparticles/ nanofibers using polymers, Structural control at the nanoscale.

UNIT II NANOMATERIALS USED IN POLYMERS 9

Nanofillers in bulk polymers - overview of potential nanostructured fillers - types - nanoparticles, nanofibers, nanotubes, nanosheets; surface features and layers and its modification. Techniques used to characterize nanostructured materials –XRD, AFM, etc.

UNIT III CARBON NANOTUBES AND THEIR APPLICATION 9

Structure of carbon nanotubes, processing methods for nanotube based polymer nanocomposites, nanotube alignment, characterization, properties and applications,

UNIT IV PREPARATION AND PROCESSING OF POLYMER NANOCOMPOSITE 9

Preparations of polymer nanocomposites - melt blending, solution blending, latex coagulation, in-situ polymerization, characterization, properties and application.

UNIT V APPLICATION OF POLYMER NANOCOMPOSITES 9

Polymers in nanoelectronics, Magnetic polymer nanocomposites, Wear resisting polymer nanocomposites, Packaging, Bio-medical, surface coatings, etc.

TOTAL : 45 PERIODS

REFERENCES

1. Yiu-Wing Mai and Zhong-Zhen Yu, “Polymer Nanocomposites”, Woodhead Publishing Limited, 2006.
2. Klaus Friedrich, Stoyko Fakirov and Zhong Zhang, “Polymer Composites from Nano to Macro”, Springer 2005.
3. C.N.R.Rao, A.Muller, and A.K.Cheetham, “The chemistry of Nanomaterials”, Vol 1 & Vol. 2, Wiley-VCH, 2005.
4. Joseph H.Kao,”Polymer Nanocompsoites”, McGraw-Hill Pub.,2006.

RT7012 POLYMER REACTION ENGINEERING L T P C
3 0 0 3

OBJECTIVES

- To impart knowledge on the kinetics related to polymerization.
- To study about the fundamentals of reactor design.

OUTCOME

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

- Understand the principle behind reactor design and polymer kinetics.
- Design a reactor for a particular process.

UNIT I ELEMENTS OF CHEMICAL REACTION ENGINEERING 9

Introduction to chemical kinetics - Representation of expression for reaction rate, Temperature dependent and concentration dependent -Interpretation of Batch Reactor data for various types of reactions taking place in constant volume and variable volume batch reactors.

UNIT II REACTOR DESIGN 9

Performance equations for batch and flow reactors – design for single reactions – multiple reactions - Single Ideal Reactors: Batch, CSTR and Plug Flow Reactors - Reactor choices for single and multiple reactions Viz. series and parallel reactions -Residence time distribution in non-ideal flow reactors

UNIT III HEAT EFFECTS IN REACTORS 9

Isothermal and non isothermal homogenous system – adiabatic reactors – rates of heat exchange for different reactors – design for constant rate heat impact and constant heat transfer coefficient operations – batch and continuous reactors conversions – equilibrium – non-ideal flow in reactors

UNIT IV POLYMERISATION REACTORS 9

By free radical mechanism – characterization of mixtures of polymers – mechanism – kinetics – design of reactors for free radical polymerisation – stepwise addition & condensation polymerization & copolymerization – analysis of rate equation – polymerization in batch reactors – flow reactors

UNIT V MODELS OF HETEROGENEOUS POLYMERIZATIONS 9

Solution / precipitation, suspension and Emulsion polymerization - Smith Ewart Model Application to continuous emulsion polymerization - Co-ordination polymerization in fluidized bed reactor – Design - fundamentals of reactors for tailor making polymers example metalocene polyolefins - Qualitative account of control engineering considerations in operation of batch and continuous polymerization process

TOTAL : 45 PERIODS

REFERENCES

1. J .M. Smith, Chemical Engineering Kinetics, Mc-Graw Hill, 1975.
2. H. Scott Fogler, Elements of chemical reaction engineering, PHI, 1992.
3. M.Kh. Karapetyants, Chemical Thermodynamics, Mir Publications, USSR, 1978.
4. G.N.Pandy, J.C.Chaudari, Chemical Engg. Thermodynamics –Khanna Publishers.
5. L.H.Sperling, Introduction to Physical polymer science, John Wiley & Sons. London. \
6. Octave Levenspiel, Chemical Reaction Engineering, Wiley Eastern Ltd.
7. C.D. Holland & G. Rayboard Anthony, Fundamentals of chemical reaction Engineering.

RT7013 **POLYMER TESTING** **L T P C**
3 0 0 3

OBJECTIVES

- To realize the importance of testing at different stages while converting a raw material into a desired product.
- To introduce various testing methods for raw materials, rubber compound and its product.

OUTCOME

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

- Select a suitable testing method to check the various quality aspects.

Use advanced engineering tools and analyzes the problems within the domains of rubber and plastic

UNIT I TESTING IN PERSPECTIVE 9

Quality systems- assurance and management, standards and specifications, Statistical analysis of test data, polymer sample preparation and conditioning.

UNIT II TESTS FOR PROCESSABILITY 9

Viscosity - flow characteristics – Melt Flow Index, Gel Permeation Chromatography - tests for thermosets - spiral flow - bulk factor - Gelation and gel time.

UNIT III TESTS FOR MECHANICAL PROPERTIES 9

Hardness, Stress – strain properties – Permenant set, creep and stress relaxation, impact properties – Flexural properties.

UNIT IV TESTS FOR DURABILITY 9

Abrasion, fatigue, S-N Curves - Crack growth-low temperature and high temperature properties, accelerated aging, Failure and Fracture analysis,reverse engineering

UNIT V TESTS FOR SPECIFIC PROPERTIES 9

Media tests - solvent, and gas permeability, optical, flammability, electrical and testing of finished products and non destructive tests etc.

TOTAL : 45 PERIODS

REFERENCES

1. Physical Testing of Rubbers, R P Brown, Applied Science Publishers Ltd, 1979.
2. Handbook of Plastics Testing Technology, Vishu Shah, Wiley- Interscience Publication, 1984.
3. Plastics Engineering, R J Crawford, Pergamon Press, 1989.
4. Basic Rubber Testing: selecting methods for a rubber test program (ed), John S Dick, ASTM International, 2003.
5. Polymer Analysis, Barbara H Stuart, John Wiley & Sons, Ltd, 2002.
6. ASTM New Standard Guide for Nondestructive Testing of Polymer Matrix Composites used in Aerospace Applications.
7. Handbook on Statistical Quality Control (first revision), BIS, New Delhi.

RT7014 POLYMERS AND ENVIRONMENT L T P C
3 0 0 3

OBJECTIVES
- To know the various recycling methods of polymers.
- To impart knowledge on degradation of polymers.

OUTCOMES

By the end of this course, students will be able to
- Understand the professional and ethical responsibility to solve the environmental issues related to polymers.
- Demonstrate the necessity to develop new material, design, process, testing and solution for environmental related problems related to their field.

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 TECHNIQUES 7

Polymer degradation techniques – types of degradation – thermal – oxidative – photo – mechanical – biodegradation – process technology for biodegradable polymers

UNIT III PLASTICS RECYCLING 11

Recycling of thermoplastics - Polyolefins - PVC, PET, Polystyrene, Nylon, Polyurethanes, polyacetals-mechanical process and chemical process - applications of recycled materials. - 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 means – recycling cross linked 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

REFERENCES

1. John Scheirs., - "Polymer Recycling" John Wiley and Sons, 1998.
2. Nabil Mustafa – "Plastics Waste Management" John Wiley and Sons, 1998.
3. Muna Bitter, Johannes Brandup, Georg Menges "Recycling and Recovery of plastics" 1996
4. Attilio.L.Bisio,Marino Xanthos, " How to manage plastics waste: Technology and market Opportunities" Hanser Publishers, 1994.
5. Francesco La Mantia., " Handbook of Plastics Recycling" Chem Tec Publishing, 2002.
6. Sadhan K.De, Avraam. I.Isayev, Klementina Khait," Rubber Recycling", CRC Press, Taylor and Francis Group, 2005.

RT7015 POLYMERS FOR ELECTRICAL AND ELECTRONIC APPLICATIONS L T P C
3 0 0 3

OBJECTIVES

- To study the electrical behaviour of polymers
- To study the conduction mechanism of polymers and its application

OUTCOMES

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

- Able to select the polymers for electrical and electronic applications
- Able to test the electrical properties of polymers

UNIT I INTRODUCTION TO POLYMERS 9

Structure of polymers- saturated and un saturated polymers, Effect of polymer structure on electrical properties- Chemical and physical variant, conformation and hindered rotation, co polymers, crystallization and orientation, Polymers as non-conductive and conductive materials.

UNIT II DIELECTRICS IN STATIC FIELDS 9

Electrostatic relation, molecular polarisability local field Clausius-Mosotti relation, relative permittivity of polymer, dielectric relaxation in solid polymers, polymer liquids.

UNIT III MECHANISM OF CONDUCTION 9

Theories of electronic conduction -Band theory of conduction, properties of semi conductors, hopping conduction, metal insulator transition, band theory applied to polymers, super conduction, and ionic conduction-polyelectrolyte's and protonic conductors, solid polymer electrolytes, ionic impurities and antistatic agent.

UNIT IV MEASUREMENT OF DIELECTRIC PROPERTIES 9

Introduction, Bridge methods, Resonance methods, Wave transmission methods, Time – domain methods.

UNIT V APPLICATIONS OF ELECTRO-ACTIVE AND CONDUCTIVE POLYMERS 9

Electro-active polymers – xerography, OLEDS and Solar cells, Non-linear optics, intrinsically conductive polymers – soft electronics, LEDs, Photovoltaic devices, Sensors, Electrochemical applications, conductive coatings and composites and other applications.

TOTAL : 45 PERIODS

REFERENCES

1. Electrical properties of polymers, A.R.Blythe, Cambridge University Press,1979.
2. Electrical properties of polymers, Tony Blythe and David Bloor, Cambridge University Press, 2005.
3. Polymers for electronic and photonic applications, I.Bowden

RT7016 RESEARCH METHODOLOGY L T P C
3 0 0 3

OBJECTIVES

- To impart the knowledge on research design
- To know about the data processing, report writing and Intellectual property rights

OUTCOME

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

- Understand the concepts of various approaches of research, literature survey methods, data analysis, report preparation and significance of Intellectual property Rights

UNIT I INTRODUCTION TO RESEARCH 7

Research – Objective – Significance – Types – approaches; Research and scientific research – The hall marks of scientific research; Research process – steps involved; Current literature survey methods – abstraction of research papers –

UNIT II RESEARCH DESIGN AND SAMPLE DESIGN 10

Research Design – Need for Research Design – steps involved - features of Good Design – Important concepts relating to Research Design – Different Research designs – Basic Principles of Experimental Designs – Sample Design – steps involved – sampling techniques – Hypothesis testing to determine optimal sample size.

UNIT III ANALYSIS OF DATA 9

Statistics in Research – Measures of Central Tendency – Measures of Dispersion - Measures of Asymmetry (Skewness) – Measures of Relationship – Simple Regression Analysis – Multiple Correlation and Regression Partial Correlation – Association in case of attributes – Other Measures – Summary chart concerning Analysis of Data.

UNIT IV INTERPRETATION AND REPORT WRITING 9

Interpretation – need for interpretation - Technique of interpretation – precaution in interpretation – Report writing - Significance of Report writing – Different steps in report writing – Layout of the Research report – Types of reports – Oral presentation – Mechanics of writing Research Reports.

UNIT V INTELLECTUAL PROPERTY RIGHTS 10

An overview of Intellectual property (IP) – Importance – Protection of IPR – Patents – Patentable and Non-Patentable inventions – Procedure for filing of patents – acquisition of patent rights – patents offices in India and jurisdiction – Modification of granted patents – protection against unfair competition – Enforcement of IPR.

TOTAL : 45 PERIODS

REFERENCES

1. Research Methodology – C.R.Kothari., Wishwa Prakashan Publishers, India, 2001.
2. Murray R.Spigel, "Theory and problems of Statistics". Schaum Publishing Co., New York, 2000.
3. R.Panner selvam, "Research Methodology", Prentice hall of India, New Delhi, 2004.
4. P. Narayanan, Intellectual property Rights, Eastern law House, Third Edition, 2002.
5. G.P.Reddy, , Intellectual Property Rights & other Law, Gogia law agency, 2004.
6. Prof.A.Chandrasekaran, Intellectual property law, C.Sitaraman & Co.,Pvt.Ltd., 2004.

RT7017 SPECIALTY POLYMERS L T P C
3 0 0 3

OBJECTIVES

- To understand the fundamental behaviour of non Newtonian fluids.
- To introduce the properties and applications of engineering thermoplastics, thermosets and other strategic polymer materials.

OUTCOMES

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

- Select an appropriate polymer for the required application.
- Demonstrate the necessity for new material development to replace the existing one.

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, polyarylethesulphones, 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

REFERENCES

1. R.W. Dyson "Specialty Polymers", 2nd 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, 1988.

RT7018 STRESS ANALYSIS OF POLYMERS L T P C
3 0 0 3

OBJECTIVES

- To understand the stress strain behavior in polymers.
- To impart knowledge on analysis of different beams.
- To educate students on fracture mechanics in polymers.

OUTCOMES

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

- Understand the various design aspects to be considered for manufacturing the products.
- Utilize the stress strain mechanism while designing and manufacturing.

UNIT I ANALYSIS OF STRESS AND STRAIN 9

Analysis of stress at point and plane – principal stress – hydrostatic stress, stress at adjacent points and the equilibrium equations – strain in two dimensions – strain energy – yield criteria.

UNIT II TIME DEPENDENT BEHAVIOUR 9

Creep – Visco Elastic Theory – Linear Visco Elastic materials and models - Maxwell - Voight models - Power law materials

UNIT III BENDING AND TORSION 9

Simple elastic beam theory – Shear deflection in beams – Sandwich beams. Torsion of non circular sections – Torsion of solid bars - warping function and prandtl stress function – Solutions for elliptical and triangular bars – Torsion of thin walled sections – membrane analogy relationship between shear stress, applied torque, geometry and angle of twist

UNIT IV STRESS FUNCTIONS 9

Stress functions in Cartesian coordinates – Axial symmetry – Stresses around a circular hole – Stresses around crack tips

UNIT V FRACTURE MECHANICS 9

Energy release rates (G&K)– The relationship between G and K – Solutions for K in some cases like elliptical hole, uniformly loaded sheet – Cracks in three dimensions – Fracture criteria and crack propagation – Blunt cracks and notches

TOTAL : 45 PERIODS

REFERENCES

1. C Williams, J.G. "Stress Analysis of Polymers", Ellis Horwood, 1980.
2. B Timoshenko, S.P. and Goodier, J.N. "Theory of Elasticity", 3rd Edition, McGraw Hill, 1970 (Definitive).
3. Fenner, R.T. "Engineering Elasticity", Ellis Horwood, 1986.
4. Kolsky, H. "Stress Waves in Solids", Dover, 1963.
5. Johnson, W, "Impact Strength of Materials", Edward Amold, 1972.

RT7019 THEORY OF VISCOELASTICITY L T P C
3 0 0 3

OBJECTIVES

- To know the fundamentals of viscoelastic behaviour of a polymer.
- To understand the effect of various parameters like temperature, time etc on viscoelasticity.
- To impart an idea about the relation between viscoelasticity and microstructure.
- To know about the various experimental studies about viscoelastic behaviour of polymer.

OUTCOMES

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

- Predict the melt behaviour.
- Adapt a suitable method to study about the rheological behaviour and properties while processing the compound.
- Correlate and fix the external parameter to achieve desirable flow behaviour.

UNIT I INTRODUCTION TO VISCOELASTICITY 9

Nature of viscoelastic behaviour – Molecular mechanisms – phenomenological aspects Illustrations – Interrelations among viscoelastic functions – viscoelastic liquids – soft viscoelastic solids.

UNIT II TIME, TEMPERATURE EFFECTS ON VISCOELASTICITY 9

Temperature and viscoelasticity – Different zones – behaviour of linear and crosslinked polymers – Time temperature superposition – Viscoelastic correspondence principle - Theory and Applications.

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.

UNIT IV VISCOELASTICITY AND MICROSTRUCTURE 9

Viscoelasticity in amorphous and semicrystalline states – Polymer solutions and gels Rheological properties of polymer melts - Flow analysis and measurements.

UNIT V MEASUREMENT OF VISCOELASTICITY 9

Experimental viscoelasticity – Complex modulus – Dynamic modulus – Loss modulus – Dielectric relaxation spectra – Molecular relaxation studies.

TOTAL : 45 PERIODS

REFERENCES

1. John D.Ferry, Viscoelastic Properties of Polymers, John Wiley & Sons, 1980
2. Richard M Christensen, Theory of Viscoelasticity, Dover Publications, 2003
3. Alkonis J.J. and MacKnight, Introduction to Polymer Viscoelasticity, John Wiley & Sons (1983)

AL7017 THEORY OF VIBRATIONS L T P C
3 0 0 3

OBJECTIVE

- To study the dynamic behaviour of different aircraft components and the interaction among the aerodynamic, elastic and inertia forces

UNIT I SINGLE DEGREE OF FREEDOM SYSTEMS 8

Simple harmonic motion, definition of terminologies, Newton's Laws, D'Alembert's principle, Energy methods. Free vibrations, free damped vibrations, and forced vibrations with and without damping, base excitation, and vibration measuring instruments.

UNIT II MULTI-DEGREES OF FREEDOM SYSTEMS 12

Two degrees of freedom systems, Static and dynamic couplings, eigen values, eigen vectors and orthogonality conditions of eigen vectors, Vibration absorber, Principal coordinates, Principal modes. Hamilton's Principle, Lagrangean equation and their applications.

UNIT III VIBRATION OF ELASTIC BODIES 10

Transverse vibrations of strings, Longitudinal, Lateral and Torsional vibrations. Approximate methods for calculating natural frequencies.

UNIT IV EIGEN VALUE PROBLEMS & DYNAMIC RESPONSE OF LARGE SYSTEMS 10

Eigen value extraction methods – Subspace hydration method, Lanczos method – Eigen value reduction method – Dynamic response of large systems – Implicit and explicit methods.

UNIT V ELEMENTS OF AEROELASTICITY 5

Aeroelastic problems – Collar's triangle of forces – Wing divergence – Aileron control reversal – Flutter.

TOTAL : 45 PERIODS

TEXT BOOKS

1. Timoshenko, S. “Vibration Problems in Engineering”, John Wiley & Sons, Inc., 1987.
2. Meirovitch, L. “Elements of Vibration Analysis”, McGraw-Hill Inc., 1986.
3. Thomson W.T, Marie Dillon Dahleh, “Theory of Vibrations with Applications”, Prentice Hall, 1997

REFERENCES

1. F.S. Tse., I.F. Morse and R.T. Hinkle, “Mechanical Vibrations”, Prentice-Hall of India, 1985.
2. Rao.J.S. and Gupta.K. “Theory and Practice of Mechanical Vibrations”, Wiley Eastern Ltd., New Delhi, 1999.
3. Fung, Y.C., “An Introduction to the Theory of Aeroelasticity”, John Wiley & Sons Inc., New York, 1985.

AM7251	VEHICLE DYNAMICS	L T P C
		3 0 0 3

UNIT I BASIS OF VIBRATION 9

Definitions, Modeling and Simulation, Global and Vehicle Coordinate System, Free, Forced, Undamped and Damped Vibration, Response Analysis of Single DOF, Two DOF, Multi DOF, Magnification factor, Transmissibility, Vibration absorber, Vibration measuring instruments, Torsional vibration, Critical speed. Modal analysis

UNIT II TYRES 9

Tyre forces and moments, Tyre structure, Longitudinal and Lateral force at various slip angles, rolling resistance, Tractive and cornering property of tyre. Performance of tyre on wet surface. Ride property of tyres. Magic formulae tyre model, Estimation of tyre road friction. Test on Various road surfaces. Tyre vibration.

UNIT III VERTICAL DYNAMICS 9

Human response to vibration, Sources of Vibration. Design, analysis and computer simulation of Passive, Semi-active and Active suspension using Quarter car, half car and full car model. Influence of suspension stiffness, suspension damping, and tyre stiffness. Control law for LQR, H-Infinite, Skyhook damping. Air suspension system and their properties.

UNIT IV LONGITUDINAL DYNAMICS AND CONTROL 9

Aerodynamic forces and moments. Equation of motion. Tyre forces, rolling resistance, Load distribution for three wheeler and four wheeler. Calculation of Maximum acceleration, Reaction forces for Different drives. Braking and Driving torque. Prediction of Vehicle performance. ABS, stability control, Traction control. Case Studies.

UNIT V LATERAL DYNAMICS 9

Steady state handling characteristics. Steady state response to steering input. Testing of handling characteristics. Transient response characteristics, Direction control of vehicles. Roll center, Roll axis, Vehicle under side forces. Stability of vehicle on banked road and during turn. Effect of suspension on cornering.

TOTAL : 45 PERIODS

TEXT BOOKS

1. Singiresu S. Rao, Mechanical Vibrations (5^{th} Edition), Prentice Hall, 2010
2. J. Y. Wong, Theory of Ground Vehicles, 3^{rd} Edition, Wiley-Interscience, 2001
3. Rajesh Rajamani, Vehicle Dynamics and Control, 1^{st} edition, Springer, 2005
4. Thomas D. Gillespie, Fundamentals of Vehicle Dynamics, Society of Automotive Engineers Inc, 1992

REFERENCES
1. Dean Karnopp, Vehicle Stability, 1st edition, Marcel Dekker, 2004
2. G. Nakhaie Jazar, Vehicle Dynamics: Theory and Application, 1st edition, Springer, 2008
3. Michael Blundell & Damian Harty, The Multibody Systems Approach to Vehicle Dynamics, Elsevier Limited, 2004
4. Hans B Pacejka, Tyre and Vehicle Dynamics, 2nd edition, SAE International, 2005
5. John C. Dixon, Tyres, Suspension, and Handling, 2nd Edition, Society of Automotive Engineers Inc, 1996
6. Jan Zuijdijk, Vehicle dynamics and damping, AuthorHouse, 2009

MN7151	**MATERIALS TECHNOLOGY**	**L T P C**
		3 0 0 3

AIM

To impart knowledge on the advanced concepts of material technology

OBJECTIVES
- To make the students to understand on elastic, plastic and fractured behaviour of engineering materials.
- To train the students in selection of metallic and non-metallic materials for the various engineering applications.

UNIT I ELASTIC AND PLASTIC BEHAVIOR 10

Elasticity in metals and polymers Anelastic and visco-elastic behaviour – Mechanism of plastic deformation and non metallic shear strength of perfect and real crystals – Strengthening mechanisms, work hardening, solid solutioning, grain boundary strengthening, poly phase mixture, precipitation, particle, fibre and dispersion strengthening. Effect of temperature, strain and strain rate on plastic behaviour – Super plasticity – Deformation of non crystalline materials.

UNIT II FRACTURE BEHAVIOUR 10

Griffith's theory, stress intensity factor and fracture toughness – Toughening mechanisms – Ductile, brittle transition in steel – High temperature fracture, creep – Larson Miller parameter – Deformation and fracture mechanism maps – Fatigue, low and high cycle fatigue test, crack initiation and propagation mechanisms and Paris law. Effect of surface and metallurgical parameters on fatigue – Fracture of non metallic materials – Failure analysis, sources of failure, procedure of failure analysis.

UNIT III SELECTION OF MATERIALS 10

Motivation for selection, cost basis and service requirements – Selection for mechanical properties, strength, toughness, fatigue and creep – Selection for surface durability corrosion and wear resistance – Relationship between materials selection and processing – Case studies in materials selection with relevance to aero, auto, marine, machinery and nuclear applications – Computer aided materials selection.

UNIT IV MODERN METALLIC MATERIALS 8

Dual phase steels, High strength low alloy (HSLA) steel, Transformation induced plasticity (TRIP) Steel, Maraging steel, Nitrogen steel – Intermetallics, Ni and Ti aluminides – smart materials, shape memory alloys – Metallic glass and nano crystalline materials.

UNIT V NON METALLIC MATERIALS 7

Polymeric materials – Formation of polymer structure – Production techniques of fibers, foams, adhesives and coating – structure, properties and applications of engineering polymers –

Advanced structural ceramics, WC, TIC, TaC, Al_2O3, SiC, Si_3N_4 CBN and diamond – properties, processing and applications.

TOTAL : 45 PERIODS

REFERENCES

1. Ashby M.F., Material Selection in Mechanical Design, 3rd Edition, Butter Worth 2005.
2. ASM Hand book, Vol.11, Failure Analysis and Prevention, (10th Edition), ASM, 2002.
3. Charles, J.A., Crane, F.A.A. and Fumess, J.A.G., Selection and use of engineering materials, (3rd edition), Butterworth-Heiremann, 2001.
4. Thomas H. Courtney, Mechanical Behaviour of Materials, (2nd edition), McGraw Hill, 2000
5. Flinn, R.A., and Trojan, P.K., Engineering Materials and their Applications, (4th Edition) Jaico, 1999
6. George E.Dieter, Mechanical Metallurgy, McGraw Hill, 1988

MS 7151 MANUFACTURING MANAGEMENT L T P C
3 0 0 3

OBJECTIVE

To understand the fundamentals concepts of operations management in a manufacturing and service sectors.

OUTCOME

The students will have knowledge in layout planning, forecasting, production planning, inventory control, maintenance system and effective utilization of resources in manufacturing system.

UNIT I FACILITY, CAPACITY & LAYOUT PLANNING 9

Facility planning – Factors affecting selection of plant location, Factor rating analysis: Break – event, Load distance model, closeness ratings.

Types of plant layout, criteria for good layout, Process layout, Assembly line balancing. Computer based solutions to layout problems such as CRAFT, ALDEP, CORELAP and PREP.

Capacity planning – Analysis of designed capacity, installed capacity, commissioned capacity, utilized capacity, factors affecting productivity and capacity expansion strategies.

UNIT II DEMAND FORECASTING & PROJECT MANAGEMENT 10

Demand forecasting – Quantitative and qualitative techniques, measurement of forecasting errors, numerical problems, Long term forecast methodologies.

Project management – its role in functional areas of management, network representation of a project, CPM and PERT techniques, Analyzing cost-time trade-offs – Case study.

UNIT III PRODUCTION PLANNING & CONTROL 9

Steps in PPC process mapping, preparation of process mapping and feedback control for effective monitoring. Aggregate production planning, production planning strategies, Disaggregating the aggregate plan, Materials Requirement Planning (MRP), MRP-II, Supply chain management, Operation scheduling, prioritization.

UNIT IV INVENTORY PLANNING & CONTROL 8

EOQ models- with and without shortages, price breaks, effect of quantity discount – selective inventory control techniques – ABC, FSN, VED etc. Types of inventory control – Perpetual, two-bin and periodic inventory system – JIT, SMED, kanban, Zero inventory – Case study.

UNIT V MAINTENANCE SYSTEM 9

Maintenance strategies and planning, Maintenance economics: quantitative analysis, optimal number of machines, Replacement strategies and policies – economic service life, opportunity cost, replacement analysis using specific time period, spares management. Maintenance records.

TOTAL : 45 PERIODS

REFERENCES

1. S. N. Chary, "Production and Operations Management", 4th Edition, SIE, TMH, 2009.
2. R. Pannererselvam, "Production and Operations Management", 3rd Edition, PHI, 2012.
3. James. B. Dilworth, "Operations Management – Design, Planning and Control for Manufacturing and Services", McGraw Hill Inc. Management Series, 1992.
4. Melnyk Denzler, "Operations Management – A Value Driven Approach", Irwin McGraw Hill 1996.
5. Lee. J. Krajewski, L. P. Ritzman, & M. K. Malhothra, "Operations Management – Process and Value Chains", 8th Edition, PHI/Pearson Education, 2007.
6. R. B. Chase, N. J. Aquilano, & F. R. Jacobs, "Operations Management – For Competitive Advantage", 11th Edition, SIE, TMH, 2007.
7. Kanishka Bedi, "Production and Operations Management", 2nd Edition, Oxford Higher Education, 2007.